

Notices

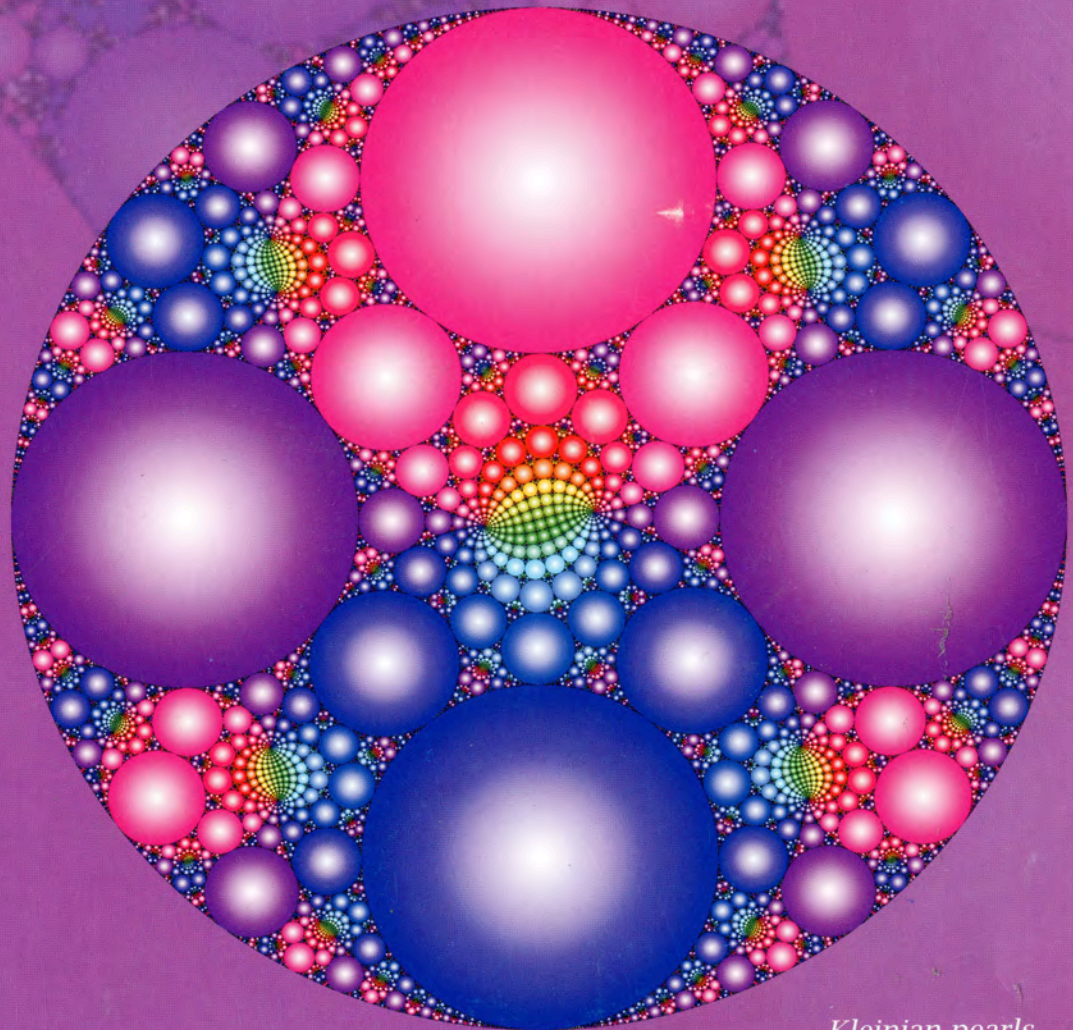
of the American Mathematical Society

December 2004

Volume 51, Number 11

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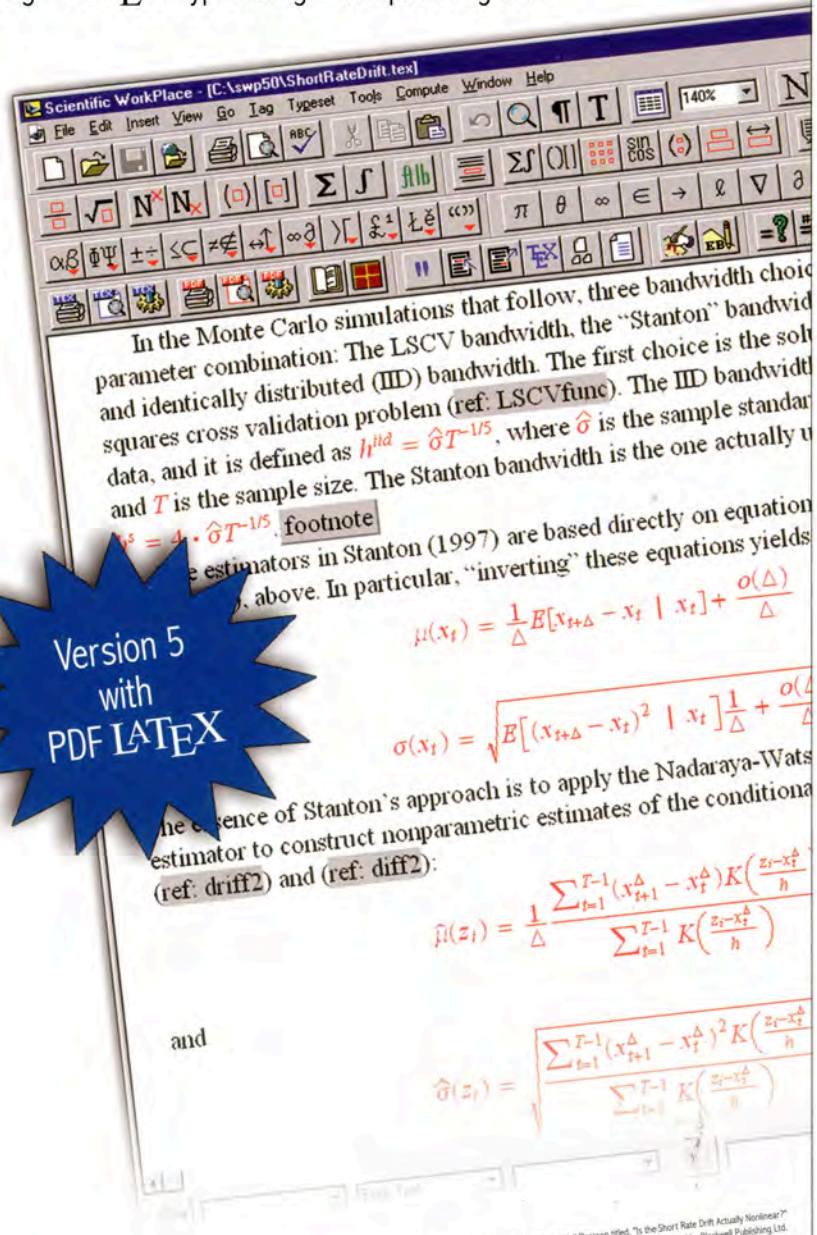
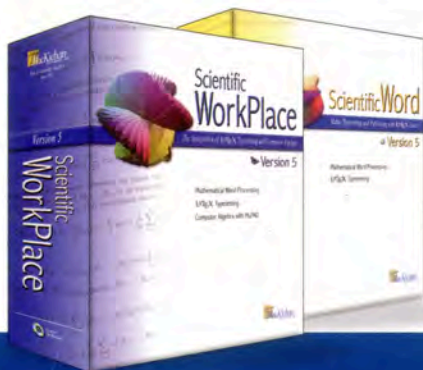
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- Space Curves Approximation Using C^1 Ball-Spline Curves, *Germain E. Randriambeloso*

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Notices

December 2004

of the American Mathematical Society

Feature Articles

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(1922–2004)

*Susan Friedlander, Peter Lax, Cathleen Morawetz,
Louis Nirenberg, Gregory Seregin, Nina Ural'tseva,
and Mark Vishik*

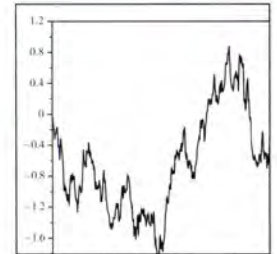
*The authors recall the life and mathematical legacy of the influential
Russian mathematician.*



1336 *Lévy Processes—From Probability to Finance
and Quantum Groups*

David Applebaum

*Stochastic processes are families of random variables; Lévy processes
are families indexed by the positive reals which are independent with
stationary increments and are stochastically continuous. The author reviews the basic proper-
ties of Lévy processes and considers some of their applications.*



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Changing Teaching of Future Teachers

Some years ago, one of us taught mathematics courses for future elementary teachers much as he did other college mathematics courses—lecture, drill, and test. Connections to school mathematics were not part of the course because they were not part of his education and experience. After reading *The Mathematical Education of Teachers* (MET), edited by Cathy Kessel (lead editor), Judith Epstein, and Michael Keynes (CBMS Issues in Mathematics Education, vol. 11, AMS and MAA, 2001) and Liping Ma's *Knowing and Teaching Elementary Mathematics: Teachers' Understanding of Fundamental Mathematics in China and the United States* (Lawrence Erlbaum Associates, 1999) and while working with mathematics educators on the Mathematical Association of America's Preparing Mathematicians to Educate Teachers (PMET) project, he is again teaching these courses—but in a very different way.

This conversion illustrates the goal of PMET and like-minded efforts to help mathematics faculty improve the mathematical preparation of future teachers. Workshops, mini-courses, and conferences for college and university faculty are PMET's main vehicles for accomplishing this goal. During the past three years, thirteen PMET workshops have been held with over 300 participants. Nine new PMET workshops are scheduled for summer 2005, including two at historically black institutions, one at the Southwest Indian Polytechnic Institute, and one at Park City Mathematics Institute. One initiative similar to PMET workshops is the Michigan-Georgia NSF Center for Proficiency in Teaching Mathematics summer institutes.

Are these efforts improving the mathematical education of teachers? Preliminary evidence suggests they are. Aimed at changing college faculty understanding and behavior, PMET is farther removed from improving K-12 learning than are projects directed at K-12 teachers. So an ultimate evaluation of impact will require considerable time. But as an intermediate step, we contacted participants in the 2003 workshops to see if they have changed how they teach future teachers.

Certainly, they overwhelmingly say they have. Ninety-five percent of those contacted report more emphasis on group work and collaborative approaches. Eighty-eight percent report requiring students to explain reasoning when solving problems—for example, through writing in and out of class, asking for oral explanations in class, and group discussion. And the changes were apparent to students as well. As one participant reported, "after a couple of days...I had one student ask me if we were only going to do 'word problems'...another asked if we were ever going to do 'a page full of calculations'...this seems to be unlike any math course they have ever had before, given their previous beliefs of what it was like to 'do math.'"

Workshop participants also told us they had changed how they teach particular mathematical concepts. These covered a wide array of topics—from greater emphasis on the concept of "the whole" in interpreting fractions, through materials for teaching algebraic reasoning, to particular approaches to teaching topics in measurement and geometry. Others reported they are much more aware of the need to instill in their students an understanding of the mathematical knowledge that

K-12 students need at every grade level to be successful. One noted, "even in Beginning Algebra I spend more time discussing the various meanings of a fraction...it helps my students gain a deeper understanding of something they felt they had already 'learned.'" Finally, participants told us they thought students learned better after these changes. One said that for the first time her students "were able to make the connection between fractions, decimals, and percents without my making it for them." Others cited differences in how students handled problems—both with respect to the explanations they provided of their own reasoning and the representations they used to construct their answers. On the latter, one noted, "units no longer disappear at the beginning of the work only to mysteriously reappear as part of the solution."

Changing teaching of future teachers can improve K-12 mathematics, and early evidence suggests the PMET workshops are effectively inducing mathematics faculty to make appropriate changes. But few mathematicians from research universities have so far participated in these workshops. In addition to the fact that their presence would enrich the experience, we believe there are several reasons why more should do so.

- Research institutions prepare future teachers, and research faculty should be involved in the development and teaching of courses for future teachers. In the words of the MET Report, "All mathematicians should be concerned about teacher education, and all have a role to play in the education of teachers."
- The mathematics required for teaching, in the words of MET, is "quite different from that required by students pursuing other mathematics-related professions." Most of us know some bits and pieces of the mathematics of K-12 teaching, but this mathematics needs more structure if we are to incorporate it coherently into college courses.
- Research mathematicians wield tremendous influence on future college and university faculty members, and the priorities and attitudes of research faculty influence all college and university faculty.
- Mathematics education is a major public policy issue, and mathematicians should be positioned to steer policy toward improving education. Research mathematicians can help add unity and credibility to this case for improvement.

In the September 2004 *Notices*, Lynn Arthur Steen wrote that to contribute to K-12 education "mathematicians should focus first on the mathematical education of teachers." We reinforce his call with some encouraging reports of changes being made through PMET, noting, as he did, that *everybody* in the mathematics community needs to be involved.

—Peter Ewell, National Center for Higher Education Management Systems (NCHEMS), PMET evaluator, peter@nchems.org

—Bernard Madison, University of Arkansas, PMET co-director, bmadison@uark.edu

Letters to the Editor

More on the Prisoner's Dilemma

In his letter (August 2004, page 735) commenting on Steven E. Landsburg's remark about the Prisoner's Dilemma ("Quantum game theory", April 2004), Dr. Marcus perpetuates the fallacious inference of Douglas R. Hofstadter in his justly admired 1985 book *Magical Themas*. The general issue is what hypotheses assure socially desirable choices when individual choices are relatively penalized unless all players choose to act for the social good. Clear thinking about this is important, since many crucial situations resemble the Prisoner's Dilemma, notably the need to limit births as we near the carrying capacity of our planet.

Before getting to the crux of the fallacy, let me repair one obvious deficiency of the argument. The hypotheses that the players are rational and selfish are what we know about them, but to impel a player to act, *he* must know this about the other, and then know that the other knows that he knows, and so *ad infinitum*. This may be a little awkward to describe, but there is no difficulty in annexing this iterated hypothesis of mutual complete knowledge (and Hofstadter essentially did so). These hypotheses remain insufficient.

Hofstadter weaves a magical spell about the theme that with symmetry selfish players will each cooperate as a rational choice. Ironically, it is the symmetry that makes it easy to refute this. A selfish player can rationally decide on cooperation only on the basis of an inference that the other player will choose cooperation—the inference must precede the decision. The symmetry guarantees that neither gets the necessary precedence. The argument never gets beyond the magic to a valid conclusion. It is the finitary nature of logic that prevents such a leap.

A simple analogy may allay any remaining doubts. The valid part of the symmetry argument is like proving that the tails of the sequence $\{1/n\}$ become arbitrarily small. Hofstadter's conclusion is like the assertion that

$\lim\{1/n\}$ exists and is 0. But the latter conclusion requires independent existence hypotheses about the presence of 0 and the nature of its neighborhood system. Choosing defection in the game contradicts none of Hofstadter's hypotheses. The reasoning is inconclusive, and rational choices are not based on inconclusive reasoning.

What the symmetry argument *does* accomplish is to demonstrate that additional hypotheses *can* consistently be added to entail mutual cooperation. What could such hypotheses be? A pre-arranged agreement? That is safe, but more than is necessary. The minimum is to assume, along with knowledge of the symmetry, a disposition to choose cooperation in a situation where all know that mutual cooperation will have a payoff in excess of any other. This, of course, is just a restatement of the conclusion. Explicitly adopting such a hypothesis renders the whole question trivial. Further, it is clearly a moral hypothesis, in the same category as selfishness, and not at all akin to rationality.

Since the behavior of the players is not determined by the hypotheses, it is clear that any claim that "Rational selfish players always choose to defect" is also incorrect—rational selfish players need not choose the Nash equilibrium in every case. Such claims as Landsburg's are epimathematical—imprecise heuristics that provide a perspective to ease the assimilation of the mathematics and to suggest applications of it. In this role they do little harm. It is when they are separated from this role and exalted into exaggerated claims that they are objectionable. Mathematicians cherish rationality and elegant arguments, and imputing to rationality more than it can deliver is sure to damage these values.

—H. E. Stone

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(Received August 18, 2004)

Underrepresentation

In his article on doctoral degrees earned by ethnic minorities, Herbert Medina points out that "Blacks, Hispanics/Latinos, Native Americans are underrepresented in earning doctoral degrees in the mathematical sciences. That is, these ethnic groups do not earn doctorates comparable to the percentage of the population they comprise." Most of the article is concerned with various attempts to try to reduce if not eliminate this underrepresentation. The final section of the article begins, "Supposing that we aim to solve the underrepresentation by the year 2025." From the discussion that follows it is clear that the problem will be "solved" when each of these groups is earning degrees at a rate roughly proportional to its percentage of the population.

I agree strongly that it is desirable to try to provide conditions that might increase the doctoral percentages of the study's underrepresented groups, but I seriously question the way the eventual goal is formulated. Do we really want to make our objective "to each according to his/her population percentage"? If this criterion is to be applied uniformly, then we will have to worry about overrepresentation as well as underrepresentation. I notice, using the data provided with the article, that the group Asian/Pac. Isl. is currently earning more than four times as many doctorates as its population would warrant. Should we then hope that by 2025 the percentage of doctorates earned by this group will be reduced by a factor of four? I doubt that Professor Medina would be in favor of such a resolution, but it's an unfortunate theorem that if we are to eliminate underrepresentation we will have to suppress overrepresentation. (Unfortunately we can't be like the students in the schools of Lake Woebegone who are all above average).

I have seen the criterion of population proportionality applied in other cases, notably that of gender, and I object to it there for the same reasons. The fact is, some groups in our society—whether cultural, ethnic, or even religious—have put more emphasis on mathematical achievement than

others. It seems to me that to try to level everyone by imposing the arbitrary criterion of population percentage would be a serious mistake.

—David Gale
UC Berkeley

(Received August 26, 2004)

Homework and Google

For decades calculus texts included answers to their odd-numbered exercises in an appendix; answers to the even-numbered exercises were available only in limited circulation instructor's answer manuals. This pedagogical arrangement was undercut here in Chapel Hill a decade ago when a teaching assistant put the answer manual on reserve in the library: Not only did his 35 students receive access to solutions for all of their assigned even-numbered problems, but so did some of the 700-odd students in the other 20-odd sections of that course that semester (namely, those students who happened upon the manual or who learned about it from a friend).

After I turned in my undergraduate group theory grades in May, one student told me that he had been able to find solutions for some standard problems via Web searches when he got completely stuck. Later I tried typing the following into Google:

Solution Prove that the composition of two injective functions is injective

Some of the top ten hits gave solutions for related problems, but none included a solution for this problem. Recently I reported this failed effort to the student while a friend of his was present. She opined that her peers were far more adept at Googling than faculty and suggested artfully placing quotes while using her favorite search engine. So I then typed

Solution "Prove that" "the composition of" "injective functions is" "injective"

into <http://www.dogpile.com>. One of the top five hits (which was not in North America) provided a solution to this problem (in English). My brief sojourns indicated that the instructors who posted solutions were providing them to their students *after the fact* (following a quiz or an assignment).

Postings that are not removed then provide solutions to students elsewhere *before the fact*.

The first student also told me that he was also able to find many posted solutions for our current discrete mathematics text at one site by Googling a combination of the author's name and some other suggestive words.

Not everyone will agree that posting solutions on the Web nets out negatively. We're supposed to be in the business of disseminating mathematical knowledge! All along, many of us have accepted solutions from students industrious enough to comb library books. However, the excessive convenience of the Web (copy and paste!) could soon remove many nice/classic problems from being eligible for graded homework assignments. If you are concerned about the potential effects of your actions on the pedagogical approaches of fellow instructors (even if this does not affect your own teaching techniques), you may wish to consider posting your solutions in a secure area requiring a password for access. If this approach is not readily available, some low-tech strategies could be considered: Avoid including the name of the text's author in your website. Do not include the statement of the problem. Deliberately misspell the key words. (This could be fun: "Let f and g be infective functions...") Remove your posting as soon as possible.

Some solutions will always be available on the Web. Proofs/solutions of all standard statements/problems will eventually appear on the Web, perhaps in a central eBourbaki repository. But in the meantime: If most instructors post their solutions below the search engines' radars, this could lower the Googling success ratio sufficiently so that the less industrious students won't bother.

—Bob Proctor
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Review of *A Handbook of Mathematical Discourse*

Steven G. Krantz's review of my book, *A Handbook of Mathematical Discourse*, in the August 2004, issue of *Notices of the American Mathematical Society* shows that he misunderstood the purpose of the book. Its focus is on mathematical discourse, that is, the way math is communicated in speech and writing. It is not primarily about math itself.

Students may deal dysfunctionally with quantifiers, definitions, the use of English words such as *if* with meanings different from those of ordinary discourse, and other aspects of mathematical discourse. Much of the book is devoted to discussing these difficulties, which inhibit understanding of many mathematical ideas. No attempt was made to cover all the important specific mathematical concepts.

The *Handbook* has entries about certain ideas from linguistics, rhetoric, cognition theory, and research in mathematical education and argues that, if teachers and students are aware of these ideas from outside mathematics, they will improve their chances of communicating successfully. These ideas may not belong in a book about math, but they do belong in a book about mathematical discourse.

As the introduction states, the book is incomplete in meeting its own goals, never mind the goals Professor Krantz expected it to have. Much more work in this field is necessary.

—Charles Wells
Oberlin, OH

(Received September 1, 2004)

Olga Alexandrovna Ladyzhenskaya (1922–2004)

*Susan Friedlander, Peter Lax, Cathleen Morawetz,
Louis Nirenberg, Gregory Seregin, Nina Ural'tseva,
and Mark Vishik*



Olga Alexandrovna Ladyzhenskaya died in her sleep on January 12th, 2004, in St. Petersburg, Russia, at the age of eighty-one. She left a wonderful legacy for mathematics in terms of her fundamental results connected with partial differential equations and her “school” of students, collaborators, and colleagues in Russia. In a life dedicated to mathematics she overcame personal tragedy arising from the cataclysmic events of twentieth century Russia to become one of that country’s leading mathematicians. Denied a place as an undergraduate at

university, she was an exceptionally gifted young girl, but one whose father disappeared in Stalin’s gulag. She eventually became a leading member of the Steklov Institute (POMI) and was elected to the Russian Academy of Science. Her mathematical achievements were honored in many countries. She was a foreign member of numerous academies, including the Leopoldina, the oldest German academy. Among other offices, she was president of the Mathematical Society of St. Petersburg and, as such, a successor of Euler.

Ladyzhenskaya made deep and important contributions to the whole spectrum of partial differential equations and worked on topics that ranged

from uniqueness of solutions of PDE to convergence of Fourier series and finite difference approximation of solutions. She used functional analytic techniques to treat nonlinear problems using Leray-Schauder degree theory and pioneered the theory of attractors for dissipative equations. Developing ideas of De Giorgi and Nash, Ladyzhenskaya and her coauthors gave the complete answer to Hilbert’s nineteenth problem concerning the dependence of the regularity of the solution on the regularity of the data for a large class of second-order elliptic and parabolic PDE. She published more than 250 articles and authored or coauthored seven monographs and textbooks. Her very influential book *The Mathematical Theory of Viscous Incompressible Flow*, which was published in 1961, has become a classic in the field. Her main mathematical “love” was the PDE of fluid dynamics, particularly the Navier-Stokes equation. This equation has a long and glorious history but remains extremely challenging: for example, the issue of existence of physically reasonable solutions to the Navier-Stokes equations in three dimensions was chosen as one of the seven millenium “million dollar” prize problems of the Clay Mathematical Institute. (The CMI website gives a description by Fefferman of the prize problem.) The three-dimensional problem remains open to this day, although it was in the 1950s that Ladyzhenskaya obtained the key result of global unique solvability of the initial boundary problem for the two-dimensional Navier-Stokes equation. She continued to obtain influential results and to raise stimulating issues in fluid dynamics, even up to the days before her death.

This memorial article contains brief surveys of some of Ladyzhenskaya's significant mathematical achievements by two of her collaborators in St. Petersburg, Gregory Seregin and Nina Ural'tseva. These are followed by "memories" of Olga Alexandrovna by other distinguished mathematicians who have known her and her work for many years, namely Peter Lax, Cathleen Morawetz, Louis Nirenberg, and Mark Vishik.

Olga Alexandrovna was a woman of great charm and beauty. We are very grateful to Tamara Rozhkovskaya for presenting some of the lovely photographs of Olga that appear in the two volumes in honor of the eightieth birthday of Ladyzhenskaya edited by Rozhkovskaya, who is a "mathematical grandchild" of Olga and editor and publisher of the International Mathematical Series in which these volumes appear. At the conclusion of her appreciation article in the second of these two volumes, Nina Ural'tseva (a "mathematical child" and close friend and collaborator of Olga) writes "In the Science Museum in Boston there is an exhibition devoted to mathematics. The names of the most influential mathematicians of the 20th century are carved on a large marble desk...and Olga Ladyzhenskaya is among them".

—Susan Friedlander

Gregory Seregin and Nina Ural'tseva

Olga Alexandrovna Ladyzhenskaya passed away quite unexpectedly on January 12 this year. She was in good spirits two days before that. She had just sketched a paper on some computational aspects in hydrodynamics and planned to finish it in Florida. Olga was fond of sunlight; therefore, every winter, the darkest period in our St. Petersburg, she longed for the South.... In her last years she had serious problems with her eyes, and she suffered enormously because of the winter darkness. She resisted such problems by all means, for example, using special pencils when writing. She was to leave for Florida on January 12. On the eve of January 11 she went to rest before her long trip and did not wake up. God gave her an easy death.

Olga Ladyzhenskaya was a brilliant mathematician and an outstanding person who was admired by distinguished scientists, writers, artists, and musicians, often becoming a source of inspiration

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Selected Honors of Olga Ladyzhenskaya

- 1969 The State Prize of the USSR
- 1985 Elected a foreign member of the Deutsche Akademie Leopoldina
- 1989 Elected a member of the Accademia Nazionale dei Lincei
- 1990 Elected a full member of the Russian Academy of Science
- 2002 Awarded the Great Gold Lomonosov Medal of the Russian Academy
- 2002 Doctoris Honoris Causa, University of Bonn



Н. Н. Уральцева О. А. Ладыженская В. И. Смирнов

Left to right, Nina Ural'tseva, Olga Ladyzhenskaya, V. Smirnov.

for them. The eminent mathematician V. Smirnov; the great pianist and professor of the Academy of Music, N. Golubovskaja; the distinguished world-famous poets A. Akhmatova and J. Brodsky; and the famous writer A. Solzhenitsyn are found among them.

Her influence on twentieth century mathematics is highly valued by the world scientific community. It was not only Olga's scientific results, though truly deep and fundamental, but also her personal integrity and energy that played an especial role in her contribution to mathematics.

Olga's focus in life was not limited to mathematics and science. She was deeply interested in arts and intellectual life in general. She loved animals, was a passionate mushroom lover, and enjoyed flowers. She was an enthusiastic traveler and had the wonderful skill of a storyteller when sharing her impressions with friends.

There were few things that did not touch her; she reacted keenly to any injustice, to the misfortunes of others; and she helped lone and feeble people. She took this very personally.

She expressed openly her views on social matters, even in the years of the totalitarian political regime, often neglecting her own safety.

Olga grew up during very hard times in Russia. She was born on March 7, 1922, in the tiny town of Kologriv in the north part of Russia. Her father, Alexander Ivanovich, taught mathematics in a high school. Her mother, Anna Mikhailovna, kept house



Olga as a baby, with her father, mother, and two sisters.

and looked after her husband and three daughters. Olga's "grandfather"¹, Gennady Ladyzhensky, was a famous painter. There were many books, including books on history and fine arts, in their house. Books were almost the only source of cultural education, because Kologriv was too far from cultural centers. The town was situated among wild forests, near the picturesque river Unzha. All her life Olga carefully kept beautiful landscape paintings by her grandfather, some of them depicting fine views of the Unzha.

It was in the summer of 1930 that Alexander Ivanovich decided to teach mathematics to his own daughters. After he made some explanation of the basic notions of geometry, he formulated a theorem and suggested that his daughters prove it themselves. It turned out that the youngest one, Olga, was the best of his students. She loved to discuss mathematics with her father, and soon they studied calculus together.



In October 1937 Alexander Ivanovich was arrested and soon killed by NKVD, the forerunner of the KGB. It was a great shock for the family. Later, in 1956, he was officially exonerated "due to the absence of a corpus delicti". His death put the family in a very distressed situation. The mother and older daughters had to go to work. Olga's mother had grown up in a small village in Estonia and could do craft work. She made dresses, shoes, soap, and many other things. That was the way the family survived in those days.

In 1939 Olga graduated with honors from Kologriv High School and went to Leningrad to continue her education. However, it was forbidden for a person whose father was considered an "enemy of his Nation" to enter Leningrad State University.² She was accepted at Pokrovskii Pedagogical Institute, and finished two years of studies there in June 1941. The war forced her to leave Leningrad. In the

¹ Olga's actual grandfather was Ivan whose brother was the painter Gennady Ladyzhensky. Gennady lived with Ivan and his family. Olga and her sisters always called Gennady "Dedushka" which means grandfather.

²She had passed the entrance exams to this university which at the time was considered the best in the Soviet Union.

fall of 1941 she worked as a teacher in the town of Gorodets, and in the spring of 1942 she returned to Kologriv, where she took her father's position as a high school mathematics teacher. In October 1943 she finally became a student at Moscow State University and graduated in 1947. During these years, I. G. Petrovskii was her adviser. At that time she was strongly influenced by Gelfand's seminar.

In 1947 Olga married A. A. Kiselev, a Leningrad resident, so she moved there, with a recommendation from Moscow State University to the graduate school of Leningrad State University (LGU). At LGU S. L. Sobolev was appointed to be her scientific adviser. From the time she came to LGU, a very close friendship developed between Olga and V. I. Smirnov and his family. In the fall of 1947 Smirnov, at Ladyzhenskaya's request, became head of a seminar on mathematical physics, which has been active ever since. The seminar brought together many mathematicians of the city working in the area of partial differential equations and their applications. Until her last days Ladyzhenskaya was one of the leading participants.

Finite-Difference Method and Hyperbolic Equations

Even the first results that Ladyzhenskaya obtained in the late 1940s and in the early 1950s were a breakthrough in the theory of PDEs. In her Ph.D. thesis, defended at LGU in 1949, she proposed a difference analog of Fourier expansions for periodic functions on grids and investigated their convergence as the grid step goes to zero in the difference analogues of the space W_2^k . Using these



expansions, she investigated various difference schemes for model equations, distinguished those that are stable for certain ratios of grid steps in the space and time variables, and then proved the stability of these schemes for equations with variable coefficients. In particular, she gave a simpler proof of unique local solvability of the Cauchy problem for hyperbolic quasilinear systems than the proof that Petrovskii had given.

After defending her Ph.D. thesis, Ladyzhenskaya decided to study initial boundary-value problems for linear hyperbolic equations of second order. She started with justification of the Fourier method. In her publications of 1950–1952, Ladyzhenskaya gave exhaustive answers concerning series expansions of functions in $W_2^k(\Omega)$ in the eigenfunctions of arbitrary symmetric second-order elliptic

operators in a bounded domain $\Omega \in \mathbb{R}^n$, under any of the classical boundary conditions on $\partial\Omega$. Moreover, in [1] she found a solution to the problem of describing the domain of the closure in $L_2(\Omega)$ of an elliptic operator \mathcal{L} with the Dirichlet boundary condition. The solution is based on the inequality

$$(1) \quad \|u\|_{W_2^2(\Omega)} \leq C(\Omega)(\|\mathcal{L}u\|_{L_2(\Omega)} + \|u\|_{L_2(\Omega)}),$$

proved by Ladyzhenskaya. Here, \mathcal{L} is a general second-order elliptic operator with smooth coefficients in front of the second derivatives, Ω is a bounded domain in \mathbb{R}^n with smooth boundary, and u is an arbitrary function in $W_2^2(\Omega)$ that vanishes on the boundary or satisfies a nondegenerate homogeneous boundary condition of the first order. The significance of this result for the theory of differential operators, including spectral theory, can hardly be overestimated.

Most of the results mentioned above were included in her first monograph [2], published in 1953. Unfortunately, this book was not translated into European languages.

Thanks to this work, the notion of a weak solution to an initial boundary-value problem becomes an important concept in mathematical physics. Systematic investigation of the entire scale of weak solutions in various function spaces, masterly analytic techniques for obtaining estimates for the integral norms, together with general arguments of functional analysis, provided Ladyzhenskaya with a strong background that led to success in the study of the solvability of the boundary-value problems and initial boundary-value problems for linear PDEs of classical type.

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Quasilinear PDEs of Elliptic and Parabolic Types

An extensive series of joint papers by Ladyzhenskaya and Nina Ural'tseva was devoted to the investigation of quasilinear elliptic and parabolic equations of the second order. At the beginning of the last century S. N. Bernstein proposed an approach to the study of the classical solvability of boundary-value problems for such equations based on a priori estimates for solutions. He also described conditions that are in a certain sense necessary for such solvability. These conditions, which are usually called natural growth restrictions, are formulated in terms of growth orders of functions entering the equations with respect to gradients of solutions. Due to works by Leray and Schauder, investigation of the classical solvability of the

Dirichlet problem was reduced to obtaining a priori bounds for its solutions in $C^{1+\alpha}$ norm. Up to the mid-1950s the program had been realized for the Dirichlet problem for two-dimensional elliptic equations, but even in those cases some unnatural conditions were supposed.

The conception of a generalized solution first showed up in the calculus of variations. The efforts of many outstanding mathematicians such as Hilbert, Tonelli, Morrey, and A. G. Sigalov led to the construction of direct methods for proving the existence of solutions to the Euler equations of the corresponding variational integrals. In contrast to the existence of minimizers, the number of independent variables plays a significant role in the study of their differentiability properties. By the beginning of the 1940s Morrey was investigating the regularity for the case $n = 2$.

The attack on higher-dimensional problems



started in the mid-1950s.

In 1955, at the Department of Physics of LGU, Ladyzhenskaya delivered a special course of lectures about her new results on quasilinear parabolic equations, later published in [1] and [2]. These papers contained a rather general form of the method of auxiliary functions, which goes back to Bernstein's work. Ladyzhenskaya set herself the task of unraveling the secret of finding auxiliary functions for the evaluation

of the maximum modulus of the gradient of the solution in the multidimensional case. She reduced it to solving a nonlinear differential inequality for functions of one variable and proved its solvability under a certain condition of smallness. This made it possible to estimate the spatial gradient for any solution in terms of its modulus of continuity under natural growth conditions. In papers [1] and [2], she applied her result to a narrower class of quasilinear elliptic and parabolic equations that does not require a preliminary estimate for the oscillations of the solution. Almost simultaneously with [1], in papers by J. Nash and E. de Giorgi, a bound for the Hölder norm of solutions was established for the simplest case of linear parabolic and elliptic equations having a divergence form with bounded measurable coefficients.

De Giorgi's ideas were further developed in [3]–[8]. The results of these investigations were the main content of monographs [9]–[11] on the theory of quasilinear equations of elliptic and

parabolic types (the latter written jointly with Solonnikov). The books presented a rather complete theory for quasilinear equations of divergence form and, in particular, global solvability of the classical boundary-value problems under natural growth restrictions. Moreover, the methods developed by the authors in [9] enabled them to analyze the dependence of smoothness of generalized solutions on the smoothness of data for equations of divergence form. It was proved that under natural growth restrictions, the regularity of weak extremals for the higher-dimensional variational is completely determined by the smoothness of the integrand. In a sense this concluded the investigation of Hilbert's nineteenth and twentieth problems for second-order equations. Also, classes of quasilinear systems with diagonal principal part and a special structure of the terms quadratic in gradients were singled out there, and it was shown that they share properties that are characteristic of scalar divergence equations. Such systems later became the object of detailed studies in research on harmonic maps of manifolds.

The books [9]–[11] also presented a number of deep results in the theory of quasilinear equations of general nondivergence form. However, for such equations it was only later, at the beginning of the 1980s, that unnatural restrictions were completely removed and the results brought to the same level of generality as in the divergence form case. This required techniques developed by N. V. Krylov and M. V. Safonov for investigating linear equations of nondivergence form with bounded measurable coefficients. In [12]–[14], the conditions on the data were made even weaker, the presence of integrable singularities with respect to the independent variables was allowed, and the solvability of the Dirichlet problem was studied in Sobolev spaces.

The methods developed in the monographs [9]–[11] turned out to be effective also in the study of broader classes of equations that contain non-uniformly elliptic operators like mean curvature operator [15]. The joint work of Ladyzhenskaya with N. M. Ivochkina was devoted to geometric topics as well. In 1994–1997, they published a series of papers investigating the global classical solvability of the first initial boundary-value problem for nonlinear equations of parabolic type that describe the flows generated by the symmetric functions of the Hessian of the unknown surface or by its principal curvatures.

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Hydrodynamics

The mathematical theory of viscous incompressible fluids was the favorite topic of Olga Ladyzhenskaya. She was involved with this activity from the middle of the 1950s till the very end of her life. Her personal contributions to mathematical hydrodynamics were deep and very important. But what was perhaps even more important is that she was a great source of new problems for others.

In the middle of the 1950s, Ladyzhenskaya began with the simplest case, the stationary Stokes system:

$$(0.1) \quad \left. \begin{aligned} \mu \Delta u - \nabla p &= -f \\ \operatorname{div} u &= 0 \end{aligned} \right\} \text{ in } \Omega, \quad u|_{\partial\Omega} = 0$$

Here, Ω is a domain in $\mathbb{R}^n (n = 2, 3)$, $f \in L_2(\Omega; \mathbb{R}^n)$ is a given force, μ is constant viscosity, u and p are unknown velocity field and pressure. If we define by $H(\Omega)$ and $H^1(\Omega)$ the closures of the set

$$\overset{\circ}{C}_0^\infty(\Omega; \mathbb{R}^n) = \{v \in C_0^\infty(\Omega; \mathbb{R}^n) \mid \operatorname{div} v = 0\}$$

in $L_2(\Omega; \mathbb{R}^n)$ and $W_2^1(\Omega; \mathbb{R}^n)$, respectively, the velocity can be determined from the variational identity

$$(0.2) \quad \mu \int_{\Omega} \nabla u : \nabla v \, dx = \int_{\Omega} f \cdot v \, dx, \quad \forall v \in H^1(\Omega).$$

At that time, Ladyzhenskaya had already been able to prove that the solution u to (0.2) has the second derivatives which are locally square summable in Ω . In order to recover the pressure, she proved the following fundamental fact:

Theorem 0.1. *Let $w \in L_2(\Omega; \mathbb{R}^n)$ be orthogonal to all $v \in \overset{\circ}{C}_0^\infty(\Omega; \mathbb{R}^n)$, then $w = \nabla p$ for some $p \in L_{2,\text{loc}}(\Omega)$ with $\nabla p \in L_2(\Omega; \mathbb{R}^n)$.*

The theorem was proved in the celebrated monograph [1], which contains the main results obtained by Ladyzhenskaya in the 1950s on Stokes and Navier-Stokes equations.

In 1957, the joint paper [2] by Ladyzhenskaya and Kiselev was published, in which they considered the first initial boundary value problem for the Navier-Stokes equations:

$$(0.3) \quad \left. \begin{aligned} \partial_t v + v \cdot \nabla v - \mu \Delta v + \nabla p &= f \\ \operatorname{div} v &= 0 \end{aligned} \right\} \text{ in } Q_T = \Omega \times]0, T[\\ v|_{\partial\Omega \times]0, T[} = 0, \quad v|_{t=0} = a$$

and proved unique solvability of it in an arbitrary three-dimensional domain. At that time, the only one result of such kind was the pioneering result [3] of J. Leray on the Cauchy problem. All statements in [2] were proved without any special representation of solutions but allowed freedom in the choice for a class of generalized solutions in which the uniqueness theorem is preserved. In particular, they worked in the class $W_2^1(Q_T) \cap L_\infty(0, T; L_4(\Omega))$ for v , with $\partial_t \nabla v \in L_2(Q_T)$, and showed that unique solvability in the class on a non-empty interval $]0, T[$, where T depends on W_2^2 -norm of a and on L_2 -norms of the known functions f and $\partial_t f$. If these norms are sufficiently small, then $T = +\infty$. In this paper, they cited Hopf's work [5],



Ladyzhenskaya near the River Dnieper in the Ukraine, while on a break from a math conference.

saying that the class of weak solutions introduced by E. Hopf is too wide to prove uniqueness.

One of the most remarkable results, proved by Ladyzhenskaya at the end of the 1950s and published in [4], was the global unique solvability of the initial boundary problem for the 2D Navier-Stokes equations. For the Cauchy problem, it was established by J. Leray. The proof was based on ideas developed in [2] and on new types of inequalities, which nowadays are called multiplicative inequalities. In particular, Ladyzhenskaya proved that, for any $v \in C_0^\infty(\Omega)$, it holds:

$$(0.4) \quad \|v\|_{L_4(\Omega)}^2 \leq C \|\nabla v\|_{L_2(\Omega)} \|v\|_{L_2(\Omega)}.$$

Here, Ω is an arbitrary domain in \mathbb{R}^2 and C is a universal constant. The inequality (0.4) now bears her name. At almost the same time, Lions and Prodi proved in [6] the global unique solvability of the two-dimensional problem in a different way but with the help of Ladyzhenskaya's inequality (0.4).

As to the three-dimensional case, Ladyzhenskaya did not pay special attention to additional conditions that provide uniqueness of the so-called weak Leray-Hopf solutions. A function u is called a weak Leray-Hopf solution if it has the finite energy, satisfies a certain variational identity in which test functions are divergence free and compactly supported in the space-time cylinder Q_T , is continuous in time with values in $L_2(\Omega)$ equipped with the weak topology, and satisfies the energy inequality for all moments of time and the initial condition in L_2 -sense. It was mentioned in the first edition of her monograph [1] that the additional condition $v \in L_{4,8}(Q_T) \equiv L_8(0, T; L_4(\Omega))$ gives uniqueness in the class of weak Leray-Hopf solutions. This condition is a particular case of the following theorem proved essentially by Prodi in [7] and by Serrin in [8].



Ladyzhenskaya, age 79, in her St. Petersburg apartment.

Theorem 0.2. Assume that v is a weak Leray-Hopf solution and

$$(0.5) \quad v \in L_{s,l}(Q_T)$$

for positive numbers s and l satisfying the condition

$$(0.6) \quad \frac{3}{s} + \frac{2}{l} \leq 1, \quad s > 3.$$

Then any other weak Leray-Hopf solution to the same initial boundary-value problem coincides with v .

Ladyzhenskaya later included results of this type in the second Russian edition [9] of her monograph.

In 1967, Ladyzhenskaya proved in [10] that in fact weak Leray-Hopf solutions satisfying conditions (0.5) and (0.6) are smooth.

Theorem 0.3. Assume that all conditions of Theorem 0.2 are fulfilled. Let, in addition, $f \in L_2(Q_T)$, $a \in H^1(\Omega)$, and Ω is the bounded domain in \mathbb{R}^3 of class C^2 . Then $\partial_t v$, $\nabla^2 v$, and ∇p are in $L_2(Q_T)$.

As it was indicated in one of the last papers by Ladyzhenskaya [11], this theorem might be a good guideline for those who would like to solve the main problem of mathematical hydrodynamics. By the way, Ladyzhenskaya formulated it as follows: One should look for the right functional class in which global unique solvability for initial boundary value problems for the Navier-Stokes takes place.

Up to now, very few qualitatively new results on global unique solvability results for the three-dimensional nonstationary problem are known. The most impressive among them is Ladyzhenskaya's result for the Cauchy problem in the class of radially asymmetric flows with zero angular velocity. This was proved in [12].

As we mentioned above, Ladyzhenskaya believed that in the 3D case the Navier-Stokes equations, even with very smooth initial data, do not provide uniqueness of their solutions on an arbitrary time interval. Hopf and later other mathematicians, Ladyzhenskaya among them, tried unsuccessfully to state a reasonable principle of choice for determinacy. Giving up these attempts, Ladyzhenskaya introduced the so-called modified Navier-Stokes equations, which are now known as Ladyzhenskaya's model. These equations differ from the classical ones only for large-velocity gradients. For them, she proved global unique solvability under reasonably wide assumptions on the data of the problem. These results were the main content of her report to the International Congress of Mathematicians in 1966. For a long time, problems of this type were not very popular due to their difficulties, and it is only in the last decade that they have attracted the attention of many mathematicians trying to improve on Ladyzhenskaya's old results.

At the end of this section, we would like to mention the remarkable results Ladyzhenskaya obtained on the solvability of stationary problems for the Navier-Stokes equations. The first attempts in this direction were made by Odqvist and Leray. However, the question of global solvability (for all values of Reynolds numbers) had remained open till the end of the 1950s. Ladyzhenskaya's approach was based on her conception of weak solution and a good choice of the energy space. This turned out to be the space $H^1(\Omega)$, the closure of $C_0^\infty(\Omega)$ in the Dirichlet integral norm. Using known a priori estimates for the velocity gradient in $L_2(\Omega)$, she proved in [13] and [14] the existence of at least one solution in the energy space $H^1(\Omega)$. Later, in the 1970s, Ladyzhenskaya, together with Solonnikov, successfully studied stationary problems in domains with noncompact boundaries.

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Attractors for PDEs

In [1], Ladyzhenskaya considered a semigroup generated by the two-dimensional initial boundary-value problem for the Navier-Stokes equations. Solution operators were defined as $V_t(a) = v(t)$, and the phase space was $H(\Omega)$. It was assumed that the force f in (0.3) is independent of time and belongs to $L_2(\Omega)$. It was known that solution operators are continuous in (a, t) on $H(\Omega) \times \mathbb{R}_+^1$ and each bounded set $B \subset H(\Omega)$ is pulled into the ball $\mathcal{B}(R_0) = \{u \mid \|u\|_{L_2(\Omega)} < R_0\} \subset H(\Omega)$ of radius $R_0 > (\lambda\mu)^{-1} \|f\|_{L_2(\Omega)}$ in a finite time, where λ is the first eigenvalue of the Stokes operator for the domain Ω , and B stays there for all large t . She showed that solution operators are compact on $H(\Omega)$ for each fixed positive t . For finite-dimensional phase spaces this result is immediate, but in the case of infinite-dimensional phase spaces that was a very important step. Then Ladyzhenskaya took the intersection

$$(0.1) \quad \mathcal{M} = \bigcap_{t>0} V_t(\mathcal{B}(R_0))$$

and proved that the set \mathcal{M} is nonempty and compact and attracts any bounded subsets of the phase space. She found many other interesting proper-

ties of \mathcal{M} . It is invariant, each trajectory on \mathcal{M} can be extended to negative times, and in a sense it is finite-dimensional. The latter means that there is a number N with the following property: If for two full trajectories lying in \mathcal{M} the projections on the finite dimensional space spanned by the first N eigenfunctions of the Stokes operator coincide, then the trajectories themselves coincide. In the conclusion of this remarkable paper, it was claimed that the proposed approach is applicable to many other dissipation problems, in particular, to problems of parabolic types. So, [1] opened a chapter in the theory of PDE, namely the theory of stability "in the large". This program was realized in her last monograph [3].



In her survey article [2], she proposed to call the set \mathcal{M} a "global minimal \mathcal{B} -attractor". Her explanation of that was as follows. The word "minimal" indicates that no proper subset of \mathcal{M} attracts the whole of $H(\Omega)$, and the letter \mathcal{B} emphasizes that any bounded set in $H(\Omega)$ is uniformly attracted to \mathcal{M} . Certainly, this makes sense.

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M. I. Vishik

I first met Olga Alexandrovna Ladyzhenskaya in 1945, and we became friends at once. She was then a third-year student at Moscow State University. We often met at the seminars, and we discussed mathematical problems while walking along the wide corridors of the Department of Mechanics and Mathematics of the university.

Her scientific adviser at Moscow State University was Ivan Georgievich Petrovskii. In 1946 Israel

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Moiseevich Gelfand organized a seminar for three young mathematicians: O. A. Ladyzhenskaya, O. A. Oleĭnik, and myself. As a result each participant of the seminar got an interesting mathematical problem to seriously work on. O. A. Ladyzhenskaya got the problem of describing the domain of an elliptic operator of the second order with Dirichlet boundary conditions and with right-hand side belonging to $L_2(\Omega)$. She proved that if this boundary-value problem has a unique solution, then the elliptic operator is an isomorphism between the Sobolev space $H^2(\Omega) \cap H_0^1(\Omega)$ and $L_2(\Omega)$. She also found an estimate for the norm for the corresponding inverse operator.

In the late forties Olga Alexandrovna moved to Leningrad, where she became a postgraduate student of Vladimir Ivanovich Smirnov. Vladimir Ivanovich admired her talent, and she took an active part in his seminar. Later Olga Alexandrovna became the head of the seminar. From time to time Olga Alexandrovna organized conferences on differential equations and their applications. These conferences were very popular. Many mathematicians from other universities and institutes in the Soviet Union used to take part in them.

In Leningrad Olga Alexandrovna married Andrey Alekseevich Kiselev, who looked very much like Pierre Bezukhov, the hero of the novel *War and Peace* by Leo Tolstoy. My wife and I often visited them when we were in Leningrad. We witnessed how tender and loving Andrey Alekseevich was. She literally meant the world to him. However, they separated later. Andrey Alekseevich wanted to have children, but Olga Alexandrovna did not. She justified her decision by her wish to devote her life to mathematics only, to which children might be an obstacle. Thus, Olga Alexandrovna stayed single for the rest of her life.

For many years starting in the late forties, Olga Alexandrovna visited us many times, and sometimes even stayed with us. She was usually interested in what new mathematical ideas I had worked out over the summer, and she told me, in turn, of her own new achievements. We also used to discuss with her new compelling and timely mathematical problems; the connections between functional analysis and the theory of differential equations and many other things. Ladyzhenskaya and I published a paper on these problems in *Uspekhi Matematicheskikh Nauk* (see [1]).



Olga Ladyzhenskaya with her husband, Andrey Kiselev.

In 1953, at Moscow State University, Olga Alexandrovna defended her "habilitation" dissertation devoted to the problem of regularity of solutions of a mixed boundary-value problem for a general hyperbolic equation of the second order. She found rather sharp conditions guaranteeing that the solutions of these equations are the solutions in the classical sense. Olga Alexandrovna justified the Fourier method for the solution of hyperbolic boundary-value problems. Furthermore, she also



studied the application of the method of the Laplace transform to these equations. All these problems were expounded in her book [2].

In the fifties and sixties Olga Alexandrovna often gave talks at the seminars of Ivan Georgievich Petrovskii at Moscow State University. I recall how greatly the listeners were impressed by her

proof of the uniqueness theorem for the initial boundary-value problem for the two-dimensional Navier-Stokes system. Since the existence theorem for these equations was proved earlier, the well-posedness of the main boundary-value problem for the Navier-Stokes system in two dimensions was established thanks to the remarkable result of Olga Alexandrovna. The uniqueness theorem for the three-dimensional Navier-Stokes system is still not proved. Olga Alexandrovna devoted her book on fluid dynamics to three people she most respected, namely, her father, Vladimir Ivanovich Smirnov, and Jean Leray. In this book she studied in great detail many problems related to the stationary and nonstationary Navier-Stokes system.

In collaboration with Nina Nikolaevna Ural'tseva, Olga Alexandrovna wrote a book [4] on linear and quasilinear elliptic equations. Many fundamental results were obtained in this book, which remains a real encyclopedia on the subject. In the sixties, Olga Alexandrovna, Nina Nikolaevna Ural'tseva, and Vsevolod Alekseevich Solonnikov wrote a book [5] on linear and quasilinear parabolic equations. In section 2 of this memorial article, Nina Nikolaevna writes more about this wonderful monograph. Olga Alexandrovna is also the author of the book [6] on the attractors of semigroups and evolution equations. This book is based on a lecture course that Olga Alexandrovna gave in different universities in Italy, the so-called *Lezioni Lincei*.

Olga Alexandrovna was a very educated and highly cultured person. The famous Russian poet, Anna Akhmatova, who knew Ladyzhenskaya very well, devoted a poem to her.

Olga Alexandrovna was once a member of the city council of people's deputies. She helped many mathematicians in Leningrad to obtain apartments (free of charge) for their families.

Once in the Steklov Mathematical Institute in Leningrad, removing my coat in the cloakroom, I said jokingly to the cloakroom attendant that I was going to take away Olga Alexandrovna to Moscow with me, and I got a serious answer: "We will never give up our Olga Alexandrovna!"

Olga Alexandrovna was a deeply religious woman.

Olga Alexandrovna devoted her life to mathematics, sacrificing her own happiness for it. Now, we can surely say that she has become a "classic figure" of mathematical science.

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Peter Lax, Cathleen Morawetz, and Louis Nirenberg

Young mathematicians today would have a hard time imagining how thoroughly the Iron Curtain isolated the Soviet Union from the rest of the world in the 1940s and 1950s. Mathematics was no exception. We were generally aware who the leading

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figures were—Gelfand, Kolmogorov, Petrovsky, Pontryagin, Sobolev, Vinogradov—and knew the names of some of the up-and-coming new postwar generation—Faddeev, Arnold, Ladyzhenskaya, Oleinik. We were aware of Gelfand's spectacular work on normed rings and were influenced by Petrovsky's survey article on partial differential equations. But in general we were woefully ignorant—few of us knew Russian, or even the Cyrillic alphabet; personal encounters were highly restricted.

The thaw started only after Stalin died; a key event was Khrushchev's denunciation of Stalin's crimes in 1956, the year the Soviet Government rehabilitated Ladyzhenskaya's father, shot as a traitor in 1937. Khrushchev's speech was meant only for the party faithful, but it was soon disseminated generally thanks to the CIA—credit where credit is due. A few visitors were allowed to enter the Soviet Union and have relatively free access to Soviet scientists; the impressions of these visitors were eagerly sought. Leray reported that in Leningrad he saw the Hermitage, Peterhof, and Ladyzhenskaya.



The Iron Curtain worked in both directions; when Ladyzhenskaya first started to work on the Navier-Stokes equation, she was unaware of the work of Leray and Hopf.

A major sign of a thaw was the large Soviet delegation, Olga among them, at the Edinburgh International Congress of Mathematicians in 1958. For many of us this was the beginning of a mathematical and personal friendship with Olga. After the close of the Congress, by chance I (PDL) ran into a group of Soviet mathematicians at the National Gallery in London. Olga and I started talking and got separated from the group. Unfortunately Olga did not remember the name of the hotel where the delegation was staying, so we were forced to go to the Soviet Consulate; with their help the lost sheep was reunited with her flock.

The trickle of Western visitors turned to a tide in the 1960s. An outstanding event was the Opening Conference of the University and Science City at Novosibirsk in 1963, under the direction of Lavrentiev. Here friendships started at Edinburgh were renewed under much more relaxed conditions. LN recalls that Olga had arranged a sailing

party on the Ob Sea on a vessel with a red sail, made available by Sobolev, director of the Mathematics Institute at Novosibirsk.

The International Congress of Mathematicians in Moscow in 1966 was another outstanding occasion for Western and Soviet mathematicians to get together.

Western publishers started putting out English translations of important books that originally appeared in Russian, including Olga's *Mathematical Theory of Viscous Incompressible Flow* and her book with Ural'tseva, *Linear and Quasilinear Elliptic Equations*. The AMS performed an immensely useful service with its vast translation program of articles and books, including Olga's book with Ural'tseva and Solonnikov on parabolic equations.

Olga's first work was to use the method of finite differences to solve the Cauchy problem for hyperbolic equations, giving a new proof of Petrovsky's result—Petrovsky's method is incomprehensible. This work of Olga's is little known in the West; Olga herself did not return to it, very likely because she decided (as did Friedrichs) that a priori estimates and the methods of functional analysis are more effective tools. She did, however, devise numerical schemes for solving the Navier-Stokes equation.

Olga consistently used the concept of weak solutions, a point of view championed by Friedrichs, whom Olga admired. She was in the forefront of the upsurge of interest in elliptic equations. In a very early work she showed that second-order elliptic boundary-value problems have square integrable solutions up to the boundary under very general boundary conditions. Her books with Ural'tseva and Solonnikov contain many deep results concerning estimates for solutions of elliptic and parabolic equations. They have greatly extended ideas of Serge Bernstein and techniques of DiGiorgi, Moser, and Nash. These books are basic sources for these subjects.

The work for which Olga will be remembered longest is on the Navier-Stokes equation. This is a technically very difficult field in which every advance, even modest, requires great effort. One of the goals is to decide if the initial value problem in three dimensions has a smooth solution for all time, and if not, whether a generalized solution is uniquely determined by the initial data. But even if at some future time these questions are decided, and the Clay Foundation rewards its solver with one of its million-dollar prizes, the main task of hydrodynamics remains to deduce the laws governing turbulent flow.

In addition to a large body of technical results, Olga boldly proposed a modification of the Navier-Stokes equations in regions where the velocity fluctuates rapidly. She also made important contributions to the theory of finite-dimensional

attractors of solutions of the Navier-Stokes equations. Flow-invariant measures on manifolds of such attractors might be a building block of turbulence.

On her last visit abroad, at a conference held in Madeira in June 2003, she gave a spirited personal account of her work on the Navier-Stokes equation.

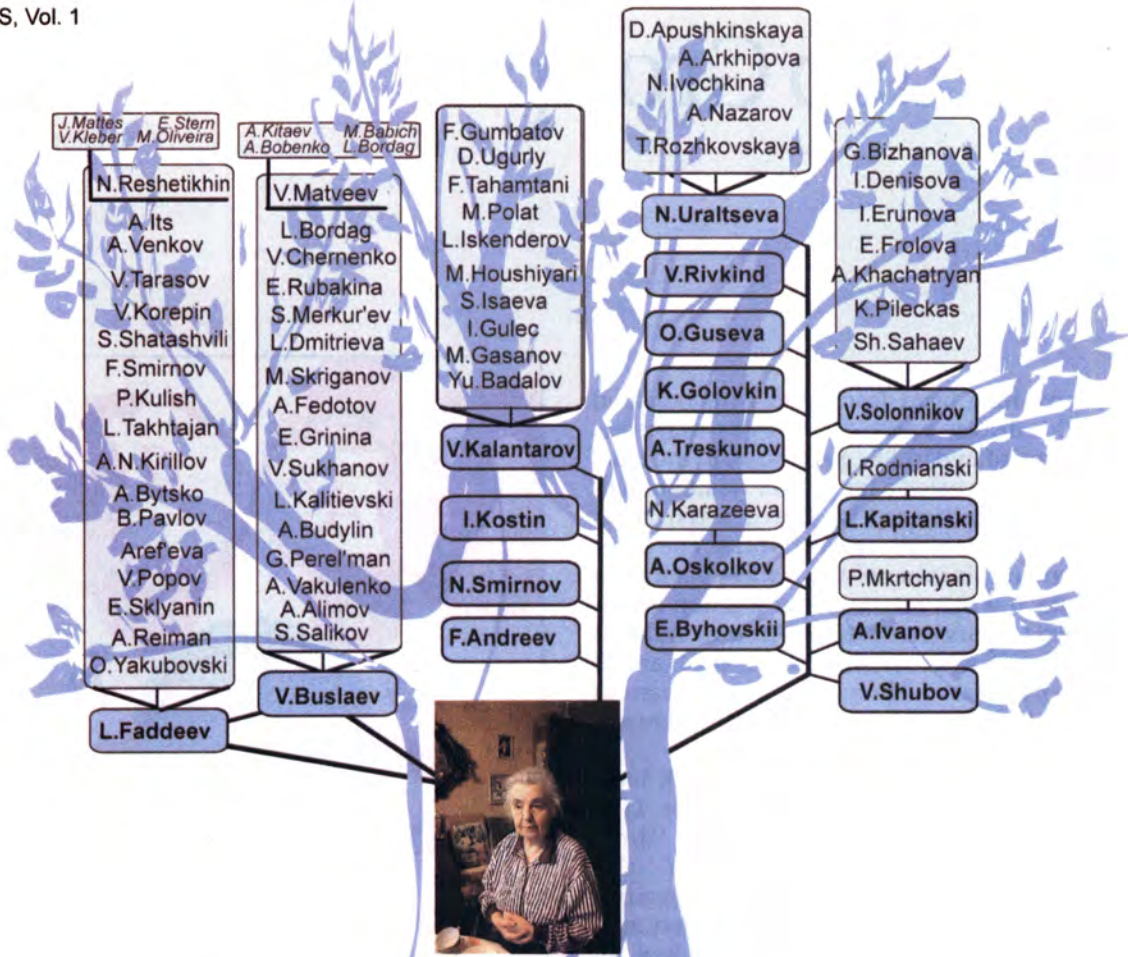
For decades, Olga ran a seminar on partial differential equations that kept up with the development of the subject worldwide; it had a great influence in the Soviet Union.

Olga's career shows that even in the darkest days of Soviet totalitarianism there were courageous academics, Petrovsky and Smirnov in Olga's case, who were willing to defy official proscription of the daughter of a man shot as a traitor, perceive her ability, and ease her path so her talent could bloom and gain recognition.

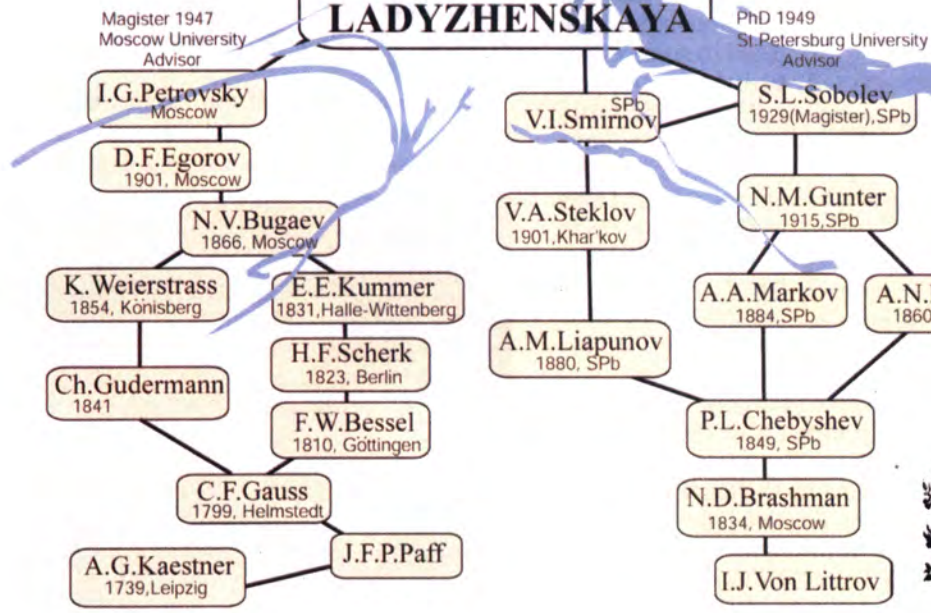
It is to the great credit of the international mathematical community that at the height of the Cold War, when both sides were piling thousands of nuclear weapons on top of each other, Soviet and Western mathematicians formed an intimate family, where scientific and personal achievements were admired independently of national origin. Olga was among the most admired, for her courage, for overcoming enormous obstacles, for supporting those under attack, for her mathematical achievements, and for her overwhelming beauty.

Acknowledgement

Photographs and the mathematical family tree are reproduced from the first two volumes, *Nonlinear Problems in Mathematical Physics and Related Topics. In Honor of Professor O. A. Ladyzhenskaya I, II*, M. Sh. Birman, S. Hildebrandt, V. A. Solonnikov, N. N. Ural'tseva, eds., of the International Mathematical Series published by Kluwer/Plenum Publishers (English) and by Tamara Rozhkovskaya (publisher, Russian). These photos are reproduced here with permission of the publishers of the International Mathematical Series.



**Olga Aleksandrovna
LADYZHENSKAYA**



The Mathematics Genealogy Project
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Double Cusp Group

David J. Wright

People have long been fascinated with repeated patterns that display a rich collection of symmetries. The discovery of hyperbolic geometries in the nineteenth century revealed a far greater wealth of patterns, some popularized by Dutch artist M. C. Escher in his *Circle Limit* series of works. The cover illustration on this issue of the *Notices* portrays a pattern which is symmetric under a group generated by two Möbius transformations $a(z)$ and $b(z)$ of the form $\frac{\alpha z + \beta}{\gamma z + \delta}$ where $\alpha, \beta, \gamma,$ and δ and z are all complex numbers. These are not distance-preserving, but they do preserve angles between curves and they map circles to circles.

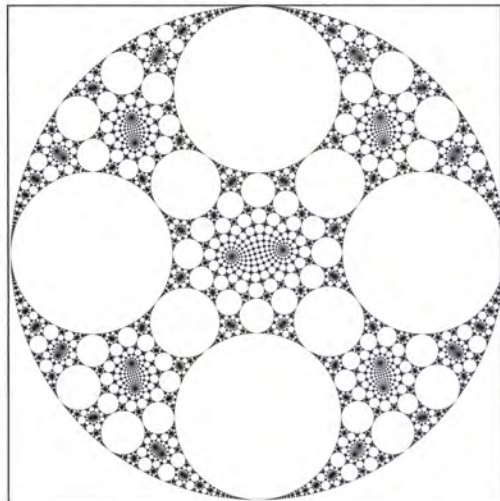


Figure 1.

and the accumulation points of these circles.

Figure 2 is a finite web of tangent disks from the cover picture that defines how the transformations a and b operate. The violet disks are moved from one to the next by the transformation a , indicated by red arrows. The two light blue disks are invariant by the transformation b , shown by the blue arrows. Any Möbius transformation that leaves invariant two tangent disks is called 'parabolic', and has a unique fixed point at the point of

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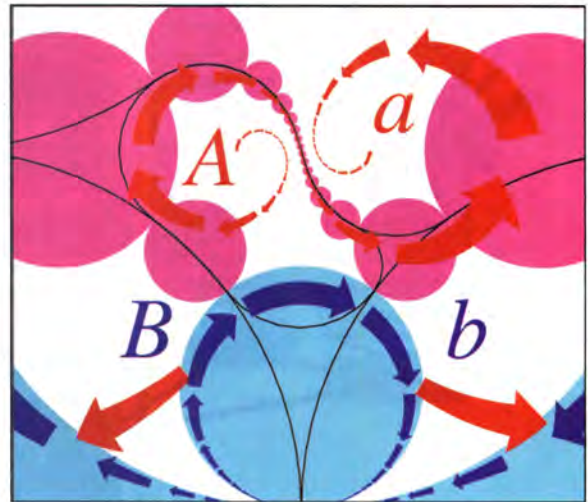


Figure 2.

tangency. The trace of the matrix corresponding to b must be ± 2 , giving a polynomial condition on the generators a and b . On the other hand, the a transformation moves points in infinite double spirals from its 'repelling' fixed point to its 'attractive' fixed point.

The complement of the circle web consists of four white regions or 'blobs' labelled a, A, b and B . We stipulate that the a transformation map the

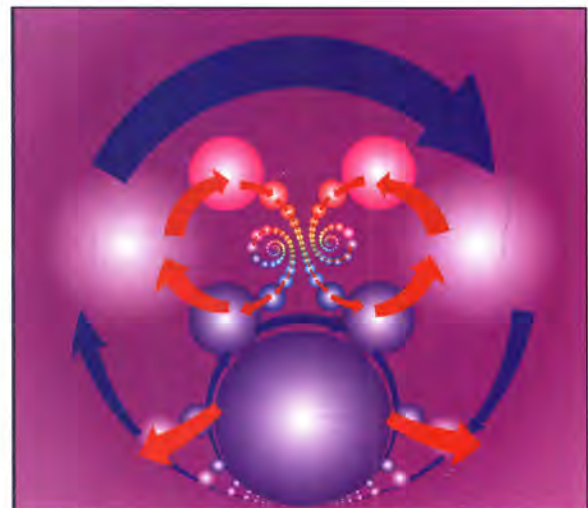


Figure 3.

ring of circles around the A blob into the ring of circles around the a blob in reverse order, and similarly for the b transformation and blobs. Also, disks must be mapped to disks of the same color.

Figure 3 shows some closed loops of arrows between the disks. Following the arrows corresponding to the composition $a \circ b^{-1} \circ a^{-1} \circ b$, namely, a forward blue arrow, then a backward red arrow, then a backward blue arrow, then a forward red arrow, we see that this transformation fixes the large outer ‘disk’ containing ∞ (which we’ll denote D_1) as well as the largest purple disk at the left (which we’ll denote D_2). That implies that $a \circ b^{-1} \circ a^{-1} \circ b$ is also parabolic, another polynomial condition on a and b .

Furthermore, if we start at D_2 and proceed by exactly 15 applications of a (red arrows), we arrive at the symmetrical large purple disk at the right, and then we can jump back to D_2 by b^{-1} (backwards blue arrow). This same composition also fixes the disk $a^{-1}(D_2)$ just one red arrow prior to D_2 , implying that $b^{-1} \circ a^{15}$ is parabolic. These parabolic conditions uniquely determine the pattern (up to conjugacy).

The coloring of disks works as follows. Applying b doesn’t change the color; applying a changes the color of the disk to the next one in a cycle of fifteen colors. That this is consistent depends on some properties of this group.

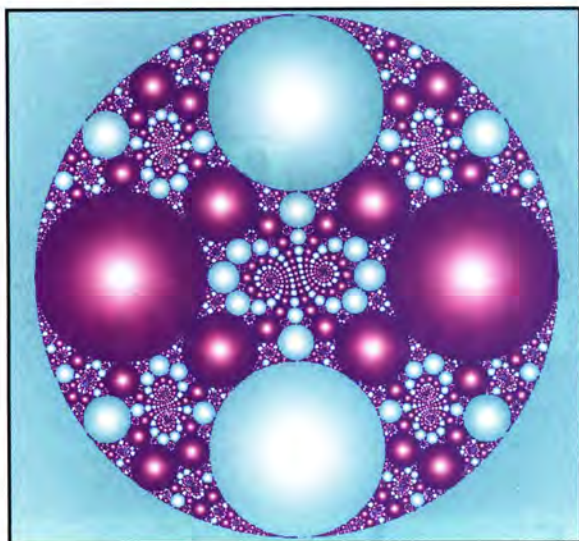


Figure 4.

Figure 4 simply shows the two equivalence classes of disks under the action of the group. It extends the coloring of the disks in the original circle web. Each disk is fixed by a sizeable subgroup of transformations. For example, we have seen the outer disk D_1 containing ∞ is invariant under b and $a \circ b^{-1} \circ a^{-1} \circ b$; these two ‘words’ generate the stabilizer subgroup of this disk. All the words in this subgroup have the sum of the exponents of the

a terms equal to 0. Thus, the color of the image of this disk under any word in a and b is determined just by the sum of the exponents of the a terms.

Similarly, the disk D_2 has stabilizer generated by $a \circ b^{-1} \circ a^{-1} \circ b$ and $b^{-1} \circ a^{15}$. Any word in this subgroup has the exponents of the a ’s summing to a multiple of 15. Hence, our coloring will be consistent if we use 15 colors.

Choosing the same color for the D_1 and D_2 , we see the following rule throughout the pattern: two tangent disks belong to different classes if and only if they have the same color.

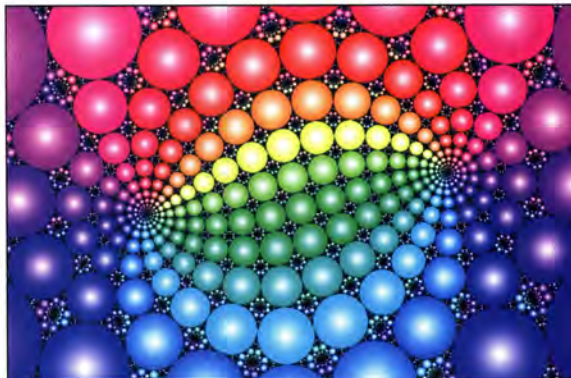


Figure 5.

Figure 5 is a zoom into the center of the picture, where the fixed points of the a transformation appear like hypnotic eyes. The title ‘double cusp group’ refers to this group’s origin as an extreme ‘deformation’ of two-generator ‘quasi-fuchsian’ groups. Some discussion of this may be found in Chapter 9 of [2].

About similar kinds of groups and their limit sets, Klein wrote in 1894 [1]:

“The question is, what will be the configuration formed by the totality of all the circles, and in particular what will be the position of the limiting points. There is no difficulty in answering these questions by purely logical reasoning; but the imagination seems to fail utterly when we try to form a mental image of the result.”

All the pictures were rendered using a program ‘kleinian’ written by the author in collaboration with David Mumford. This note was prepared while the author was on sabbatical at the University of Oklahoma in Norman, and the author wishes to thank the department there for indulging his activities.

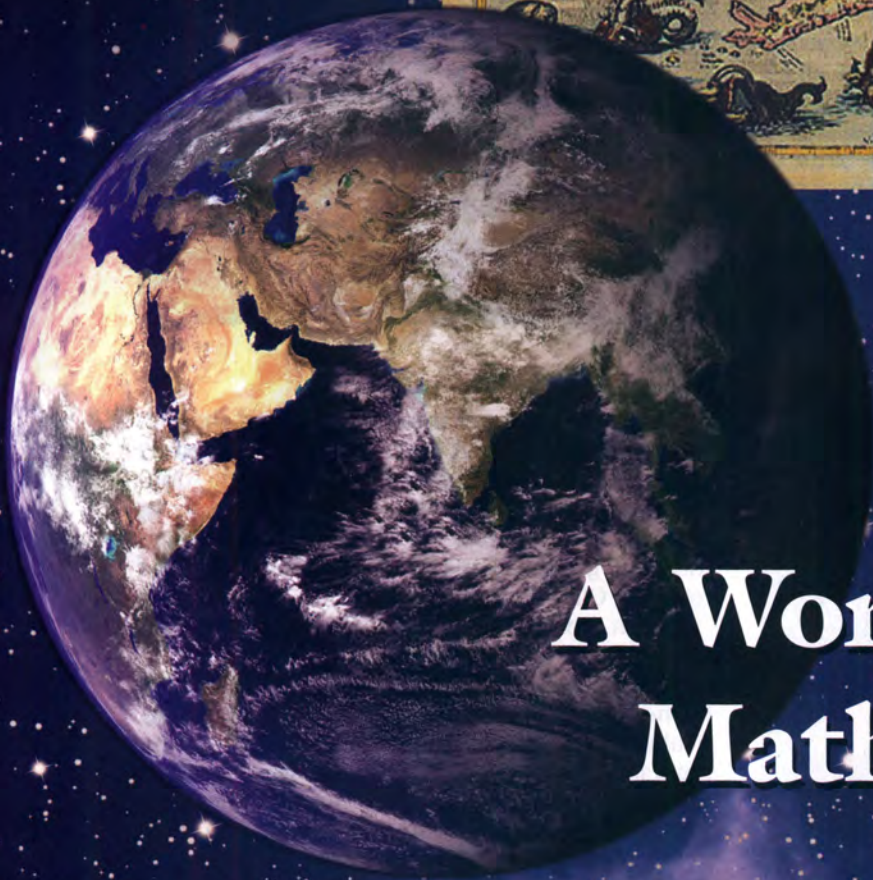
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Lévy Processes—From Probability to Finance and Quantum Groups

David Applebaum

The theory of stochastic processes was one of the most important mathematical developments of the twentieth century. Intuitively, it aims to model the interaction of “chance” with “time”. The tools with which this is made precise were provided by the great Russian mathematician A. N. Kolmogorov in the 1930s. He realized that probability can be rigorously founded on measure theory, and then a stochastic process is a family of random variables $(X(t), t \geq 0)$ defined on a probability space (Ω, \mathcal{F}, P) and taking values in a measurable space (E, \mathcal{E}) . Here Ω is a set (the sample space of possible outcomes), \mathcal{F} is a σ -algebra of subsets of Ω (the events), and P is a positive measure of total mass 1 on (Ω, \mathcal{F}) (the probability). E is sometimes called the state space. Each $X(t)$ is a $(\mathcal{F}, \mathcal{E})$ measurable mapping from Ω to E and should be thought of as a random observation made on E at time t . For many developments, both theoretical and applied, E is Euclidean space \mathbb{R}^d (often with $d = 1$); however, there is also considerable interest in the case where E is an infinite dimensional Hilbert or Banach space, or a finite-dimensional Lie group or manifold. In all of these cases \mathcal{E} can be taken to be the Borel σ -algebra generated by the open sets. To model probabilities arising within quantum theory, the scheme described above is insufficiently general and must

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be embedded into a suitable noncommutative structure.

Stochastic processes are not only mathematically rich objects. They also have an extensive range of applications in, e.g., physics, engineering, ecology, and economics—indeed, it is difficult to conceive of a quantitative discipline in which they do not feature. There is a limited amount that can be said about the general concept, and much of both theory and applications focusses on the properties of specific classes of process that possess additional structure. Many of these, such as random walks and Markov chains, will be well known to readers. Others, such as semimartingales and measure-valued diffusions, are more esoteric. In this article, I will give an introduction to a class of stochastic processes called *Lévy processes*, in honor of the great French probabilist Paul Lévy, who first studied them in the 1930s. Their basic structure was understood during the “heroic age” of probability in the 1930s and 1940s and much of this was due to Paul Lévy himself, the Russian mathematician A. N. Khintchine, and to K. Itô in Japan. During the past ten years, there has been a great revival of interest in these processes, due to new theoretical developments and also a wealth of novel applications—particularly to option pricing in mathematical finance. As well as a vast number of research papers, a number of books on the subject have been published ([3], [11], [1], [2], [12]) and there have been annual international conferences devoted to these processes since 1998. Before we begin the main part of the article, it is worth

listing some of the reasons why Lévy processes are so important:

- There are many important examples, such as Brownian motion, the Poisson process, stable processes, and subordinators.
- They are generalizations of random walks to continuous time.
- They are the simplest class of processes whose paths consist of continuous motion interspersed with jump discontinuities of random size appearing at random times.
- Their structure contains many features, within a relatively simple context, that generalize naturally to much wider classes of processes, such as semimartingales, Feller-Markov processes, processes associated to Dirichlet forms, and (generalizing the strictly stable Lévy processes) self-similar processes.
- They are a natural model of noise that can be used to build stochastic integrals and to drive stochastic differential equations.
- Their structure is mathematically robust and generalizes from Euclidean space to Banach and Hilbert spaces, Lie groups, and symmetric spaces, and algebraically to quantum groups.

The Structure of Lévy Processes

We will take $E = \mathbb{R}^d$ throughout the first part of this article.

Definition. A Lévy process $X = (X(t), t \geq 0)$ is a stochastic process satisfying the following:

(L1) X has independent and stationary increments,

(L2) Each $X(0) = 0$ (with probability one¹),

(L3) X is *stochastically continuous*, i.e., for all $a > 0$ and for all $s \geq 0, \lim_{t \rightarrow s} P(|X(t) - X(s)| > a) = 0$.

Of these three axioms, (L1) is the most important, and we begin by explaining what it means. It focusses on the increments $\{X(t) - X(s); 0 \leq s \leq t < \infty\}$. Stationarity of these means that $P(X(t) - X(s) \in A) = P(X(t-s) - X(0) \in A)$ for all Borel sets A , i.e., the distribution of $X(t) - X(s)$ is invariant under shifts $(s, t) \rightarrow (s+h, t+h)$. Independence means that given any finite ordered sequence of times $0 \leq t_1 \leq t_2 \leq \dots \leq t_n < \infty$, the random variables $X(t_1) - X(0), X(t_2) - X(t_1), \dots, X(t_n) - X(t_{n-1})$ are (statistically) independent. We emphasize again that (L1) is the key defining axiom for Lévy processes; indeed, for many years they were known as “processes with stationary and independent increments”. Of the other axioms, (L2) is a convenient normalization and (L3) is a technical (but important) assumption that enables us to do serious analysis.

The Lévy-Khintchine Formula

To understand the structure of a generic Lévy process, we employ Fourier analysis. The

¹To be denoted w.p.1, henceforth.

characteristic function of $X(t)$ is the mapping $\phi_t : \mathbb{R}^d \rightarrow \mathbb{C}$ defined by

$$\phi_t(u) = \mathbb{E}(e^{iu \cdot X(t)}) = \int_{\mathbb{R}^d} e^{iu \cdot y} p_t(dy),$$

where p_t is the law (or distribution) of $X(t)$, i.e., $p_t = P \circ X(t)^{-1}$, and \mathbb{E} denotes expectation. ϕ_t is continuous and positive definite; indeed, a famous theorem of Bochner asserts that all continuous positive definite mappings from \mathbb{R}^d to \mathbb{C} are Fourier transforms of finite measures on \mathbb{R}^d .

It follows from the axiom (L1) that each $X(t)$ is infinitely divisible, i.e., for each $n \in \mathbb{N}$, there exists a probability measure $p_{t,n}$ on \mathbb{R}^d with characteristic function $\phi_{t,n}$ such that $\phi_t(u) = (\phi_{t,n}(u))^n$, for each $u \in \mathbb{R}^d$. The characteristic functions of infinitely divisible probability measures were completely characterized by Lévy and Khintchine in the 1930s. Their result, which we now state, is fundamental for all that follows:

Theorem 0.1 [The Lévy-Khintchine Formula]. *If $X = (X(t), t \geq 0)$ is a Lévy process, then $\phi_t(u) = e^{t\eta(u)}$, for each $t \geq 0, u \in \mathbb{R}^d$, where*

$$(0.1) \quad \eta(u) = ib \cdot u - \frac{1}{2}u \cdot au +$$

$$\int_{\mathbb{R}^d - \{0\}} [e^{iu \cdot y} - 1 - iu \cdot y 1_{\|y\| < 1}(y)] \nu(dy),$$

for some $b \in \mathbb{R}^d$, a non-negative definite symmetric $d \times d$ matrix a and a Borel measure ν on $\mathbb{R}^d - \{0\}$ for which $\int_{\mathbb{R}^d - \{0\}} (\|y\|^2 \wedge 1) \nu(dy) < \infty$. Conversely, given a mapping of the form (0.1) we can always construct a Lévy process for which $\phi_t(u) = e^{t\eta(u)}$.

One of our goals is to give a probabilistic interpretation to the Lévy-Khintchine formula. The mapping $\eta : \mathbb{R}^d \rightarrow \mathbb{C}$ is called the *characteristic exponent* of X . It is conditionally positive definite in that $\sum_{i,j=1}^n c_i \bar{c}_j \eta(u_i - u_j) \geq 0$, for all $n \in \mathbb{N}, c_1, \dots, c_n \in \mathbb{C}$ with $\sum_{i=1}^n c_i = 0$. A theorem due to Schoenberg asserts that all continuous, hermitian (i.e., $\eta(u) = \overline{\eta(-u)}$, for all $u \in \mathbb{R}^d$), conditionally positive maps from \mathbb{R}^d to \mathbb{C} that satisfy $\eta(0) = 0$ must take the form (0.1). The triple (b, a, ν) is called the *characteristics* of X . It determines the law p_t . The measures ν that can appear in (0.1) are called *Lévy measures*.

We begin the task of interpreting (0.1) by examining some examples. The first two that we consider are very well known in probability theory—indeed, each has an extensive theoretical development in its own right with many applications.

Examples of Lévy Processes

1. Brownian Motion and Gaussian Processes

We define a Brownian motion $B_a = (B_a(t), t \geq 0)$ to be a Lévy process with characteristics $(0, a, 0)$.

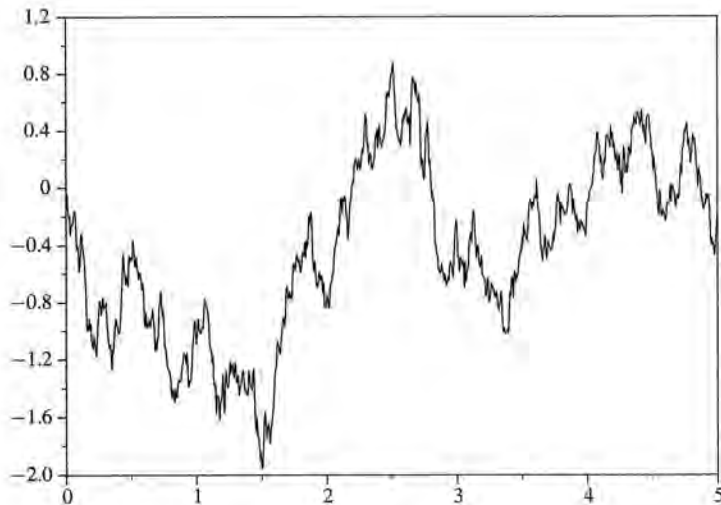


Figure 1. Simulation of standard Brownian motion. The path is continuous but nowhere differentiable. If you were to zoom in, the fractal nature of the path would become apparent and this reflects the self-similarity of the process.

It has mean zero and covariance $\mathbb{E}(B_a^i(s)B_a^j(t)) = a^{ij}(s \wedge t)$ (where $B_a^i(s)$ is the i th component of the vector $B_a(s)$). If a is positive definite, then each $B_a(t)$ has a normal distribution with density $f_{a,t}$ where

$$f_{a,t}(x) = \frac{1}{(2\pi t)^{\frac{d}{2}} \sqrt{\det(a)}} \exp\left(-\frac{1}{2t}(x \cdot a^{-1}x)\right).$$

When $d = 1$, we write $B_1 = B$ and call it a standard Brownian motion. Brownian motion has a fascinating history. It is named after the botanist Robert Brown, who first observed, in the 1820s, the irregular motion of pollen grains immersed in water. By the end of the nineteenth century, the phenomenon was understood by means of kinetic theory as a result of molecular bombardment. Indeed, in 1905, Einstein, although ignorant of the discovery of the phenomenon and of previous work on it, predicted its existence from purely theoretical considerations. Five years earlier L. Bachelier had employed it to model the stock market, where the analogue of molecular bombardment is the interplay of the myriad of individual market decisions that determine the market price.

Standard Brownian motion was rigorously constructed by N. Wiener in the 1920s as a family of functionals on the space $C = C_0([0, \infty), \mathbb{R})$ of real-valued continuous functions on $[0, \infty)$ that vanish at zero. In so doing, he equipped the infinite-dimensional space C with a Gaussian measure that is now called *Wiener measure* in his honour. It follows that the paths $t \rightarrow B_a(t)(\omega)$, where $\omega \in C$, are continuous. In the 1930s Wiener, together with R. Paley and A. Zygmund, showed that the paths are nowhere differentiable (w.p.1).

Figure 1 presents a simulation of the paths of standard Brownian motion.

Brownian motion with drift is the Lévy process $C_{a,b} = (C_{a,b}(t), t \geq 0)$, with characteristics $(b, a, 0)$. Each $C_{a,b}(t)$ is a Gaussian random variable having mean vector tb and covariance matrix ta . In fact each $C_{a,b}(t) = bt + B_a(t)$. A Lévy process has continuous sample paths (w.p.1), or is Gaussian if and only if it is a Brownian motion with drift.

2. The Poisson Process

A Poisson process $N_\lambda = (N_\lambda(t), t \geq 0)$ with intensity $\lambda > 0$ is a Lévy process with characteristics $(0, 0, \lambda\delta_1)$, where δ_1 is a Dirac mass concentrated at 1. N_λ takes non-negative integer values, and we have the Poisson distribution:

$$P(N_\lambda(t) = n) = \frac{e^{-\lambda t}(\lambda t)^n}{n!}.$$

The paths of N_λ are piecewise constant on each finite interval, with jumps of size 1 at the random times $\tau_n = \inf\{t \geq 0, N_\lambda(t) = n\}$.

3. The Compound Poisson Process

Let $(Y_n, n \in \mathbb{N})$ be a sequence of independent identically distributed random variables with common law q and let N_λ be an independent Poisson process. The compound Poisson process is the Lévy process $Z_\lambda(t) = \sum_{j=1}^{N_\lambda(t)} Y_j$. It has characteristic exponent $\eta(u) = \int_{\mathbb{R}^d} (e^{iu \cdot y} - 1)\lambda q(dy)$. The compound Poisson process (with $d = 1$) can be used to model the takings at a till in a supermarket, where $N_\lambda(t)$ is the number of customers in the queue at time t and Y_j is the amount paid by the j th customer.

4. Interlacing Processes

We can define a Lévy process by the prescription $X(t) = C_{a,b}(t) + Z_\lambda(t)$, provided the two summands are assumed to be independent. We call this an *interlacing process* since its paths have the form of continuous motion interlaced with random jumps of size $\|Y_n\|$ occurring at the random times τ_n (where the Y_n s are as in Example 3 above). X has characteristic exponent

$$(0.2) \quad \eta(u) = ib \cdot u - \frac{1}{2}u \cdot au + \int_{\mathbb{R}^d} (e^{iu \cdot y} - 1)\lambda q(dy),$$

which is quite close to the general form (0.1). Indeed (0.2) was proposed as the form of the most general η by the Italian mathematician B. de Finetti in the 1920s. His error was in failing to appreciate that the finite measure λq can be replaced by a σ -finite Lévy measure ν . But if we do this, $(e^{iu \cdot y} - 1)$ may not be ν -integrable and hence we must adjust the integrand. Probabilistically, this corresponds to a lack of convergence of a countable number of "small jumps", as we will see in the next section. Although (0.2) is incorrect, the most general η can be obtained as a pointwise limit of terms of similar type, i.e., $\eta(u) = \lim_{n \rightarrow \infty} \eta_n(u)$, where each

$$\eta_n(u) = i \left(b - \int_{\frac{1}{n} < \|y\| < 1} y \nu(dy) \right) \cdot u - \frac{1}{2} u \cdot a u + \int_{\|y\| \geq \frac{1}{n}} (e^{iu \cdot y} - 1) \lambda q(dy),$$

and the integrals must be combined together before the passage to the limit. In the next section we will see the intuition behind this.

From the above examples, the reader may be forgiven for thinking that a Lévy process is nothing but the interplay of Gaussian and Poisson measures. In a sense this is correct; however, note that the Gaussian and Poisson measures give rise to extreme points of the convex cone of all characteristic exponents. As the following shows, there are some interesting inhabitants of the interior.

5. Stable Lévy Processes

Stable probability distributions arise as the possible weak limits of normalized sums of i.i.d. (i.e., independent, identically distributed) random variables in the central limit theorem. The normal distribution is stable and corresponds to the case in which each of the i.i.d. random variables has finite mean and variance. Stable random variables are those whose laws are stable. They are characterized by the property that if X_1 and X_2 are independent copies of a stable random variable X , then for each $c_1, c_2 > 0$, there exists $c > 0$ and $d \in \mathbb{R}^d$ such that $cX + d$ has the same law as $c_1X_1 + c_2X_2$. A Lévy process is stable if each $X(t)$ is stable in this sense. The characteristics of a stable Lévy process are either of the form $(b, a, 0)$ (so it is a Brownian motion with drift) or $(b, 0, \nu)$, where $\nu(dx) = \frac{C}{|x|^{\alpha+d}} dx$, with $0 < \alpha < 2$ and $C > 0$. α is called the index of stability. With the sole exception of the Brownian motions with drift, the random variables of a stable Lévy process all have infinite variance, and if $\alpha \leq 1$, they also have infinite mean. One example of interest (in the case $d = 1$) for which $\alpha = 1$ is the Cauchy process, which has the density $f_t(x) = \frac{t}{\pi(x^2 + t^2)}$. Figure 2 presents a simulation of its paths in which jump discontinuities are represented by vertical lines.

With a little calculus, the characteristic exponent can be transformed to a more useful form. This is particularly simple when X is rotationally invariant, i.e., $P(X(t) \in OA) = P(X(t) \in A)$, for all $O \in O(d)$, $t \geq 0$, and Borel sets A . We then obtain $\eta(u) = -\sigma^\alpha |u|^\alpha$, where $\sigma > 0$. Rotationally invariant stable processes are an important class of self-similar processes, i.e., $(X(ct), t \geq 0)$ and $(c^{\frac{1}{\alpha}} X(t), t \geq 0)$ have the same finite dimensional distributions (for each $c > 0$), and this is one reason why such processes are important in applications. Another reason, applying to general stable random variables X , is that they have “heavy

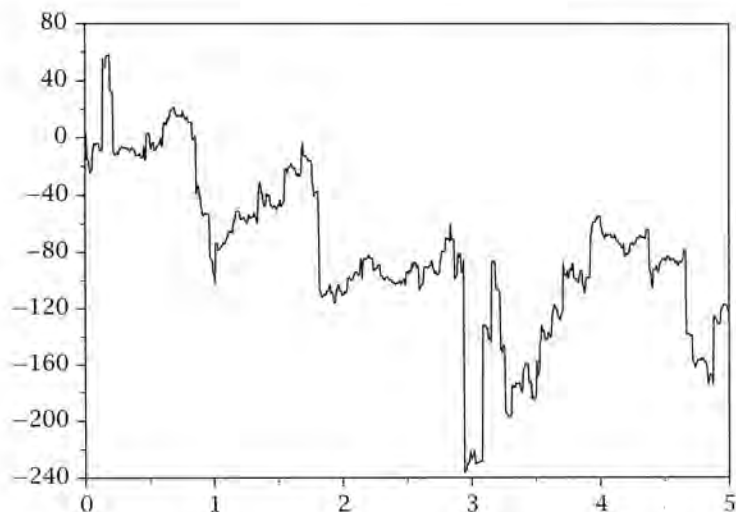


Figure 2. Simulation of the Cauchy process. The Cauchy process is stable with $\alpha = 1$. Jump discontinuities are represented by vertical lines. This process is also self-similar so the path has a fractal nature.

tails”, i.e. $P(X > y)$ behaves asymptotically like $y^{-\alpha}$ as $y \rightarrow \infty$, as opposed to the exponential decay found in the Gaussian case. Such behavior has been found in models of telecommunications traffic on the Internet.

6. Relativistic Processes

1905 was a busy year for Albert Einstein. As well as his work on Brownian motion, mentioned above, he also gave a quantum mechanical explanation of the photoelectric effect (for which he won his Nobel Prize) and developed the special theory of relativity. According to the latter, a particle of rest mass m moving with momentum p has kinetic energy $E(p) = \sqrt{m^2 c^4 + c^2 |p|^2} - mc^2$, where c is the velocity of light. If we define $\eta(p) = -E(p)$, then η is the characteristic exponent of a Lévy process. We will explore some consequences of this below.

7. Subordinators

A *subordinator* is a one-dimensional Lévy process $(T(t), t \geq 0)$ that is nondecreasing (w.p.1). In this case, the Fourier transform that defines the characteristic function can be analytically continued to yield the Laplace transform $\mathbb{E}(e^{-uT(t)}) = e^{-t\psi(u)}$, for each $u > 0$, where

$$\psi(u) = -\eta(iu) = bu + \int_{(0, \infty)} (1 - e^{-uy}) \lambda(dy).$$

Here $b \geq 0$ and λ is a Lévy measure that satisfies the additional constraints $\lambda(-\infty, 0) = 0$ and $\int_{(0, \infty)} (y \wedge 1) \lambda(dy) < \infty$.

ψ is called the *Laplace exponent* of the subordinator. The set of all of these is in one-to-one correspondence with the set of Bernstein functions for which $\lim_{x \rightarrow 0} f(x) = 0$, where we recall that an infinitely differentiable function f on $(0, \infty)$ is a Bernstein function if and only if $f \geq 0$ and $(-1)^n f^{(n)} \leq 0$, for all $n \in \mathbb{N}$.

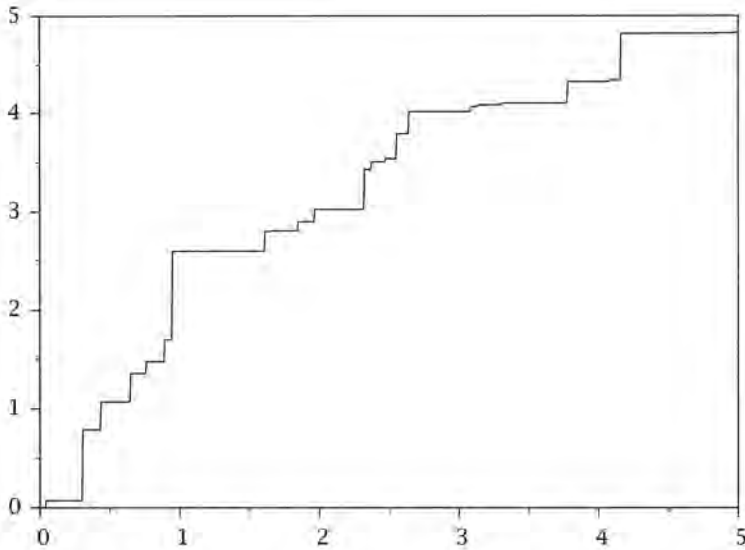


Figure 3. Simulation of the gamma subordinator. In contrast to the cases shown by the previous two figures, the sample paths of subordinators are considerably more regular. The path is a non-decreasing step function with jump discontinuities again shown as vertical lines.

Examples of subordinators include the α -stable ones ($0 < \alpha < 1$) that have Laplace exponent $\psi(u) = u^\alpha$. For the case $\alpha = \frac{1}{2}$, each $T(t)$ is the first hitting time of a standard Brownian motion to a level, i.e., $T(t) = \inf\{s > 0; B(s) = \frac{t}{\sqrt{2}}\}$. Furthermore, each $T(t)$ has a Lévy distribution with density $f_t(s) = \left(\frac{t}{2\sqrt{\pi}}\right) s^{-\frac{3}{2}} e^{-\frac{t^2}{4s}}$. Another well-known example of a subordinator, where each $T(t)$ has a gamma distribution, is depicted in Figure 3.

An important application of subordinators is to the time change of Lévy processes. If X is a Lévy process with characteristic exponent η_X and T is an independent subordinator with Laplace exponent λ , then $Y(t) = X(T(t))$ is a new Lévy process with characteristic exponent $\eta_Y = -\lambda \circ -\eta_X$. This procedure was first investigated by S. Bochner in the 1950s and is sometimes called “subordination in the sense of Bochner” in his honor. In particular, if X is a Brownian motion (with a a multiple of the identity) and T is an independent α -stable subordinator, then Y is a 2α -stable rotationally invariant Lévy process.

8. The Riemann-Zeta Process

Readers who are interested in number theory may find this example of interest. If ζ is the usual Riemann zeta function, we obtain a Lévy process for each $u > 1$ by the following prescription for the characteristic exponent,

$$\eta_u(v) = \log \left(\frac{\zeta(u + iv)}{\zeta(u)} \right).$$

This was established by Khintchine in the 1930s.

The Lévy-Itô Decomposition

With the insight we obtained from Example 4, we can now return to the task of trying to understand

the structure of the sample paths of Lévy processes. Given a characteristic exponent, we can always associate to it a Lévy process whose paths are right continuous with left limits (w.p.1). It follows that this process X can only have jump discontinuities, and there are, at most, a countable number of these on each closed interval. We formally write $X(t) = X_c(t) + \sum_{0 \leq s \leq t} \Delta X(s)$, where X_c has continuous paths (w.p.1) and $\Delta X(s) = X(s) - X(s-)$ is the “jump” at time s where $X(s-) = \lim_{u \uparrow s} X(u)$ is the left limit.

We can describe X_c quite easily. It is a Brownian motion with drift, $X_c(t) = bt + B_a(t)$ (although this is by no means easy to prove). The second term is more problematic—in particular, the sum may not converge. It turns out to be helpful to count the jumps up to time t that are in a given Borel set A and to introduce

$$N(t, A) = \#\{0 \leq s \leq t; \Delta X(s) \in A\}.$$

N is a very interesting object—it is in fact a function of three variables—time t , the set A , and the sample point ω . If we fix t and ω , we get a σ -finite measure on the Borel sets of \mathbb{R}^d . On the other hand, if we fix the set A and ensure that it is bounded away from zero, we get a Poisson process with intensity $\lambda = \nu(A)$. For these reasons N is called a *Poisson random measure*.

In any finite time, X can have only a finite number of jumps of size greater than 1 (or indeed greater than any $\epsilon > 0$). We can write this finite sum of jumps as $\int_{|x| > 1} xN(t, dx)$. Similarly, the sum of all the jumps of size greater than $\frac{1}{n}$ but less than 1 is $\int_{\frac{1}{n} < |x| < 1} xN(t, dx)$; however, the limit may not converge as $n \rightarrow \infty$. Paul Lévy argued that the accumulation of a large number of very small jumps may be difficult to distinguish from bursts of deterministic motion, so one should consider $M_n(t) = \int_{\frac{1}{n} < |x| < 1} x(N(t, dx) - t\nu(dx))$. ($M_n, n \in \mathbb{N}$) is a sequence of square-integrable, mean zero martingales and hence is a very pleasant object from both a probabilistic and an analytic viewpoint. In particular the sequence converges in mean square to a martingale $M(t) = \int_{0 < |x| < 1} x\tilde{N}(t, dx)$, where $\tilde{N}(t, dx) = N(t, dx) - t\nu(dx)$ is called a *compensated Poisson random measure*. Lévy’s intuition was made precise by K. Itô, and we can now give the celebrated Lévy-Itô decomposition for the sample paths of a Lévy process:

$$(0.3) \quad X(t) = bt + B_a(t) + \int_{|x| < 1} x\tilde{N}(t, dx) + \int_{|x| \geq 1} xN(t, dx).$$

Readers should beware of generalizing from the Gaussian to this more general case. For example, bt is not in general the mean of $X(t)$ —indeed, as we saw in Example 5, this may not exist. The

“martingale part” of $X(t)$, i.e., the process $M(t) + B_a(t)$, has moments to all orders, so if $X(t)$ itself fails to have an n th moment this is entirely due to the influence of “large jumps”.

Applications to Finance

A sociologist investigating the behavior of the probability community during the early 1990s would surely report an interesting phenomenon. Many of the best minds of this (or any other) generation began concentrating their research in the area of mathematical finance. The main reason for this can be summed up in two words—option pricing.

Essentially, an option is a contract that confers upon the holder the right, but not the obligation, to purchase (or sell) a unit of a certain stock for a fixed price k on (or perhaps before) a fixed expiry date T , after which the option becomes worthless. For the option to make sense, k should be considerably less than the current price of the stock. If the stock price rises above k , the holder of the option may make a considerable profit; on the other hand, if the stock price falls dramatically, losses will be considerably less through buying options than by purchasing the stock itself.

The key question is—does the market determine a unique price for a given option, and if so, can this price be explicitly computed? Much of the current interest in the subject derives from Nobel-prize winning work of F. Black, M. Scholes and R. Merton in the 1970s who gave a positive answer to this question. Underlying their analysis was a model of stock prices that improved upon that of Bachelier by using *geometric Brownian motion*, i.e., the price $S(t)$ of a given stock at time t is

$$S(t) = S(0) \exp \left\{ \left(\mu - \frac{1}{2} \sigma^2 \right) t + \sigma B(t) \right\}.$$

The constant $\mu \in \mathbb{R}$ is the (logarithmic) expected rate of return, while $\sigma > 0$, called the *volatility*, is a measure of the excitability of the market. We will have more to say about volatility below. Black and Scholes obtained an exact formula for the unique price of a *European option* (i.e., one that can only be exercised at time T) using the normal distribution. The derivation of this formula involves the use of tools such as martingales and Girsanov transforms, and it is this link with stochastic analysis that so excited the probabilistic community.

Although very elegant, the Black-Scholes-Merton model has limitations and possible defects that have led many probabilists to query it. Indeed, empirical studies of stock prices have found evidence of heavy tails, which is incompatible with a Gaussian model, and this suggests that it might be fruitful to replace Brownian motion with a more general Lévy process. Indeed, H. Geman, D. Madan and M. Yor have argued that this is quite natural from

the point of view of the Lévy-Itô decomposition (0.3), where the small jumps term $\int_{|x|<1} x \tilde{N}(t, dx)$ describes the day-to-day jitter that causes minor fluctuations in stock prices, while the big jumps term $\int_{|x|\geq 1} x N(t, dx)$ describes large stock price movements caused by major market upsets arising from, e.g., earthquakes or terrorist atrocities.

If we set aside Brownian motion, there are a plethora of Lévy processes to choose from, and our choice must enable us to derive a pricing formula that market analysts can compute with. One interesting group of candidates is the (symmetric) *hyperbolic Lévy processes*, whose financial applications have been extensively developed by E. Eberlein and his group in Freiburg, Germany. These are processes with no Brownian motion part in (0.3), and the characteristic function is given by

$$\phi_t(u) = \left(\frac{\zeta}{K_1(\zeta)} \frac{K_1(\sqrt{\zeta^2 + \delta^2 u^2})}{\sqrt{\zeta^2 + \delta^2 u^2}} \right)^t,$$

where K_1 is a Bessel function of the third kind, and ζ and δ are non-negative parameters.

Hyperbolic Lévy processes were discovered by O. Barndorff-Nielsen in the 1970s and used as models for the distribution of particle size in wind-blown sand deposits. N. H. Bingham and R. Keisel make an interesting analogy between the dynamics of sand production and stock prices in that just as large rocks are broken down to smaller and smaller particles “this ‘energy cascade effect’ might be paralleled in the ‘information cascade effect’, whereby price-sensitive information originates in, say, a global newsflash and trickles down through national and local level to smaller and smaller units of the economic and social environment.”

A problem with non-Gaussian option pricing is that the market is “incomplete”, i.e., there may be more than one possible pricing formula. This is clearly undesirable, and a number of selection principles, such as entropy minimization, have been employed to overcome this problem. For hyperbolic processes, a pricing formula has been developed that has minimum entropy and that is claimed to be an improvement on the Black-Scholes formula.

Another problem with the Black-Scholes-Merton formula is the constancy of the volatility. Empirical studies suggest that this should vary to give a curve called the “volatility smile”. This has prompted some authors to propose “stochastic volatility models” wherein σ is replaced in the standard Black-Scholes model by a random process that solves a stochastic differential equation. There are a number of different approaches to this; e.g., O. Barndorff-Nielsen and N. Shephard have recently proposed that $(\sigma(t)^2, t \geq 0)$ should be an Ornstein-Uhlenbeck process driven by a subordinator $(T(t), t \geq 0)$, i.e.,

$$\sigma(t)^2 = e^{-\lambda t} \sigma(0)^2 + \int_0^t e^{-\lambda(t-s)} dT(\lambda s),$$

where $\lambda > 0$. As T has finite variation (w.p.1), the integral is well defined in the random Lebesgue-Stieltjes sense.

Readers who want to learn more about “Lévy finance” should consult [12], [4], chapter 5 of [1], and references therein.

Markov Processes, Semigroups, and Pseudodifferential Operators

Lévy processes are, in particular, Markov processes, i.e., their past and future are independent, given the present. This is formulated precisely using the conditional expectation: $\mathbb{E}(f(X(t+u)) | \mathcal{F}_t) = \mathbb{E}(f(X(t+u)) | X(t))$, for all $t, u \geq 0$ and all $f \in B_b(\mathbb{R}^d)$ —the Banach space, under the supremum norm, of all bounded Borel measurable functions on \mathbb{R}^d . Here “the past” \mathcal{F}_t is the smallest sub- σ -algebra of \mathcal{F} with respect to which all $X(s) (0 \leq s \leq t)$ are measurable. We define a two-parameter family of linear contractions $(T_{s,t}; 0 \leq s \leq t < \infty)$ on $B_b(\mathbb{R}^d)$ by the prescription $(T_{s,t}f)(x) = \mathbb{E}(f(X(t)) | X(s) = x) = \int_{\mathbb{R}^d} f(x+y) p_t(dy)$. Then the Markov property implies that these form an *evolution*, i.e., $T_{r,s}T_{s,t} = T_{r,t}$, for all $r \leq s \leq t$. Note that these operators all commute with the natural action of the translation group of \mathbb{R}^d on $B_b(\mathbb{R}^d)$.

Lévy processes form a nice subclass of Markov processes. First, they are time-homogeneous, i.e., $T_{s,t} = T_{0,t-s}$ for all $s \leq t$. If we now write $T_t = T_{0,t}$, the evolution property becomes the semigroup law $T_s T_t = T_{s+t}$. Second, Lévy processes are Feller processes, i.e., each T_t preserves the Banach space $C_0(\mathbb{R}^d)$ of continuous functions on \mathbb{R}^d that vanish at infinity and $\lim_{t \downarrow 0} \|T_t f - f\| = 0$, for all $f \in C_0(\mathbb{R}^d)$. Hence $(T_t, t \geq 0)$ is a strongly continuous, one-parameter contraction semigroup on $C_0(\mathbb{R}^d)$, and by the general theory of such semigroups, we can assert the existence of the generator $Af = \lim_{t \downarrow 0} \frac{T(t)f - f}{t}$, for all $f \in D_A$. The domain D_A is a linear space that is dense in $C_0(\mathbb{R}^d)$ and A is a closed linear operator. We can explicitly compute the semigroup and its generator as pseudodifferential operators. For convenience, we work in Schwartz space $S(\mathbb{R}^d)$ —the space of all smooth functions on \mathbb{R}^d that are such that they and all their derivatives decay to zero at infinity faster than any negative power of $|x|$. $S(\mathbb{R}^d)$ is dense in $C_0(\mathbb{R}^d)$ and is a natural domain for the Fourier transform $\hat{f}(u) = (2\pi)^{-\frac{d}{2}} \int_{\mathbb{R}^d} e^{-i(u,x)} f(x) dx$. Fourier inversion then yields $f(x) = (2\pi)^{-\frac{d}{2}} \int_{\mathbb{R}^d} \hat{f}(u) e^{i(u,x)} du$. Applying theorem 0.1, we compute

$$(T_t f)(x) = (2\pi)^{-\frac{d}{2}} \int_{\mathbb{R}^d} e^{i(u,x)} e^{t\eta(u)} \hat{f}(u) du,$$

so that T_t is a pseudodifferential operator with symbol $e^{t\eta}$. Formal differentiation can be justified, and we find that

$$(Af)(x) = (2\pi)^{-\frac{d}{2}} \int_{\mathbb{R}^d} e^{i(u,x)} \eta(u) \hat{f}(u) du,$$

so A is also a pseudodifferential operator, with symbol η . Using the Lévy-Khintchine formula (0.1) and elementary properties of the Fourier transform, we obtain the following explicit form for the action of the generator on $S(\mathbb{R}^d)$

$$(0.4) \quad \begin{aligned} (Af)(x) = & \sum_{i=1}^d b_i \partial_i f(x) + \frac{1}{2} \sum_{i,j=1}^d a_{ij} \partial_i \partial_j f(x) \\ & + \int_{\mathbb{R}^d - \{0\}} \left[f(x+y) - f(x) - \sum_{i=1}^d y_i \partial_i f(x) 1_{\|y\| < 1}(y) \right] \nu(dy). \end{aligned}$$

Using more sophisticated methods the domain in (0.4) can be extended to a larger space of twice differentiable functions in $C_0(\mathbb{R}^d)$. Here are some specific examples of interesting generators:

1. Brownian motion (with $a = I$) is generated by (one-half times) the Laplacian, i.e., $A = \frac{1}{2} \sum_{i=1}^d \partial_i^2 = \frac{1}{2} \Delta$.
2. Rotationally invariant α -stable processes (with $\sigma = 1$) are generated by fractional powers of the Laplacian: $A = -(-\Delta)^{\frac{\alpha}{2}}$.
3. For the relativistic process, we have $A = -(\sqrt{m^2 c^4 - c^2 \Delta} - mc^2)$.

In the last example, $-A$ is called a *relativistic Schrödinger operator* in quantum theory. Note that A is obtained from its symbol through the correspondence $p \leftrightarrow -i\nabla$, which is precisely the usual rule for quantization, although this is more naturally carried out in a Hilbert space setting (see below).

If A_Z is the generator of the Lévy process $Z(t) = X(T(t))$ obtained from a Lévy process X with characteristic exponent η_X , associated semigroup $(T_t^X, t \geq 0)$, and generator A_X using an independent subordinator T with Laplace exponent ψ , then the identity $\eta_Z = -\psi \circ -\eta_X$, quantizes nicely to yield $A_Z = -\psi(-A_X)$. In particular, we can use the α -stable subordinators to define fractional powers of $-A_X$ using the following beautiful formula

$$-(-A_X)^\alpha f = \frac{\alpha}{\Gamma(1-\alpha)} \int_{(0,\infty)} (T_s^X f - f) \frac{ds}{s^{1+\alpha}}.$$

A deep generalization due to R. S. Phillips allows the replacement of A_X and T_t^X with the generator of a general contraction semigroup on a Banach space.

The semigroup associated with each Lévy process also operates in each $L^p(\mathbb{R}^d) (1 \leq p < \infty)$ and is again strongly continuous and contractive.

Since $S(\mathbb{R}^d)$ is dense in each $L^p(\mathbb{R}^d)$, the pseudodifferential operator representations discussed above still hold here. From now on, we take $p = 2$. The generator corresponding to the symbol η has maximal domain $\mathcal{H}_\eta(\mathbb{R}^d)$ —the *nonisotropic Sobolev space* of all $f \in L^2(\mathbb{R}^d)$ for which $\int_{\mathbb{R}^d} |\eta(u)|^2 |\hat{f}(u)|^2 du < \infty$.

Standard semigroup theory tells us that a necessary and sufficient condition for each T_t to be self-adjoint is that $-A$ is positive, self-adjoint. A necessary and sufficient condition for this is that the associated Lévy process is symmetric, i.e., $P(X(t) \in A) = P(X(t) \in -A)$, and this holds if and only if

$$\eta(u) = -\frac{1}{2}u \cdot au + \int_{\mathbb{R}^d - \{0\}} (\cos(u \cdot y) - 1)v(dy).$$

This yields a probabilistic proof of self-adjointness (on $\mathcal{H}_\eta(\mathbb{R}^d)$) of each of the three operators discussed above.

Let A be the self-adjoint generator of a symmetric Lévy process and for each $f, g \in C_c^\infty(\mathbb{R}^d)$, define $\mathcal{E}(f, g) = -\langle f, Ag \rangle$, then \mathcal{E} extends to a symmetric Dirichlet form in $L^2(\mathbb{R}^d)$, i.e., a closed symmetric form in H with domain D , such that $f \in D \Rightarrow (f \vee 0) \wedge 1 \in D$ and $\mathcal{E}((f \vee 0) \wedge 1) \leq \mathcal{E}(f)$ for all $f \in D$, where we have written $\mathcal{E}(f) = \mathcal{E}(f, f)$. A straightforward calculation yields

$$\begin{aligned} \mathcal{E}(f, g) &= \frac{1}{2} \sum_{i,j=1}^d a_{ij} \int_{\mathbb{R}^d} (\partial_i f)(x) (\partial_j g)(x) dx \\ &+ \frac{1}{2} \int_{(\mathbb{R}^d \times \mathbb{R}^d) - D} (f(x) - f(x+y)) \cdot \\ &(g(x) - g(x+y))v(dy)dx, \end{aligned}$$

where D is the diagonal, $D = \{(x, x), x \in \mathbb{R}^d\}$. This is the prototype for the *Beurling-Deny formula* for symmetric Dirichlet forms.

Now we return to the space $C_0(\mathbb{R}^d)$. The ideas we explored there have a far-reaching generalization, originally due to W. von Waldenfels and P. Courrège in the early 1960s and recently systematically explored by N. Jacob and his school in Erlangen and Swansea [7]. The main starting point of this is that if X is a general Feller process defined on \mathbb{R}^d that has the property that the smooth functions of compact support are contained in the domain of its generator A , then we can always represent A as a pseudodifferential operator

$$(Af)(x) = (2\pi)^{-\frac{d}{2}} \int_{\mathbb{R}^d} e^{i(u,x)} \eta(x, u) \hat{f}(u) du.$$

Note that the symbol η now has an additional x -dependence; however, each $\eta(x, \cdot)$ is still a characteristic exponent, so that we get an appealing intuitive understanding of X as a “field of Lévy processes” indexed by space. Aficionados of pseu-

dodifferential operators should be aware that the map $x \rightarrow \eta(x, u)$ does not, in general, have nice smoothness properties.

Recurrence, Transience, and Bound States

From an intuitive point of view a stochastic process is *recurrent* at a point x if it visits any arbitrarily small neighborhood of that point an infinite number of times (w.p.1), and it is *transient* if each such neighborhood is only visited finitely many times (w.p.1). More precisely, a Lévy process is recurrent (at the origin) if $\liminf_{t \rightarrow \infty} |X(t)| = 0$ (w.p.1) and transient (at the origin) if $\lim_{t \rightarrow \infty} |X(t)| = \infty$ (w.p.1). The recurrence/transience dichotomy holds in that every Lévy process is either recurrent or transient. In the 1960s, S. C. Port and C. J. Stone proved that a Lévy process is recurrent if and only if $\int_{|u| < a} \Re\left(\frac{1}{-\eta(u)}\right) du = \infty$ for any $a > 0$. It follows that Brownian motion is recurrent for $d = 1, 2$ and that for $d = 1$ every α -stable process is recurrent if $1 \leq \alpha < 2$ and transient if $0 < \alpha < 1$. For $d \geq 3$, every Lévy process is transient.

In the 1990s, R. Carmona, W. C. Masters, and B. Simon studied the spectral properties of Hamiltonian operators acting in $L^2(\mathbb{R}^d)$ of the form $H = H_0 + V$, where H_0 is (minus) the generator of a symmetric Lévy process X and V is a suitable potential. In particular, they were able to show that H has at least one bound state (i.e., a negative eigenvalue) if and only if X is recurrent. In particular, in the physically interesting case in which H_0 is a relativistic Schrödinger operator, bound states are obtained only in dimension 1 and 2.

Lévy Processes in Groups

So far we have dealt exclusively with Lévy processes taking values in a Euclidean space. Now we will replace \mathbb{R}^d with a topological group G . First some general remarks. The interaction between probability theory and groups has been an active area of research since the 1960s—indeed, this is the natural setting for studying the interaction of “chance” with “symmetry”. One area of research that is currently attracting enormous interest is random matrix theory [5], partly because of intriguing links between the asymptotics of uniformly distributed matrices in the unitary group $U(n)$ and the zeros of the Riemann zeta function. A survey on random walks and invariant diffusions in groups can be found in [10], with particular emphasis on the relationship between the asymptotic behavior of the process and the volume growth of the group.

A Lévy process on a topological group G is defined exactly as in the Euclidean case, but within the axioms (L1) and (L3), the increment $X(t) - X(s)$ is replaced by $X(s)^{-1}X(t)$ (with the group operation written multiplicatively), whereas in (L2), the role of 0 is played by the neutral element that we denote by e . If p_t is the law of $X(t)$, then $(p_t, t \geq 0)$ is a weakly continuous convolution semigroup of

probability measures on G , so that in particular $p_{s+t}(A) = \int_G p_t(\tau^{-1}A)p_s(d\tau)$.

There are three cases of interest—locally compact abelian groups (LCA groups), Lie groups, and general locally compact groups. The LCA case was extensively studied during the 1960s. The fact that the dual group \hat{G} of characters is itself an LCA group allows a natural generalization of the Fourier transform from \mathbb{R}^d to G , and a Lévy-Khintchine formula that characterizes Lévy processes can hence be developed similarly to the Euclidean case. We will not dwell further on this topic here; interested readers are directed to section 5.6 in [6].

The case in which G is a Lie group has been extensively studied. For non-abelian G , there is no direct analogue of the Fourier transform available, and one of the joys of the subject is the challenge of surmounting this obstacle using tools from semigroup theory, stochastic analysis, group representations, and noncommutative harmonic analysis. The first important step in this direction was taken by G. A. Hunt in 1956. He effectively characterized Lévy processes in Lie groups by generalizing the formula (0.4) for the generator in \mathbb{R}^d . To be precise, let $X = (X(t), t \geq 0)$ be a Lévy process on a d -dimensional Lie group G and let p_t be the law of each $X(t)$. We obtain a one-parameter, strongly continuous, contraction semigroup $(T_t, t \geq 0)$ with generator A on $C_0(G)$ by the prescription

$$(T_t f)(\tau) = \mathbb{E}(f(\tau X(t))) = \int_G f(\tau\sigma)p_t(d\sigma).$$

Note that T_t commutes with left translations. Now let $\{Y_1, \dots, Y_d\}$ be a fixed basis for the Lie algebra \mathfrak{g} of left-invariant vector fields on G . Define a linear manifold $C_2(G)$ that is dense in $C_0(G)$ by the prescription $C_2(G) = \{f \in C_0(G); Y_i f \in C_0(G) \text{ and } Y_i Y_j f \in C_0(G) \text{ for all } 1 \leq i, j \leq d\}$. Hunt showed that there exist functions $x_i \in C_2(G)$, $1 \leq i \leq d$ so that (x_1, \dots, x_d) is a system of canonical coordinates for G at e . A Lévy measure ν is a Borel measure on $G - \{e\}$ for which $\int_{G-\{e\}} \left[\left(\sum_{i=1}^d x_i(\sigma)^2 \right) \wedge 1 \right] \nu(d\sigma) < \infty$. Hunt was then able to obtain the following key result:

Theorem 0.2 [Hunt's Theorem]. *If X is a Lévy process in G with infinitesimal generator \mathcal{A} , then*

1. $C_2(G) \subseteq \text{Dom}(\mathcal{A})$.
 2. For each $\tau \in G, f \in C_2(G)$,
- (0.5)

$$\begin{aligned} (\mathcal{A}f)(\tau) = & \sum_{i=1}^d b_i Y_i f(\tau) + \frac{1}{2} \sum_{i,j=1}^d a_{ij} Y_i Y_j f(\tau) \\ & + \int_{G-\{e\}} \left[f(\tau\sigma) - f(\tau) - \sum_{i=1}^d x_i(\sigma) Y_i f(\tau) \right] \nu(d\sigma), \end{aligned}$$

where $b = (b^1, \dots, b^d) \in \mathbb{R}^d, a = (a_{ij})$, is a non-negative definite, symmetric $n \times n$ real-valued matrix and ν is a Lévy measure on $G - \{e\}$.

Conversely, any linear operator with a representation as in (0.5) is the restriction to $C_2(G)$ of the infinitesimal generator of some Lévy process.

The characteristics (b, a, ν) of a Lévy process determine its law, just as in the Euclidean case.

In the 1990s, H. Kunita and the author were able to generalize the Lévy-Itô decomposition to the extent that for each $f \in C_2(G)$, the real-valued process $f(X) = (f(X(t)), t \geq 0)$ can be described (using stochastic integrals in the sense of K. Itô) in terms of a Brownian motion on \mathbb{R}^d and a Poisson random measure on $\mathbb{R}^+ \times (G - \{e\})$. We now give some examples of Lévy processes on a Lie group G :

1. Brownian motion in G .

This is a Lévy process that has characteristics $(0, I, 0)$. It has continuous sample paths (w.p.1), and its generator is (up to the usual factor of one-half) a left-invariant Laplacian on G , $\Delta_G = \sum_{i=1}^d Y_i^2$. The basis dependence is a nuisance here. It can be dispensed with by equipping G with a left-invariant Riemannian metric m , with respect to which $\{Y_1, \dots, Y_d\}$ is orthonormal. Δ_G is then the Laplace-Beltrami operator associated to (G, m) and the corresponding Brownian motion is a geometrically intrinsic object—indeed, it has played a central role in recent years within the development of analysis in path and loop spaces.

2. The Compound Poisson Process

Let $(y_n, n \in \mathbb{N})$ be a sequence of i.i.d. random variables taking values in G with common law μ and let $(N(t), t \geq 0)$ be an independent Poisson process with intensity $\lambda > 0$. We define the compound Poisson process in G by $Y(t) = y_1 y_2 \dots y_{N(t)}$. In this case the generator is bounded and is given by $(\mathcal{A}f)(\tau) = \int_G (f(\tau\sigma) - f(\tau)) \nu(d\sigma)$, for each $f \in C_0(G)$ where the Lévy measure $\nu(\cdot) = \lambda\mu(\cdot)$ is finite.

3. Stable Processes

The theory of stable processes in Lie groups was developed by H. Kunita in the 1990s. His approach was to generalize the self-similarity property, and for this he needed a notion of scaling. This is provided by a *dilation*, i.e., a family of automorphisms $\delta = (\delta(r), r > 0)$ for which $\delta(r)\delta(s) = \delta(rs)$ for all $r, s > 0$, which also possess suitable continuity properties. A Lévy process X in G is *stable* with respect to the dilation δ if $\delta(r)X(s)$ has the same law as $X(rs)$ for each $r, s > 0$. Dilations (and hence stable Lévy processes) can exist only on simply connected nilpotent groups. Stable processes

in such groups have some surprising properties, e.g., Kunita has shown that there is no dilation with respect to which Brownian motion in the Heisenberg group is stable. It is however possible to construct a stable process on this group whose first two components are Brownian motion whereas the third is a Cauchy process.

4. Subordinated Processes

Let $Y = (Y(t), t \geq 0)$ be a Lévy process on G and $T = (T(t), t \geq 0)$ be a subordinator that is independent of Y . Just as in the Euclidean case, we can construct a new Lévy process $Z = (Z(t), t \geq 0)$ by the prescription $Z(t) = Y(T(t))$, for each $t \geq 0$.

Lévy processes in Lie groups is a subject that is currently undergoing intense development—see the author's survey article in [2] and the recent book by M. Liao [8]. The latter contains a lot of interesting material on the asymptotics of Lévy processes on noncompact semisimple Lie groups, as $t \rightarrow \infty$.

Liao has also found some classes of Lévy processes on compact Lie groups that have L^2 -densities. The density then has a “noncommutative Fourier series” expansion via the Peter-Weyl theorem. In the special case of Brownian motion on $SU(2)$, Liao obtains the following beautiful formula for its density ρ_t at time t :

$$\rho_t(\theta) = \sum_{n=1}^{\infty} n \exp\left(-\frac{(n^2-1)t}{64\pi^2}\right) \frac{\sin(2\pi n\theta)}{\sin(2\pi\theta)},$$

where $\theta \in (0, 1]$ parameterizes the maximal torus $\{\text{diag}(e^{2\pi i\theta}, e^{-2\pi i\theta}), \theta \in [0, 1)\}$.

Another important theme, originally due to R. Gangolli in the 1960s, is to study *spherically symmetric Lévy processes* on semisimple Lie groups G (i.e., those whose laws are bi-invariant under the action of a fixed compact subgroup K). Using Harish-Chandra's theory of spherical functions, one can carry out “Fourier analysis” and obtain a Lévy-Khintchine-type formula. One of the reasons why this is interesting is that G/K is a Riemannian (globally) symmetric space and all such spaces can be obtained in this way. The Lévy process in G projects to a Lévy process in G/K , and this is the prototype for constructions of Lévy processes in more general Riemannian manifolds.

Before leaving the subject of Lévy processes in groups, we briefly mention the general locally compact case. Work on Hilbert's fifth problem during the 1950s established that every such group has an open subgroup of the identity that is a projective limit of Lie groups. This enables the use of Lie group methods within the more general case, and there has been intensive work on this subject since the 1970s by the German school of H. Heyer, W. Hazod, E. Siebert, and their students ([6]). Quite recently, the path properties of Brownian motion in general locally compact groups have been investi-

gated by A. Bendikov and L. Saloff-Coste at Cornell. It will be interesting to see if the new techniques they've developed can be applied to more general classes of Lévy processes.

Lévy Processes in Quantum Groups

Through the work of physicists such as N. Bohr, M. Born, and W. Heisenberg and its mathematical formulation by J. von Neumann, we came to a dual understanding of quantum mechanics. On the one hand, physical observables such as position, momentum, energy, and spin should be described as (not necessarily bounded) self-adjoint linear operators acting in a complex Hilbert space. On the other hand, these observables are also random quantities whose statistical properties are determined by a unit vector in Hilbert space (for pure states) or a more general density matrix (for mixed states). However, the celebrated Heisenberg uncertainty principle tells us that certain pairs of these operators, such as those representing position and momentum, fail to commute. Consequently they cannot both be described together as measurable functions on the same probability space using Kolmogorov's prescription, and hence they cannot have a joint probability distribution.

To describe the probabilistic features of quantum theoretic phenomena systematically, we need to take an algebraic viewpoint. We define a *quantum probability space* to be a pair (B, ω) where B is a complex $*$ -algebra (with identity I) and ω is a state on B , i.e., a positive, linear map for which $\omega(I) = 1$. If B is a C^* -algebra, we can recover a Hilbert space viewpoint by taking the Gelfand-Naimark-Segal representation.

Quantum stochastic processes were introduced by L. Accardi, A. Frigerio, and J. T. Lewis in the 1980s. Every “classical” stochastic process $(X(t), t \geq 0)$ with state space E gives rise to a family of $*$ -homomorphisms $(j_t, t \geq 0)$ from the $*$ -algebra $B_b(E)$ of bounded measurable functions on E into the $*$ -algebra $L^\infty(\Omega, \mathcal{F}, P)$ by the prescription $j_t(f) = f \circ X(t)$. Given a quantum probability space (B, ω) and a $*$ -algebra A , a *quantum stochastic process* is a family $(j_t, t \geq 0)$ of $*$ -homomorphisms from A into B . Many concrete examples of these have been constructed using the quantum stochastic calculus of R. L. Hudson and K. R. Parthasarathy as solutions of operator-valued stochastic differential equations driven by “quantum noise”, i.e., the creation, conservation, and annihilation processes acting in a suitable Fock space.

In order to clarify the last remark, we make a brief diversion. *Fock space* $\Gamma(h)$ over a complex Hilbert space h is $\Gamma(h) := \bigoplus_{n=0}^{\infty} h^{(n)}$, where $h^{(0)} = \mathbb{C}$, $h^{(1)} = h$, and $h^{(n)}$ is the tensor product of n copies of h . It is often desirable to restrict to boson (symmetric) or fermion (antisymmetric) Fock

space, which are the closed subspaces obtained by restricting to symmetric or antisymmetric tensors, respectively. For each $f \in h$ the creation operator $a^\dagger(f)$ maps each $h^{(n)}$ to $h^{(n+1)}$ while the annihilation operator $a(f)$ maps each $h^{(n)}$ to $h^{(n-1)}$. For each self-adjoint T acting in h , the conservation operator $d\Gamma(T)$ maps $h^{(n)}$ to itself. All three types of operators are densely defined linear operators in $\Gamma(h)$ (see, e.g., [9] for precise definitions). As a by-product of work on factorizable representations of current groups in the 1960s and 1970s it was found that any Lévy process $X = (X(t), t \geq 0)$ on \mathbb{R}^d can be realized as a family of self-adjoint operators acting in a symmetric Fock space, where the Lévy-Itô decomposition (0.3) appears as a certain combination of creation, conservation, and annihilation operators. In the 1980s, Hudson and Parthasarathy realized that they could build interesting classes of quantum stochastic processes by developing a stochastic calculus in which each of the creation, conservation, and annihilation parts is treated as a separate operator-valued process rather than in a special “classical” self-adjoint combination.

We can now make an attempt at defining a “quantum Lévy process”. At the very least this should be a quantum stochastic process $(j_t, t \geq 0)$ where each j_t is embedded as $k_{0,t}$ into an associated two-parameter family of $*$ -homomorphisms $(k_{s,t}, 0 \leq s \leq t < \infty)$ which are the “increments” of the process. We generalize the key axiom (L1). The stationary increments requirement becomes $\omega(k_{s,t}(a)) = \omega(k_{0,t-s}(a))$, for each $a \in A$. For independent increments, we have a choice from a number of competing algebraic notions of independence, each of which will yield a distinct notion of Lévy process. The simplest, called *tensor (or bosonic) independence*, requires that

$$\omega(k_{s_1,t_1}(a_1)k_{s_2,t_2}(a_2) \cdots k_{s_n,t_n}(a_n)) = \prod_{i=1}^n \omega(k_{s_i,t_i}(a_i)),$$

for all $n \in \mathbb{N}$, $a_1, \dots, a_n \in A$, $0 \leq s_1 \leq t_1 \leq s_2 \leq t_2 \cdots \leq s_n \leq t_n < \infty$, whenever each pair $k_{s_i,t_i}(a_i)$ and $k_{s_j,t_j}(a_j)$ commute. Other notions of independence that could be used include the fermionic (or \mathbb{Z}_2 graded version) or the free independence of D. Voiculescu. Axioms (L2) and (L3) translate rather easily into this framework; however, the concept we have thus obtained is too general, as it is not clear how $k_{s,t}$ has captured the notion of “increment”.

To overcome this problem, we need to generalize the group concept algebraically, and this is precisely the purpose of quantum groups. More precisely, we need A to be a $*$ -bialgebra, i.e., a $*$ -algebra in which the multiplication and identity have been dualized to give a compatible co-algebra structure. We thus require that there are two $*$ -homomorphisms, a comultiplication

$\Delta : A \rightarrow A \otimes A$ and a co-unit $\varepsilon : A \rightarrow \mathbb{C}$ which satisfy the co-associativity and co-unit axioms:

$$\begin{aligned} (\text{id} \otimes \Delta) \circ \Delta &= (\Delta \otimes \text{id}) \circ \Delta, \\ (\text{id} \otimes \varepsilon) \circ \Delta &= (\varepsilon \otimes \text{id}) \circ \Delta, \end{aligned}$$

where id is the identity mapping.

If A is a $*$ -bialgebra, we obtain a *quantum Lévy process* on A when we augment the generalizations of (L1) to (L3) with an additional axiom

$$(L0) \quad k_{r,s} * k_{s,t} = k_{r,t}, \text{ for all } 0 \leq r \leq s \leq t < \infty,$$

where the *convolution* is given by

$$k_{r,s} * k_{s,t} = m_B \circ (k_{r,s} \otimes k_{s,t}) \circ \Delta;$$

here m_B denotes the multiplication in B .

To understand the meaning of (L0) in the simplest possible context, let X be a Lévy process in a finite group G , and take A to be the $*$ -bialgebra of all complex valued functions on G with the usual pointwise algebra operations and comultiplication $(\Delta f)(\sigma_1, \sigma_2) = f(\sigma_1 \sigma_2)$ and co-unit $\varepsilon(f) = f(e)$. Take $B = L^\infty(\Omega, \mathcal{F}, P)$ and each $k_{s,t}f = f \circ X(s)^{-1}X(t)$. Then (L0) precisely expresses the “increment property”, $X(r)^{-1}X(s)X(s)^{-1}X(t) = X(r)^{-1}X(t)$.

Quantum Lévy processes first arose in work by W. von Waldenfels on a model of the emission and absorption of light by atoms interacting with “noise”. The quantum stochastic process obtained appeared to be a noncommutative analogue of a Lévy process on the unitary group $U(d)$, and this was made precise in terms of quantum Lévy processes when $U(d)$ was replaced by a noncommutative $*$ -bialgebra that generalizes the coefficient algebra of $U(d)$. The theory of quantum Lévy processes has been extensively developed by M. Schürmann and U. Franz in Greifswald, Germany (see [13] or Chapter 7 of [9]). In particular, all quantum Lévy processes are equivalent to solutions of quantum stochastic differential equations driven by creation, conservation, and annihilation processes acting in a suitable Fock space.

We briefly describe one interesting application of quantum Lévy processes to classical probability. Let $B = (B(t), t \geq 0)$ be a one-dimensional Brownian motion and $g(t) = \sup\{0 \leq s \leq t; B(s) = 0\}$. Azéma’s *martingale* $M(t) = \sqrt{\frac{\pi}{2}} \text{sign}(B(t))\sqrt{t - g(t)}$ is a martingale with respect to the filtration $\mathcal{F}_t = \sigma\{M(s); 0 \leq s \leq t\}$. This process has many intriguing features, e.g., M. Emery proved that it shares with Brownian motion and the compensated Poisson process the rare property of being “chaotically complete” (i.e., the linear span of all multiple Wiener integrals is dense in the natural L^2 space), but it is not a Lévy process on \mathbb{R} in the usual sense. However, Schürmann has shown that it is a quantum Lévy process on a certain $*$ -bialgebra generated by two indeterminates.

Conclusion

One way of assessing the health of an area of mathematics is to explore the extent to which it permeates other aspects of the subject. Another way is to examine its use in applications. Regarding both of these criteria, Lévy processes appears to be flourishing. Indeed, limitations of space in this article have prevented me from discussing a host of other topics, including new theoretical advances in the fluctuation theory of real-valued Lévy processes due to J. Bertoin and R. A. Doney and applications to turbulence, time series, and the codification of branching processes. Readers are invited to join the author in speculating that the interplay of Gaussian continuous motion with Poisson jumps, or alternatively its quantum theoretic manifestation within the dance of creation, conservation, and annihilation operators, is a universal feature of a class of random motions (both classical and quantum) that is sufficiently wide to keep mathematicians busy for many years to come.

Acknowledgement: Thanks are due to Chris Rogers for invaluable advice about simulation.

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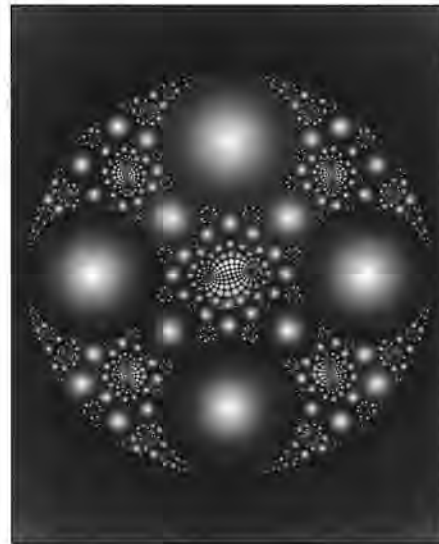
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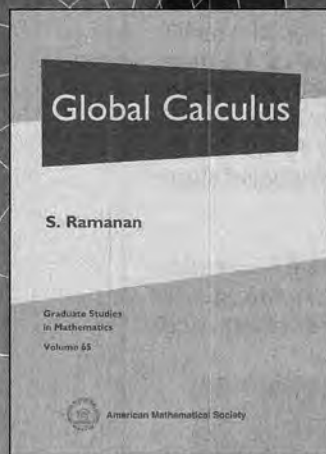
Kleinian Pearls

This month's cover was created by David Wright, who explains it in a brief article in this issue (pages 1332-1333). He entered it in the 2003 NSF Visualization Challenge, in which it was a semifinalist. Limit sets of Kleinian groups and how to draw them are major themes of the well-illustrated book *Indra's Pearls* (Cambridge University Press, 2002), written by Wright with coauthors David Mumford and Caroline Series.

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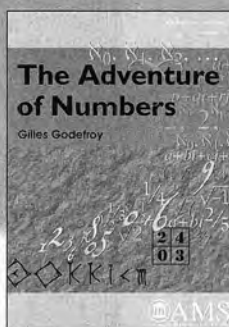
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a Flip?

Alessio Corti

A *flip* is a special codimension-2 surgery in algebraic geometry.

Flips turn up, for example, in the study of compactifications of moduli spaces. Constructions in algebraic geometry depend on parameters (moduli). For instance, Riemann surfaces of genus g are in natural 1-to-1 correspondence with the points of an algebraic variety M_g . Usually, the moduli space is noncompact, making it unsuitable for the study of enumerative and topological questions. Several meaningful compactifications are possible, and they are related by flips. Understanding the different compactifications in terms of flips can lead to beautiful and difficult combinatorial questions. Among the first examples of this point of view is the work of Thaddeus on stable pairs on curves; a recent variation on this theme is the treatment of 3-fold flops by Bridgeland, which I describe below (a flop is a kind of flip).

Flips are steps in Mori's *minimal model program*. Starting with a nonsingular projective variety X , the minimal model program is an analog of the geometrization program in topology; its aim is to perform surgery on X until the *canonical line bundle* $K_X = \wedge^{\text{top}} T^*X$ has global positivity properties.

The simplest example of surgery in algebraic geometry is the *blow-up* $f: Y \rightarrow X$ of a nonsingular point P of a surface X . The surface Y is formed by removing $P \in X$ and sticking the projectivized tangent space $E = \mathbb{P}T_P X$ in its place. The morphism $f: Y \rightarrow X$ identifies $Y \setminus E$ with $X \setminus \{P\}$ and con-

tracts the exceptional set E to P . If $X = \mathbb{C}^2$ with coordinates (x, y) , and $P = (0, 0)$, then

$$Y = \{xm_1 - ym_0 = 0\} \subset \mathbb{C}^2 \times \mathbb{P}^1$$

where m_0, m_1 are homogeneous coordinates on \mathbb{P}^1 . The function $m = m_1/m_0$ is well defined on the chart $\{m_0 \neq 0\}$, which is identified with the set $\{y = mx\} \subset \mathbb{C}^3$. The point at infinity corresponds to the vertical line $\{x = 0\}$.

Doing this construction inside real algebraic geometry produces the picture of a helix; topologically, one cuts out a small disk and replaces it with a Möbius strip.

In the language of algebraic geometry, a surgery is called a *birational map*. By definition, a birational map $\varphi: Y \rightarrow X$ is an isomorphism $\varphi: Y \setminus E \rightarrow X \setminus F$, where the *exceptional sets* $E \subset Y$ and $F \subset X$ are algebraic subvarieties.

In the case of a flip, the exceptional sets $E \subset Y$ and $F \subset X$ are *small*, that is, they have codimension ≥ 2 . By contrast, in the blow-up $f: Y \rightarrow X$ of a nonsingular point, the exceptional set $E \subset Y$ is of codimension 1.

Topological surgery arises in nature when we cross a critical value of a C^∞ Morse function $h: M \rightarrow \mathbb{R}$. As we cross a critical value t_0 , the level set $h^{-1}(t_0 - \varepsilon)$ is surgically modified into $h^{-1}(t_0 + \varepsilon)$. By the Morse lemma, a local model of this situation is $M = \mathbb{R}^n \times \mathbb{R}^m$ with coordinates (x, y) such that

$$(x, y) \rightarrow h(x, y) = -\|x\|^2 + \|y\|^2.$$

We see that, as t crosses t_0 , the level set undergoes a surgery in which $S^{n-1} \times D^m$ is replaced by

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$D^n \times S^{m-1}$ (where S^n and D^n denote the n -dimensional sphere and ball). Integrating along the gradient of h , we get an action of the additive group \mathbb{R} on M ; the level sets $h^{-1}(t)$ for $t = t_0 \pm \varepsilon$ are diffeomorphic to the quotients M^\pm/\mathbb{R} , where $M^- = M \setminus \{x = 0\}$ and $M^+ = M \setminus \{y = 0\}$.

I use an analog of this construction over the complex numbers to give an example of a flip. Consider the action of the multiplicative group \mathbb{C}^\times on $B = \mathbb{C}^4$ with weights $(-2, -1, 1, 1)$:

$$(x_1, x_2, y_1, y_2) \mapsto (\lambda^{-2}x_1, \lambda^{-1}x_2, \lambda y_1, \lambda y_2).$$

The quotient topology by this action is not Hausdorff. Indeed, a general orbit is asymptotic to an orbit in $\{y = 0\}$ as $\lambda \rightarrow 0$ and to an orbit in $\{x = 0\}$ as $\lambda \rightarrow \infty$. There are two meaningful ways to get a Hausdorff topological space, and they are related by a flip. Indeed, consider open subsets $B^- = B \setminus \{x = 0\}$ and $B^+ = B \setminus \{y = 0\}$. Then $X^- = B^-/\mathbb{C}^\times$ and $X^+ = B^+/\mathbb{C}^\times$ are Hausdorff topological spaces with a natural structure of algebraic varieties, and the obvious birational map $\varphi: X^- \rightarrow X^+$ is a flip. Note that X^- is covered by charts $\{x_1 \neq 0\} \cong 1/2(1, 1, 1)$ (the quotient of \mathbb{C}^3 by a reflection of all coordinates) and $\{x_2 \neq 0\} \cong \mathbb{C}^3$.

This example also illustrates Włodarczyk's view of a flip as a birational cobordism, which leads to the proof by him, with Abramovich, Karu, and Matsuki, of the factorization theorem, stating that a birational map between nonsingular varieties is a composition of blow-ups and blow-downs along nonsingular centres.

The few nineteenth-century birational geometers who ventured into higher dimensions were on some level aware of codimension-2 surgery. However, flips were only discovered recently as steps of the minimal model program. If X is a projective variety, the minimal model program performs surgery on X until the canonical line bundle K_X is nef, that is,

$$\deg K_{X|C} = \int_C c_1(K_X) \geq 0$$

for all algebraic curves $C \subset X$ (c_1 denotes the first Chern class). To achieve this, it is necessary to allow X to have mild (to be precise, terminal) singularities, for example certain orbifold singularities, for which K_X still makes sense.

The formal definition of flip requires a diagram

$$\begin{array}{ccc} X^- & \xrightarrow{\varphi} & X^+ \\ & \searrow p^- & \swarrow p^+ \\ & Z & \end{array}$$

where p^\pm are small birational morphisms with compact fibres, such that $-K_{X^-}$ is nef over Z , that is,

$-\int_C c_1(K_{X^-}) \geq 0$ on curves C contracted by p^- , and K_{X^+} is nef over Z .

Usually, $p^-: X^- \rightarrow Z$ is given, and the problem is to show that $p^+: X^+ \rightarrow Z$ exists. The flip can exist only in very restricted conditions, and the few known existence results are very difficult to establish. Mori proved that if X^- is a 3-fold with terminal singularities, then the flip exists. The example above is one of these flips considered by Mori.

In the case of *flops*, where $K_{X^-} = K_{X^+} = 0$, Bridgeland shows that X^+ is the moduli space of certain sheaves on X^- (more precisely, complexes of coherent sheaves in the derived category), thus providing a construction of X^+ . This idea has since been applied, with mixed success, to the problem of existence of flips.

Flips are fundamental in algebraic geometry in dimension ≥ 3 ; the best place to start learning about them is [1].

For many applications, it is desirable to have explicit equations of all 3-fold flips. A paper of Mori [2], which is a great place to look for examples of flips, classifies the important special case of semi-stable flips.

In his work [3], Shokurov proves the existence of flips in dimension 4. His work is based on an important extension of the Mori category, the category of *log terminal pairs* (X, B) of a variety X and a *boundary* \mathbb{Q} -divisor $B = \sum b_i B_i$. In this notation, the $B_i \subset X$ are irreducible subvarieties of codimension 1 and the coefficients $0 < b_i \leq 1$ are rational numbers. Initially at least, B is psychologically a boundary, in the sense that one's emotional investment is in the complement $X \setminus B$. The proof uses the graded ring $R = \bigoplus_{n \geq 0} \Gamma(X, n(K_X + B))$ of global holomorphic differentials satisfying growth conditions at the boundary. For an introduction, see A. Corti, *3-fold flips after Shokurov*, <http://www.dpmms.cam.ac.uk/~corti/flips.html>.

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The "WHAT IS...?" column carries short (one- or two-page) nontechnical articles aimed at graduate students. Each article focuses on a single mathematical object rather than a whole theory. The *Notices* welcomes feedback and suggestions for topics. Messages may be sent to notices-whatis@ams.org.

Book Review

Strange Curves, Counting Rabbits, and Other Mathematical Explorations

Reviewed by Harold R. Parks

Strange Curves, Counting Rabbits, and Other Mathematical Explorations

Keith Ball

Princeton University Press, 2003

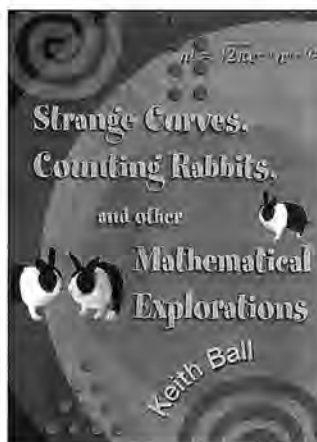
Hardcover, 296 pages, \$29.95

ISBN 0-691-11321-1

According to its preface, the genesis of this book was a lecture given to the math club at a school where a friend of the author was a teacher. That lecture and subsequent lectures on “recreational” or “popular” mathematics in schools and to school students, together with a few other topics, formed the basis for the book. The schools mentioned above were in the United Kingdom, not the United States, so the “math club” was a “maths club,” and if you have formed an impression of the level of this book, you need raise it substantially. The author’s lectures would probably be appropriate for the math club at a college or university in the United States and would be way over the top for any U.S. high school students other than the most advanced, talented, and enthusiastic. Even though the Library of Congress classification of this book is “QA93 Popular works,” a sound knowledge of calculus is a prerequisite for many parts of the book.

The “strange curves” of the title are space-filling curves (or Peano curves), the “counting rabbits” of the title refers to the Fibonacci sequence, and the “other mathematical explorations” cover quite a bit of ground. Let us now list the major topics discussed in the book: Hamming codes, Shannon’s theorem, Pick’s theorem, Fermat’s Little Theorem, space-filling curves, the probability of shared birthdays, the normal approximation to the binomial

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distribution, Stirling’s formula, coin-weighting problems, testing of pooled blood samples, Fibonacci and Lucas numbers, partial fractions, Padé approximation, and the irrationality of e and π . A number of other topics are used as motivation, mentioned in passing, used as illustrations, and so on.

The author’s writing style is informal, inviting, and clear. Some details of some arguments are stated as problems, but the solutions are provided. Not all problems are there to fill in gaps; some are there to give the reader a little more to think about (solutions are provided for those also). Every chapter has some problems stated for the reader to work on, as few as three, and as many as eight, but usually five. As in all human endeavors, there are some errors; as an existence proof, I note that the word “number” on page 194, line 10, should not be there. The errors are remarkably few, and the author is to be congratulated on a very careful job.

The first chapter, “Shannon’s Free Lunch,” is about codes. There are essentially no prerequisites until just before the end. The author begins with a discussion of the check-digit in the ISBN code. The idea of having check-digits is well known among mathematicians, but there are a lot of nonmathematicians who have never heard of such a thing. Everything in this chapter would be news to them. The first ISBN example is self-referential: The example is 0-691-11321-1, the ISBN of *Strange Curves, Counting Rabbits, and Other Mathematical*

Explorations itself. That seems a tricky thing to arrange; I was very surprised by that example.

The issue in this chapter is the transmission of data on a noisy channel. The best possible rate of transmission on a noisy channel was characterized by Claude Shannon in 1948. The author refers to this characterization as "Shannon's free lunch". I don't quite agree with the choice of metaphor. Shannon's theorem tells us that there is necessarily a trade-off: If your channel gets noisier, your maximum rate of transmission gets slower. To me a free lunch would be no slowing in transmission rate. The first time Shannon's theorem appears, it is not really stated, as "stated" is understood by a mathematician. Presumably, the first chapter is meant to be accessible, so a precise statement would be too off-putting. Later, the author does give a precise statement of Shannon's theorem.

The second chapter, "Counting Dots," is about Pick's theorem. This is also a very accessible chapter. Pick's theorem tells us that, for a simple polygon all the vertices of which are integer lattice points, the area of the polygonal region enclosed by the polygon is $I + B/2 - 1$, where I is the number of lattice points in the interior of the polygonal region and B is the number of lattice points lying on the boundary of the polygonal region, i.e., on the polygon itself. The result dates to 1899 and, we are told, is a staple of recreational mathematics. It was, in fact, the subject of that first lecture the author gave to school students, the lecture that ultimately led to this book being written. As an application, the author uses Pick's theorem to give an elegant proof of the fact that, for relatively prime p and q , there exist integers a and b so that $ap - bq = 1$. That Pick's theorem cannot hold in three dimensions is shown by a tetrahedral counterexample. The author tells us that there are some useful things that can be said about lattice points in polyhedra and that there is some current research on this topic, but, regrettably, he gives us no entrée to this current research.

The third chapter, "Fermat's Little Theorem and Infinite Decimals," begins with a look at decimal expansions of rational numbers. As we know, such decimal expansions either terminate or are infinitely recurring. The question one might not have thought about is "What is the period of recurrence in such a decimal expansion?" The most interesting cases will be those in which the denominator is prime, so we are led to consider the decimal expansion of k/p where p is prime and $1 \leq k \leq p - 1$. Since 2 and 5 are divisors of 10, they are special and, for these purposes, anomalous. But the other primes are seen, by example, to fit a nice pattern: For a given prime p , other than 2 or 5, the decimal expansion of k/p has the same period, independent of k , and the number of different types of decimal expansions is $p - 1$ divided by that period. With a

conjecture in hand, the author leads the reader through a proof. In the course of proving the preceding facts it emerges that, for primes other than 2 or 5, $10^{p-1} - 1$ is divisible by p . Consequently, for all primes p , $10^p - 10$ is divisible by p . Since 10 is not particularly special, the reader has been led to Fermat's Little Theorem: If p is a prime and a is an integer, then a^p is congruent to a modulo p .

The fourth chapter, "Strange Curves," is about space-filling curves. The author constructs examples of such curves using geometric recursion illustrated with nice figures: He starts with a basic pattern in the unit square and then proceeds to subdivide the square and put a scaled, and possibly rotated, version of the basic pattern in each subsquare. The actual curve is the limit of appropriate parametrizations of those recursively constructed curves. Since the author wants to assume that the reader does not know the basic theorems about uniform convergence of continuous functions, there is a considerable bit of hand-waving. A credible job is done, and it might be a good refresher for a student who has taken advanced calculus but who has not thought about it lately. The first example of a space-filling curve was constructed by Peano in 1890. Peano's paper, [PG], has no figures. It is a nice feature that the author shows us Peano's original construction in a pictorial form (attributed to Moore and Schönflies).

The next chapter, "Shared Birthdays, Normal Bells," begins a series of three chapters relating to probability theory. The chapter starts with the shared birthday problem. The question is "Given a group of n people, what is the probability that at least two have the same birthday, i.e., celebrate their birthdays on the same day of the year?" To solve this problem sensibly one must shift to finding the probability of the complement. At this point the reader must know about logarithms and how to use calculus to estimate them. The average person is now out of the readership.

The theme of the chapter then shifts a bit to coin-tossing, the normal approximation to the binomial distribution (with equal probabilities of success and failure), and the Central Limit Theorem. Highlights are a wonderful figure showing the annual rainfall at Kew Gardens, in London, for the years 1697-1987 and a method for computing the Gaussian integral that was new to me. No attempt is made to prove the Central Limit Theorem, but a convincing case is made for the normal distribution providing a good approximation to the binomial distribution.

Now that the gauntlet of calculus has been thrown down, the chapter "Stirling Works" tackles a derivation of Stirling's formula. The arguments feel natural and are very nicely presented. They might be heavy going for the popular reader, even the popular reader who did well in calculus.

In chapter 7, "Spare Change, Pools of Blood," the level of mathematical sophistication eases up a bit. The main point of the chapter is solving a practical medical problem: Given a blood test for a relatively rare condition, could one test a group of patients more efficiently by applying the test to pooled samples of blood? By pooling the blood to be tested, there is the chance of ruling out, with just one test, the presence of the condition in the entire group of patients whose blood was in that pooled sample. Such a blood test was, in fact, developed by the author's brother-in-law, and that test is sensitive enough to detect the condition in a pooled sample from 100 patients.

Before addressing the medical problem, the author explores the coin-weighing problem often seen in recreational mathematics, since the ideas from solving the coin-weighing problem turn out to be relevant to the pooled-blood-sample problem: The coin-weighing problem here is to determine the minimum number of weighings needed to find a coin of greater weight in a group of other coins all of which have the same weight. The solution of the coin-weighing problem very nicely motivates the "binary protocol" for the blood testing: First test a pooled sample from all the patients. If that test is negative, you are done. If the test is positive, form two equally sized groups and test each of those pooled samples. Any negative test tells you that that group does not have the condition. Any positive test tells you to divide the group into halves and test the halves. A slight refinement of the analysis shows that one ought to divide the group to be tested into subgroups of size $1/p$, where p is the probability of the condition, before running any tests. With this improvement, the author shows that the expected number of tests required for N patients is $Np[1 + \log_2(1/p)]$, and he shows that, even if the preceding value could be improved by using a different protocol, it cannot be improved by any more than a factor of two. For simplicity, the issue of false test results is not addressed. Subsequent chapters do not rely on any topics from this chapter.

Chapter 8, "Fibonacci's Rabbits Revisited," is about the Fibonacci numbers, no surprise there, and the Lucas numbers. Of course, we have all read some things about the Fibonacci numbers. Typically there is a heavy dose of examples from nature. Nature is fine, but in this chapter the author gives us some meatier mathematics of the Fibonacci numbers. For instance, we see in what sense the Fibonacci ratios (i.e., the ratios of successive Fibonacci numbers) are best approximations to the Golden Ratio. Another gem is the discussion of the fact that, for a prime number p , the p th Lucas number minus 1 is divisible by p , a fact that turns out to be an analogue of Fermat's Little Theorem. In this chapter, the author introduces continued

fractions and matrices, tools that will continue to be used as we approach the proofs of irrationality in the last chapter.

The penultimate chapter, "Chasing the Curve," has nothing to do with the earlier strange curves in chapter 4. The topic here is, rather, Padé approximation. While a Taylor approximation is a polynomial chosen so that it and its first few derivatives agree with the given function at the given point, a Padé approximation is a rational function chosen so that it and its first few derivatives agree with the given function at the given point. Now, one thing the Taylor approximation has going for it is that finding the next one is not that much more work. At first glance, that seems not to be the case with Padé approximation, but, for certain examples, when one thinks in terms of continued fractions, the situation looks better. The continued fraction for $\tan x$ is developed in some detail. For the exponential function and for the arctangent function, the treatment is lightly sketched. These continued fractions are seen again in the next chapter.

The final chapter, "Rational and Irrational," is devoted to proofs of irrationality. It is a bit ironic, after all the reader has been through up to this point, to see the classical Pythagorean proof of the irrationality of $\sqrt{2}$ given in full detail. But that is a mere moment. The author's main method for showing the irrationality of a given number α is to show that if there is a sequence of rational numbers $p_n/q_n \neq \alpha$ which converges too rapidly to α , then α is irrational. For instance, if p_n/q_n converges to α , never equals α , and $(p_n/q_n - \alpha)q_n \rightarrow 0$, then α is irrational. To see this, one argues by contradiction. Supposing $\alpha = P/Q$, then we see that

$$(p_n/q_n - P/Q)q_n = \frac{p_nQ - q_nP}{Q}$$

must converge to 0 but never equal 0. Since the numerator is an integer and the denominator is fixed, we have a contradiction. The author applies the preceding argument to show that e is irrational. A generalization of that approach, combined with the continued fraction expansion for $\tan x$, is used to show that π is irrational.

In summary, this book gives a lively and carefully written treatment of a number of interesting topics. The material should be fully accessible to mathematics majors. Those who have taken calculus (and remember some of it) should be able to follow the ideas, if not all the details. The range of topics is wide, so even the experienced mathematician may learn something new.

References

[PG] Sur une courbe, qui remplit toute une aire plane, *Mathematische Annalen* 36 (1890), 157-160.

Mathematicians' Group to Provide Advice on Math Standards

In July 2004, during the Park City Mathematics Institute (PCMI), a group of thirteen mathematicians met to discuss state mathematics standards documents and offer advice on school mathematics standards. Roger Howe of Yale University, former chair of the AMS Committee on Education, is the leader of the group. Its goal is to prepare a document that will comment generally on standards and also highlight a small number of topics the group believes are central in school mathematics curricula.

The formation of the group came about partly as a way of contributing to a project of the National Council of Teachers of Mathematics (NCTM) and the Association of School Supervisors of Mathematics (ASSM) to analyze state standards. Johnny Lott of the University of Montana, past NCTM president, is heading the NCTM-ASSM effort. After discussions last year between Howe, Lott, and PCMI director C. Herbert Clemens of Ohio State University, two companion proposals were submitted to the National Science Foundation (NSF) for two meetings to take place at the PCMI. One of these was the meeting of the group of mathematicians led by Howe. Because the funding decision came very late, many fewer mathematicians could participate than were invited.

The other meeting was organized by Lott and the past president of the ASSM, Kathleen Nishimura of the Hawaii State Department of Education. This meeting brought together about seventy-five people, including representatives of the NCTM and the ASSM and several mathematicians, some of whom were also in Howe's group. The goal of this meeting was to explore the question, To what extent does the United States have a de facto national curriculum for school mathematics? Unlike many countries around the world, the United States does not have a national mathematics curriculum.

Instead, curricula are chosen at the state and local levels. Starting in 1989, the NCTM issued a number of reports providing principles and guidelines for developing school mathematics standards. These reports were enormously influential and sparked the creation of mathematics standards in all fifty states, as well as standards in other academic disciplines.

During the meeting at the PCMI, mathematics standards documents were brought in from the fifty states, as well as from the District of Columbia and Department of Defense schools. Groups of the meeting attendees were assembled to examine the standards by grade level, and they pored over the documents and compiled information about similarities and differences. Lott explained that the aim is simply to get a "snapshot" of the content of current standards and to see to what extent the states might be moving toward common standards. In particular, this is not an effort to see whether the

Committee of Mathematicians

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Jerry Dwyer, Texas Tech University

Solomon Friedberg, Boston College

Bert Fristedt, University of Minnesota

Daniel Goroff, Harvard University

Roger Howe, Yale University

Harvey Keynes, University of Minnesota

W. James Lewis, University of Nebraska, Lincoln

Andy Magid, University of Oklahoma

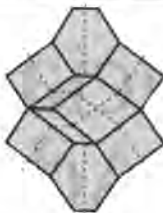
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state standards align with the principles set forth in the NCTM standards reports.

The information gleaned during the meeting is in the process of being analyzed, and Lott said that the aim is to prepare a draft report sometime during the fall of 2004 and the final report by April 2005, when the NCTM annual meeting will take place. Plans call for sessions about the report to be held during conferences later in 2005 and possibly also at the Joint Mathematics Meetings in January 2006.

At the end of the meeting during which the standards documents were analyzed, in a discussion led by Lott, the suggestion was made that Howe's group should offer a mathematical perspective on important issues in creating standards. While perhaps not unprecedented, this kind of direct interaction between mathematicians and people from groups such as the NCTM and ASSM has been rare, at least in the recent history of mathematics education reform. "It's a new stage, it's a new development," Howe said.

What the group of mathematicians will do is to write a document that first outlines some general principles for standards and then focuses more closely on a small number of mathematical ideas that it believes could help improve school mathematics instruction. The group also intends to produce an annotated set of problems that exemplify those ideas. They do not plan to cover the whole of K-12 mathematics. "We are selecting only a set of focused issues where we feel we have something definite to contribute," Howe explained. "Writing good mathematics standards is a complex task, and we have a long way to go before we can develop ideal standards. We hope to provide useful guidance and advice for the next generation of standards writers." The work of the group of mathematicians will proceed on a parallel but separate track from the work headed by Lott to analyze existing state standards.

Sponsored by the Institute for Advanced Study in Princeton, the PCMI is a yearly event in Park City, Utah, that brings together mathematicians, graduate students, postdocs, mathematics educators, and teachers for three weeks of activities designed to promote connections between teaching and research. Further meetings focused on school mathematics standards may take place at the PCMI in the summer of 2005. The report of the mathematicians' group will be posted on the PCMI website and may be produced in hard copy. "If our document is seen as being interesting, there might be a follow-up meeting, and then we will talk about next steps," Howe said. "I'm hoping it will have a positive effect on standards development in the future."

—Allyn Jackson

Deligne Receives 2004 Balzan Prize

The International Balzan Foundation has announced the winners of the 2004 Balzan Prizes. The prize in mathematics went to PIERRE DELIGNE of the Institute for Advanced Study in Princeton. The prize ceremony will take place on November 18, 2004, in Rome.

Also receiving 2004 Balzan Prizes are Nikki R. Keddie (Islamic studies), Colin A. Renfrew (prehistoric archaeology), and Sir Michael Marmot (epidemiology). Each prizewinner receives 1 million Swiss francs (about US\$800,000), half of which must be devoted to research projects involving young researchers in the prizewinner's field. The community of Sant'Egidio, Italy, received a special prize of 2 million Swiss francs for humanity, peace, and brotherhood among peoples.

Deligne is receiving the prize "for major contributions to several important domains of mathematics (like algebraic geometry, algebraic and analytic number theory, group theory, topology, Grothendieck theory of motives), enriching them with new and powerful tools and with magnificent results such as his spectacular proof of the 'Riemann hypothesis over finite fields' (Weil conjectures)."

Laudatio

During a press conference on September 7, 2004, in Milan, Balzan Prize committee member Jacques Tits of the Collège de France made the following remarks.

Pierre Deligne became famous in the mathematical world at an early age through his brilliant proof of the "Weil conjectures", which concern the number of solutions of systems of polynomial

congruences (the so-called "Riemann conjecture over finite fields" is part of them). These conjectures were both exceptionally hard to settle (the best specialists, including A. Grothendieck, had worked on them) and most interesting in view of the far-reaching consequences of their solution. The proof, subject matter of two celebrated papers totaling some 150 pages of the *Publ. Math. IHÉS* (1974 and 1980), was to make use in a remarkably ingenious way of a large combination of very difficult techniques; a real tour de force, which earned its author the Fields Medal in 1978.

The first achievement of Pierre Deligne was followed by several others of similar importance. They all have in common the extreme variety as well as the difficulty of the techniques involved and the inventiveness of the methods.

As for the results themselves, some are "elementary", in that the main statements can be understood by almost any professional mathematician. For instance: the irreducibility of the space of curves of given genus (an early joint paper with D. Mumford, 1969), the definition and application of "buildings" of generalized braid groups (1972), a new solution (also in the early 1970s) of Hilbert's 21st problem, an epoch-making paper written in common with G. Lusztig on linear representations of finite simple groups of Lie type (*Annals of Mathematics*, 1974), the construction of a remarkable central extension of the group of rational points of a reductive group over a field F by the group $K_2(F)$ (a construction first described in an unpublished seminar in 1977–1978 and further investigated in a 1996 paper in the *Publ.*

Math. IHÉS), the study with G. Mostow of the monodromy of hypergeometric functions (1986).

Other results are more technical but equally profound, creating new and powerful tools; let us just mention a few titles: "La théorie de Hodge" II and III (two fundamental papers in the *Publ. Math. IHÉS*, 1971 and 1974; number I was just an announcement), "Le symbole modéré" (ibid. 1991), "Faisceaux pervers" (in *Astérisque*, vol. 100, 1982, pp. 5–171, joint work with A. A. Beilinson and J. Bernstein), "Catégories Tannakiennes" (in *The Grothendieck Festschrift*, vol. II, 1990), "A quoi servent les motifs?" (in *Motives*, AMS, 1994; motifs are a conjectural notion, created by A. Grothendieck in the late 1960s, rich in implications and often exemplified by Deligne).

A remarkable feature of Deligne's thinking is that, when confronted with a new problem or a new theory, he understands and, so to speak, makes his own its basic principles at a tremendous speed and is immediately able to discuss the problem or use the theory as a completely familiar object. Thus, I often observed that he readily adopts the language of the persons he is talking to when engaged in discussions. This flexibility is one of the reasons for the universality of his mathematical work.

Alone or in collaboration, Pierre Deligne has written about a hundred papers, most of them of sizeable length. Because of the conciseness of his style and of his habit of never writing the same thing twice (in fact, quite a few of his best ideas have never been written!), the volume of his publications is a true measure of the richness of his scientific production.

Biographical Sketch

Pierre R. Deligne was born on October 3, 1944, in Etterbeek, Belgium. He studied mathematics at the University of Brussels from 1962 until 1966. During the academic year 1965–66 he was concurrently a foreign student (*pensionnaire étranger*) at the École Normale Supérieure in Paris. In 1968 he received the *licence en mathématiques* and the *doctorat en mathématiques* from the University of Brussels, and in 1972 he received the *doctorat d'État des Sciences Mathématiques* from the Université de Paris-Sud.

In 1968 he went to the Institut des Hautes Études Scientifiques as a visitor and in 1970 was appointed as a permanent member. In 1984, he assumed his present position as a professor at the Institute for Advanced Study in Princeton.

Deligne received the Francois Deruyts prize of the Belgium Royal Academy (1974), the Henri Poincaré medal of the Académie des Sciences of Paris (1974), and the Crafoord Prize of the Royal Swedish Academy of Sciences (1988). At the International Congress of Mathematicians in Helsinki in 1978, he

received the Fields Medal. He is a foreign member of the Académie des Sciences of Paris, a foreign honorary member of the American Academy of Arts and Sciences, and a member of the Académie Royale de Belgique.

About the Balzan Prize

The Balzan Prize is among the most important humanistic and scientific awards in the world. The winners are selected by a General Prize Committee made up of prominent European scientists and academics. The committee evaluates candidate proposals from universities and academies all over the world. The prizes are interdisciplinary in nature, and the prize categories range over literature, moral science and art, medicine, and physical, mathematical, and natural sciences. The Italian-Swiss Balzan Foundation, which has headquarters in Milan and Zurich, was started in 1956 with funds from the daughter of Eugenio Balzan, who inherited a large estate from her father and decided to use it to honor his memory. Eugenio Balzan was born in 1874 and was a proofreader, reporter, and manager for *Corriere della Sera*, the most important Italian daily newspaper. He also became a shareholder in the paper, lived parsimoniously, and invested his earnings shrewdly. In 1933, he settled in Switzerland, mostly because of his opposition to fascism. He died in 1953 in Lugano.

Among previous recipients of the Balzan Prize are the following mathematical scientists: Andrej Kolmogorov (1962), Enrico Bombieri (1980), Jean-Pierre Serre (1985), Otto Neugebauer (1986), Armand Borel (1992), Sir Robert May (1998), and Mikhael Gromov (2000).

—Allyn Jackson

Mathematics People

Bjorken and Callan Awarded 2004 Dirac Medals

The 2004 Dirac Medals of the Abdus Salam International Centre for Theoretical Physics (ICTP) have been awarded to JAMES D. BJORKEN of Stanford University and CURTIS G. CALLAN of Princeton University for their work in the use of deep inelastic scattering for shedding light on the nature of strong interactions.

The award citation reads: "Bjorken was the first to realize the importance of deep inelastic scattering and the first to understand the scaling of cross sections, an insight that ultimately bore his name—the Bjorken scaling of cross sections. Callan, together with Kurt Symanzik (now deceased), reinvented the perturbative renormalization group (in a form that now bears the name Callan-Symanzik equations) and recognized these groups as measures of scale invariance anomalies. Callan has applied these techniques to analyses of deep inelastic scattering and has made substantial contributions to particle physics and, more recently, string theory."

The ICTP awarded its first Dirac Medal in 1985. Given in honor of P. A. M. Dirac, the medal is awarded annually on Dirac's birthday, August 8, to an individual or individuals who have made significant contributions to theoretical physics and mathematics. The medalists also receive a prize of US\$5,000. An international committee of distinguished scientists selects the winners from a list of nominated candidates. The Dirac Medal is not awarded to Nobel Laureates or Wolf Foundation Prize winners.

—From an ICTP announcement

PECASE Awards Announced

Fifty-seven young researchers were chosen to receive the 2003 Presidential Early Career Awards for Scientists and Engineers (PECASE). This award is the highest honor

bestowed by the U.S. government on outstanding young scientists, mathematicians, and engineers who are in the early stages of establishing their independent research careers.

Three scholars who work in the mathematical sciences were honored for 2003. They are KONSTANTINA TRIVISA, University of Maryland, College Park; RAVI VAKIL, Stanford University; and HARRY DANKOWICZ, Virginia Polytechnic Institute and State University.

The recipients were selected from nominations made by eight participating federal agencies. Each awardee receives a five-year grant ranging from \$400,000 to nearly \$1 million to further his or her research and educational efforts.

—From an NSF announcement

Prizes of the Académie des Sciences

The Académie des Sciences, Paris, has announced the awarding of several prizes for 2004.

The Grand Prix Sophie Germain was awarded to HENRI BERESTYCKI of l'École des Hautes Études en Sciences Sociales (ÉHÉSS), Paris, for "fundamental contributions to the analysis of nonlinear partial differential equations, especially in models arising in physics, chemistry and biology," according to the prize citation. Other prizes in mathematics were as follows: the Prix Jaffé to COLETTE MOEGLIN of Institut de Mathématiques de Jussieu des Sciences; the Prix Paul Doistau-Émile Bluter to LAURENT STOLOVITCH, Laboratoire Emile Picard at Toulouse; and the Prix Servant to GUY DAVID, Université Paris-Sud, Orsay.

The Prix Aymé Poirson, for applications of science to industry, was awarded to BIJAN MOHAMMADI, Université de Montpellier. ALBERT COHEN, Université Pierre et Marie Curie, received the Prix Blaise Pascal du Gamni-Smai. The Prix Jacques Herbrand was awarded to NIKITA NEKRASSOV,

Institut des Hautes Études Scientifiques, Bures-sur-Yvette, and the Prix Leconte went to RÉMI MONASSON, Laboratoire de Physique Théorique de l'École Normale Supérieure, Paris.

—From an Académie des Sciences announcement

NDSEG Fellowships Awarded

Thirteen young mathematicians have been awarded National Defense Science and Engineering Graduate (NDSEG) Fellowships by the Department of Defense (DoD). As a means of increasing the number of U.S. citizens trained in disciplines of military importance in science and engineering, DoD awards fellowships to individuals who have demonstrated ability and special aptitude for advanced training in science and engineering. The fellowships are sponsored by the United States Army, Navy, and Air Force.

Following are the names of the fellows in mathematics and the offices that awarded the fellowships. SAMUEL ISAACSON, Air Force Office of Scientific Research (AFOSR); TIFFANY PSEMENEKI, AFOSR; NITIN SAKSENA, AFOSR; BRYAN SMITH, AFOSR; PAUL VALIANT, AFOSR; WILLIAM FONG, Army Research Office (ARO); JAYCE GETZ, ARO; PAUL HAND, ARO; PHILIP MATCHETT, ARO; JOHN WORKMAN, ARO; MEGAN GUICHARD, Office of Naval Research (ONR); BERNARD MARES, ONR; and DAVID SMYTH, ONR.

—From an NDSEG announcement

National High School Calculus Student Award

RYAN WILLIAMS, a student at Miami Springs High School, Florida, has won the fourth annual National High School Calculus Student Award. Williams has qualified three times for the USA Mathematical Olympiad (USAMO), has twice been the Florida state calculus champion, was the Florida Mathematics League individual champion in 2003–2004, and received the first-ever perfect score on the David Essner Exam, given by the University of Miami. He will attend Stanford University. The \$1,000 prize is awarded by Calculus.org, based at the University of California at Davis, Williams College, and Wake Forest University.

—Calculus.org

Pi Mu Epsilon Student Paper Presentation Awards

Pi Mu Epsilon (PME), the U.S. honorary mathematics society, makes annual awards to recognize the best papers by undergraduate students presented at a PME student-paper session. This year the PME held a session in conjunction

with the MAA MathFest in Providence, Rhode Island, August 12–14, 2004. Each awardee received a prize of \$150.

The Pi Mu Epsilon awards for best presentations are sponsored by the AMS. Seven students were chosen for this award. Their names, institutions, and titles of their talks follow: STEPHANIE BARILLE, Mount Union College, “Catch the Wave”; NATHAN EDINGTON, Hood College, “Computer Implementations of Five Important Approximations to Pi”; JEREMY HAMILTON, Youngstown State University, “Fun with Incircles”; COLLEEN HUGHES, Denison University, “Intrinsic Linking of K_6 ”; THEODORE STADNIK, Youngstown State University, “Bivariate Normal Estimation of Digitally Imaged Data”; RYAN STERNBERG, Worcester Polytechnic Institute, “Cartesian Products of Triangles as Unit Distance Graphs”; and ALYSSA WOOD, St. Norbert College, “Mathematical Espionage: Breaking the ‘Unbreakable’ Enigma Code”.

The prize for best research presentation, sponsored by the Council on Undergraduate Research, went to NICOLE CUNNINGHAM, Youngstown State University, for her paper “Comparing the Eigenvalues of Products of Matrices”. The SIAM award for best presentation on environmental issues was given to MICHAEL CORTEZ, Hope College, for his paper “A Mathematical Model of Tri-Trophic Interactions”.

—Elaine Kehoe

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Ph.D. (or completion by time of reappointment to the second year) in mathematics with specialization in real or functional analysis is required. Must exhibit evidence of strong commitment to excellence in teaching and continued scholarly activity. Must be prepared to teach a broad spectrum of undergraduate mathematics courses and have potential to contribute to the department's programs. Must complete a successful interview and teaching demonstration. Evidence of teaching effectiveness is a primary consideration. Salary/benefits are competitive.

Send application letter, vita, copies of undergraduate and graduate transcripts and three letters of reference (at least two of which attest to recent teaching effectiveness) to **Dr. Zhoudé Shao, Search Committee/AMS, Department of Mathematics, Millersville University of Pennsylvania, P.O. Box 1002, Millersville, PA 17551-0302**. Completed application must be received by **January 21, 2005** to assure full consideration. E-mail applications will not be accepted.

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Mathematics Opportunities

NDSEG Fellowships

As a means of increasing the number of U.S. citizens trained in disciplines of military importance in science and engineering, the Department of Defense (DoD) awards National Defense Science and Engineering Graduate (NDSEG) Fellowships each year to individuals who have demonstrated ability and special aptitude for advanced training in science and engineering. The fellowships are awarded for a period of three years for study and research leading to doctoral degrees in mathematical, physical, biological, ocean, and engineering sciences. The number of fellowships awarded depends on available funding.

The NDSEG Fellowship Program is open only to applicants who are citizens or nationals of the United States. NDSEG Fellowships are intended for students at or near the beginning of their graduate studies in science or engineering. Applicants must have received or be on track to receive their bachelor's degrees by fall of 2005. Applications are encouraged from women, persons with disabilities, and minorities, including members of ethnic minority groups such as African American, American Indian and Alaska Native, Asian, Native Hawaiian and other Pacific Islander, Hispanic, or Latino.

Complete applications must be submitted electronically or postmarked by **January 7, 2005**. Application materials are available from, and completed applications should be returned to, the American Society for Engineering Education (ASEE) at NDSEG Fellowship Program, c/o American Society for Engineering Education, 1818 N Street, N.W. #600, Washington, DC 20036; telephone 202-331-3516; fax 202-265-8504; email: ndseg@asee.org. For further information, see the website <http://www.asee.org/ndseg/preface.cfm>.

—From an NDSEG announcement

EDGE Summer Program

The Enhancing Diversity in Graduate Education (EDGE) Program is a postbaccalaureate summer enrichment

program designed to strengthen the ability of women and minority students to successfully complete graduate programs in the mathematical sciences.

The summer program consists of two core courses in analysis and algebra/linear algebra, a minicourse in a current area of mathematical research, short-term visitors from academia and industry, guest lectures, graduate student mentors, and problem sessions. In addition, a follow-up mentoring program and support network will be established with the participants and their respective graduate programs.

Applicants to the program should be women who either (1) have been accepted to a graduate program in the mathematical sciences or (2) have just completed their first year of graduate school in the mathematical sciences. All applicants should have completed standard junior- or senior-level undergraduate courses in analysis and abstract algebra and have a desire to earn the doctorate degree. Women who have taken time away from formal education as well as women from minority groups who fit into one of the above two categories are encouraged to apply. Final acceptance to the program is contingent on acceptance to a graduate program in the mathematical sciences.

In 2005 the eighth session of the EDGE Program will be held at North Carolina Agricultural and Technical State University, Greensboro, North Carolina. The tentative dates for the summer program are June 6–July 1, 2005. It will be co-directed by Sylvia Bozeman (Spelman College), Rhonda Hughes (Bryn Mawr College), and local coordinator Janis Oldham (North Carolina A&T). A stipend of \$2,000, plus travel and room and board will be awarded to participants. Applicants chosen to participate in the program will be notified by April 15, 2005.

Applications should consist of the following: (1) a completed application form; (2) a statement describing the expected value of this program to the applicant's academic goals; (3) two letters of recommendation from mathematical sciences faculty familiar with the applicant's work; (4) a transcript and current résumé; and (5) a list of graduate programs to which the applicant has applied, together with a ranked list of her two or three top choices.

The application deadline is **March 1, 2005**. Applications should be sent to: EDGE Program, P.O. Box 63,

Swarthmore, PA 19081. Actual conduct of the EDGE Program in 2005 is contingent upon continued funding. For more information visit the program's website at <http://www.edgeforwomen.org/>.

—EDGE Program announcement

CMI Liftoff Program for Summer 2005

The Clay Mathematics Institute (CMI) is currently accepting nominations for the 2005 Liftoff Program. Through this program, CMI will employ recent Ph.D. recipients as Liftoff Fellows to carry out mathematics research for one month during the summer of 2005. This program provides a transition for young mathematicians from student to faculty member or to a postdoctoral position. Funds for travel to conferences or to visit collaborators are also available to Liftoff Fellows.

Nominations should be made by university mathematics departments; candidates may not apply directly. Criteria for selection are the quality and significance of mathematical research already achieved by the candidate and the potential of the candidate to become a leader in mathematical research.

Nominations can be sent electronically to the attention of Maria McLaughlin at nominations@claymath.org or by mail to Clay Mathematics Institute, One Bow Street, 4th Floor, Cambridge, MA 02138. The deadline for nominations to be received is **February 15, 2005**. For more information and nomination procedures, see the website http://claymath.org/fas/liftoff_fellows/; telephone 617-995-2600; email: nominations@claymath.org.

—From a CMI announcement

Call for Nominations for Waterman Award

Congress established the Alan T. Waterman Award in August 1975 to mark the twenty-fifth anniversary of the National Science Foundation (NSF) and to honor its first director. The annual award recognizes an outstanding young researcher in any field of science or engineering supported by the NSF. In addition to a medal, the awardee receives a grant of \$500,000 over a three-year period for scientific research or advanced study in the mathematical, physical, medical, biological, engineering, social, or other sciences at the institution of the recipient's choice. Candidates must be U.S. citizens or permanent residents and must be thirty-five years of age or younger or not more than seven years beyond receipt of the Ph.D. degree by December 31 of the year in which they are nominated. Candidates should have demonstrated exceptional individual achievements in scientific or engineering research of sufficient quality to place them at the forefront of their peers. Criteria include

originality, innovation, and significant impact on the field. The deadline for nominations for the award is **November 30, 2004**. Supporting references must be submitted by **December 31, 2004**. For more detailed information concerning the nomination procedures, see the website <http://www.nsf.gov/pubs/2004/nsf0451/nsf0451.pdf>.

—From an NSF announcement

News from the Mittag-Leffler Institute

The Mittag-Leffler Institute, Djursholm, Sweden, has announced its program for the academic year 2005–2006. The fall term will be devoted to wave motion. The organizing committee consists of Adrian Constantin (chair), Lund; Constantine Dafermos, Providence; Helge Holden, Trondheim; Kenneth H. Karlsen, Oslo; and Walter Strauss, Providence. The spring term will be devoted to algebraic topology. The organizing committee consists of Björn Jähren (chair), Oslo; Kathryn Hess, Lausanne; and Bob Oliver, Paris.

The application deadline for postdoctoral fellowships is **January 31, 2005**. Applications should be sent to Marie-Louise Koskull, Institut Mittag-Leffler, Auravägen 17, SE-182 60 Djursholm, Sweden; email: kosku17@m1.kva.se. For further information see the institute's website, <http://www.m1.kva.se/grants>.

—Institut Mittag-Leffler announcement

News from The Fields Institute

The Fields Institute for Research in the Mathematical Sciences and the Perimeter Institute for Theoretical Physics will hold a thematic program on the geometry of string theory from January through July of 2005. The aim of the program is to discuss new results and put new insights gained from physics into the general mathematical framework. Specialized workshops and minicourses will be held. The program will end with the Strings 2005 Conference in July. A list of activities and dates for the winter and spring programs follows. *Winter 2005*: Graduate Course on Symplectic Geometry and Topology. Instructor: B. Khesin. *To Be Announced*: Coxeter Lecture Series. Speaker: Robbert Dijkgraaf. *January 10–14, 2005*: Workshop on Topological Strings with Emphasis on Gromov-Witten Invariants and Open-Closed Duality. Organizers: E. Getzler, K. Hori, S. Katz. *March 21–25, 2005*: Workshop on $N = 1$ Compactifications. Organizers: M. Douglas, K. Hori, S. Sethi. *March 28–April 1, 2005*: Workshop on String Phenomenology. Organizers: J. Louis, R. Myers, G. Shiu. *April 4–7, 2005*: Distinguished Lecture Series. Lecturer: Edward Witten. *May 2–6, 2005*: Workshop on Gravitational Aspects of String Theory. Organizers: C. Johnson, P. Kraus, D. Marolf, A. Peet. *June 20–July 8, 2005*: Summer School Program on Strings, Gravity, and

Cosmology. Organizers: A. Buchel, R. Myers, M. Rozali. July 11–16, 2005: Strings 2005 Conference.

For more information, including funding opportunities, see the Fields website at <http://www.fields.utoronto.ca/programs/scientific/04-05/string-theory/>.

The 2005–2006 thematic program will be on renormalization and universality in mathematics and mathematical physics and on holomorphic dynamics, laminations, and hyperbolic geometry. The fall program will concentrate on the physical aspects of renormalization: statistical physics, conformal field theory, the underlying Hopf-algebraic structure, and renormalization in PDE. The spring program will feature holomorphic and smooth dynamics, KAM theory and renormalization of Hamiltonian flows, conformal invariance and universality in 2D stochastic processes, and the recent breakthrough in the geometrization program based on the dynamics of the Ricci flow and its connection to the concept of renormalization.

The Fields Institute invites applications for postdoctoral fellowship positions at the institute during the 2005–2006 academic year. These fellowships provide an opportunity to spend at least one year engaged in research and participating in the research activities of the institute. Deadline for applications is **December 10, 2004**. Applicants seeking postdoctoral fellowships funded by other agencies (such as NSERC and international fellowships) are encouraged to request The Fields Institute as their proposed location of tenure and should apply to The Fields Institute for a letter of invitation. For further information, see <http://www.fields.utoronto.ca/proposals/postdoc.html>.

—Fields Institute announcement

News from the IMA

The theme of the 2004–2005 academic year at the Institute for Mathematics and its Applications (IMA), in Minneapolis, Minnesota, is Mathematics of Materials and Macromolecules: Multiple Scales, Disorder, and Singularities (<http://www.ima.umn.edu/matter/>). The program synthesizes a broad spectrum of problems and methodologies at the interface between mathematics, materials science, condensed matter physics, and biology.

The IMA will offer several intensive, informal workshops that will bring mathematicians together with researchers from industry and experimental biology. The winter program features two 3-day workshops that focus on industrial applications, combining mathematical tutorials, presentations by industrial scientists, and extensive group discussions. The dates and titles are:

February 7–9, 2005: Workshop on Composites: Where Mathematics Meets Industry. The workshop focuses on multiscale modeling.

March 28–30, 2005: Workshop on New Paradigms in Computation. This workshop addresses fast multipole methods, level set methods, and multiscale computation.

A workshop on Career Options for Women in Mathematical Sciences (February 4–6, 2005) is intended to familiarize women in the mathematical sciences with professional opportunities in industry and government laboratories and to suggest strategies for not merely surviving but thriving. The workshop is being organized jointly by the IMA and the Association for Women in Mathematics (AWM) and is geared primarily toward graduate students and Ph.D.'s in the early stages of their postgraduate careers, although researchers at all stages of professional development are welcome.

A two-part symposium, Experiments in Physical Biology, will be held May 2–6 and May 16–20, 2005. The symposium will give leaders in experimental quantitative biology an opportunity to present key aspects of structural biology and single molecule biophysics in a tutorial fashion and characterize the types of mathematical models needed to analyze experimental data. Other spring programs include two 5-day workshops geared primarily for mathematical audiences. Dates and titles are:

April 11–15, 2005: Workshop on Atomic Motion to Macroscopic Models: The Problem of Disparate Temporal and Spatial Scales in Matter. This workshop addresses techniques for modeling materials and macromolecular systems with multiple time and length scales.

June 8–11, 2005: Workshop on Effective Theories for Materials and Macromolecules. This will be an informal workshop on the development and analysis of effective theories that reduce the degrees of freedom and bridge time and space scales in physics, chemistry, and biology. Two programs for graduate students will be offered during the summer:

June 13–July 1, 2005: The Participating Institution Summer Program for Graduate Students: Stochastic Partial Differential Equations and Environmental and Geophysical Modeling will be hosted by the University of Wyoming and will introduce students to the stochastic analysis of nonlinear PDEs, with applications to petroleum, groundwater, and renewable resource modeling.

August 1–10, 2005: The 2005 Workshop on Mathematical Modeling in Industry will give graduate students and qualified advanced undergraduates firsthand experience in industrial research, working in teams of approximately six students under the guidance of a mentor from industry.

The 2005 Summer Program on Wireless Communications (June 22–July 1, 2005) will focus on the interplay of the physical, link, and network layers in wireless networks, emphasizing stochastic calculus, information theory, signal processing, optimization, and control theory. The program will consist of a 3-day tutorial intended for junior researchers new to the area, followed by a 5-day workshop.

Two “Hot Topics” workshops will be held during the summer:

July 25–29, 2005: The Hot Topics Workshop on Mixed Integer Programming will highlight recent advances in theoretical and computational aspects of MIP and explore the role of MIP in network design, computational biology, medical treatment planning, and cryptography.

August 5–6, 2005: The Hot Topics Workshop on New Directions in Probability Theory, organized jointly by the IMA and the Institute of Mathematical Statistics (<http://www.imstat.org>), is intended for a general probability audience. Session topics are Flows and Random Media; Probability, Combinatorics, and Statistical Mechanics; Stochastic Integration; Stochastic Partial Differential Equations; and Random Walk in Random Environment. The 2005 New Directions Short Course, Quantum Computation (<http://www.ima.umn.edu/new-directions/2005NDshort-course/>), to be held August 15–26, 2005, will introduce quantum mechanics and quantum computation, then pursue two tracks: quantum algorithms and error correction, and topological quantum computation. The course combines general lectures, topical lectures by guest speakers, and problem-solving sessions.

The theme of the 2005–2006 thematic program is Imaging (<http://www.ima.umn.edu/imaging>). The program will explore image formation (the use of data from sensors to form images), image interpretation (the extraction of information from images), and the interplay between these areas. Opportunities for participation include fellowships (application deadline is **January 5, 2005**), general memberships (visits of a month or more; no application deadline), and New Directions Visiting Professorships for established mathematicians seeking to branch into new directions and increase the impact of their research (application deadline **March 1, 2005**). Descriptions of and application forms for these IMA membership programs can be found at <http://www.ima.umn.edu/docs/membership.html>.

Further information and registration forms for all IMA workshops and tutorials are available at <http://www.ima.umn.edu>.

—*From an IMA announcement*

AMS Mentoring Workshop

The AMS is hosting a National Science Foundation (NSF) workshop on mentoring and nurturing students on December 3–4, 2004, at the Four Points by Sheraton Hotel in Tucson, Arizona. The workshop will begin at 1:00 p.m. on Friday, December 3, and last all day on Saturday, December 4.

This workshop is designed to provide participants with ideas and methods that will aid in the development of nurturing environments for students. This will be done by concentrating on mentoring mathematical sciences students through four critical stages in their academic careers: (1) Freshman-sophomore level mathematics courses, (2) Freshman-sophomore level mathematics to junior-senior level mathematics, (3) Undergraduate mathematical sciences major to the first two years of graduate school in mathematics, or to employment, or to graduate and professional schools (other than mathematics), and (4) Writing a dissertation in the mathematical sciences.

A registration fee of \$40.00 is required. Those interested in attending should complete the registration form avail-

able on the web at <http://www.ams.org/government/MentoringWorkshop.html> and send a check payable to the American Mathematical Society, 1527 Eighteenth Street, NW, Washington, DC 20036. Agenda, materials, and location information will be sent to all registered attendees prior to the workshop.

Space is limited to forty participants. Funding from the NSF will cover participant hotel expenses for up to two nights' stay and dinner Friday evening (December 3), as well as breakfast and lunch on Saturday (December 4).

—*AMS announcement*

Newton Fellowship Program

The Math for America Foundation (MfA) sponsors the Newton Fellowship Program which seeks mathematically-sophisticated individuals to become high school mathematics teachers in New York City. The five-year fellowship provides an aggregate stipend of \$90,000 over five years, a full tuition scholarship for a Master's level teaching program at one of MfA's partner universities, and ongoing support mechanisms including mentoring and professional development. The application deadline is **February 4, 2005**. Complete application requirements and deadlines can be found at <http://www.mathforamerica.org>.

MfA is a nonprofit organization with a mission to substantially improve the quality of mathematics education in our country's public schools. MfA works with teachers, school administrators, and other stakeholders through a variety of approaches to accomplish this important objective. MfA launched its first initiative, the Newton Fellowship Program, in 2004 with a group of thirteen fellows. MfA will award approximately forty fellowships in 2005. Jim Simons, who received the AMS Veblen Prize in 1975 and was on the faculty at the State University of New York at Stony Brook, serves as chairman of the MfA, and Irwin Kra, Distinguished Service Professor Emeritus at SUNY Stony Brook, is the executive director.

The Newton Fellowship Program is designed to attract mathematically talented recent college graduates and mid-career professionals into high school teaching. Candidates must have a bachelor's degree with substantial coursework in mathematics and should be able to demonstrate a strong interest in teaching. Applicants also must be willing to commit to a five-year fellowship term in New York City. Individuals who are currently teaching, are certified to teach, or have completed an education degree program are not eligible.

—*MfA announcement*

Inside the AMS

AMS Email Support for Frequently Asked Questions

The following is an updated list of non-user-specific email addresses for contacting AMS staff. This list is also available on the AMS website at <http://www.ams.org/ams/email.html>.

abs-info@ams.org

for questions regarding a particular abstract.

acquisitions@ams.org

to contact the AMS Acquisitions Department.

ams@ams.org

to contact the Society's headquarters in Providence, Rhode Island.

amsdc@ams.org

to contact the Society's office in Washington, DC.

AMS journal-specific questions should be directed to the following email addresses:

proc-query@ams.org: for questions regarding a paper to appear in the journal *Proceedings*.

tran-query@ams.org: for questions regarding a paper to appear in the journal *Transactions*.

mcom-query@ams.org: for questions regarding a paper to appear in the journal *Mathematics of Computation*.

bull-query@ams.org: for questions regarding a paper to appear in the journal *Bulletin*.

jams-query@ams.org: for questions regarding a paper to appear in the journal *Journal of the AMS*.

amsmem@ams.org

to request information about membership in the AMS or about dues payments, or to ask any general membership questions; may also be used to submit address changes.

annualsurvey@ams.org

for information or questions about the AMS-ASA-IMS-MAA *Annual Survey of the Mathematical Sciences* or to request reprints of *Survey* reports.

bookdonations@ams.org

for questions regarding the Society's overseas book donation program.

bookstore@ams.org

for inquiries related to the online AMS Bookstore.

classads@ams.org

to submit classified advertising for the *Notices*.

cust-serv@ams.org

for general information about AMS products (including electronic products); to send address changes, place credit card orders for AMS products, or conduct any general correspondence with the Society's Customer Services Department.

development@ams.org

for information about giving to the AMS, including the Epsilon Fund.

eims-info@ams.org

for general information and questions about *Employment Information in the Mathematical Sciences* (EIMS). For deadlines, rates, and the advertising submission form, go to www.ams.org/eims.

ejour-submit@ams.org

to submit papers to *Representation Theory* and *Conformal Geometry and Dynamics*, electronic journals of the AMS. Each submission must be accompanied by the journal template. A copy of the template is available by sending email to ejour-submit@ams.org. Put the word **TEMPLATE** in the subject field of the email message. To get additional help, put the word **HELP** in the subject field in a separate mail message.

emp-info@ams.org

for information on AMS employment and career services.

eprod-support@ams.org

for technical questions regarding AMS electronic products and services.

era-submit@ams.org

for authors to submit research announcements to *Electronic Research Announcements of the AMS*.

mathcal@ams.org

to send information to be included in the "Mathematics Calendar" section of the *Notices*.

mathjobs@ams.org

for questions about the automated job application website, www.mathjobs.org.

mathrev@ams.org

to submit reviews to *Mathematical Reviews* and to send correspondence related to reviews or other editorial questions.

meet@ams.org

to request general information about Society meetings and conferences.

meetreg-request@ams.org

to request email meeting registration forms.

meetreg-submit@ams.org

to submit completed email registration forms.

mmsb@ams.org

for information or questions about registration and housing for the Joint Mathematics Meetings (Mathematics Meetings Service Bureau).

msn-support@ams.org

for technical questions regarding MathSciNet.

notices@ams.org

to send correspondence to the managing editor of the *Notices*, including items for the news columns. The editor (notices@math.ou.edu) is the person to whom to send articles. Requests for permission to reprint from the *Notices* should be sent to reprint-permission@ams.org (see below).

notices-ads@ams.org

to submit paid display ads electronically for the *Notices*. (Hard copy of the ad should also be faxed or sent via postal mail.)

notices-booklist@ams.org

to submit suggestions for books to be included in the Book List in the *Notices*.

notices-letters@ams.org

to submit letters and opinion pieces to the *Notices*.

notices-whatis@ams.org

to comment on or send suggestions for topics for the WHAT IS...? column to the *Notices*.

paoffice@ams.org

to contact the AMS Public Awareness Office.

president@ams.org

to contact the president of the American Mathematical Society.

prof-serv@ams.org

to send correspondence about AMS professional programs and services.

pub@ams.org

to send correspondence to the AMS Publication Division.

pub-submit@ams.org

to submit accepted electronic manuscripts to AMS publications (other than *Abstracts*). See www.ams.org/

submit-book-journal to electronically submit accepted manuscripts to the AMS book and journal programs.

reprint-permission@ams.org

to request permission to reprint material from Society publications.

sales@ams.org

to inquire about reselling or distributing AMS publications, or to send correspondence to the AMS sales department.

secretary@ams.org

to contact the secretary of the American Mathematical Society.

statements@ams.org

to correspond regarding a balance due shown on a monthly statement.

tech-support@ams.org

to contact the Society's typesetting Technical Support group.

textbooks@ams.org

to request examination copies or to inquire about using AMS publications as course texts.

webmaster@ams.org

for general information or for assistance in accessing and using the AMS website.

Deaths of AMS Members

JAMES T. CULBERTSON, retired emeritus, California Polytechnic State University, died on July 27, 2004. Born on December 25, 1911, he was a member of the Society for 22 years.

LAWRENCE STANLEY EVANS of La Grange, IL, died on May 22, 2004. Born on October 21, 1943, he was a member of the Society for 11 years.

WALTER FEIT, of Yale University, died on July 29, 2004. Born on October 26, 1930, he was a member of the Society for 51 years.

A. W. GOODMAN, emeritus professor, the University of South Florida, died on July 30, 2004. Born on July 20, 1915, he was a member of the Society for 60 years.

RODNEY T. HOOD, emeritus professor, Franklin College, Franklin, IN, is reported to have died several years ago. Born on September 29, 1924, he was a member of the Society for about 40 years.

ARNO JAEGER, emeritus professor, Ruhr University, Bochum, Germany, died on February 24, 2004. Born in August 1911, he was a member of the Society for 63 years.

JOEL SCHNEDER, of the Sesame Workshop TV show, died on September 12, 2004. Born on April 8, 1943, he was a member of the Society for 38 years.

SHIZUO KAKUTANI, of New York City, died on August 16, 2004. Born on August 28, 1911, he was a member of the Society for 51 years.

AMBIKESHWAR SHARMA, emeritus, University of Alberta, died on December 22, 2003. Born on July 2, 1920, he was a member of the Society for 42 years.

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.ou.edu in the case of the editor and notices@ams.org in the case of the managing editor. The fax numbers are 405-325-7484 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines

November 30, 2004: Nominations for Alan T. Waterman Award. See "Mathematics Opportunities" in this issue.

December 1, 2004: Applications for AMS Centennial Research Fellowships. See <http://www.ams.org/employment/centflyer.html> or write to the Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; telephone: 401-455-4107; email: prof-serv@ams.org.

December 1, 2004: Nominations for the Ferran Sunyer i Balaguer Prize. See <http://www.crm.es/FerranSunyerBalaguer/ffsb.htm>.

December 10, 2004: Applications for East Asia and Pacific Summer Institutes. See <http://www.nsf.gov/pubs/2003/nsf03608/nsf03608>.

December 10, 2004: Applications for postdoctoral fellowships for 2005-2006 Fields Institute thematic program. See "Mathematics Opportunities" in this issue.

Where to Find It

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

AMS Bylaws—November 2003, p. 1283

AMS E-mail Addresses—December 2004, p. 1365

AMS Ethical Guidelines—June/July 2004, p. 673

AMS Officers 2002 and 2003 (Council, Executive Committee, Publications Committees, Board of Trustees)—May 2004, p. 566

AMS Officers and Committee Members—October 2004, p. 1082

Conference Board of the Mathematical Sciences—September 2004, p. 921

Information for Notices Authors—June/July 2004, p. 668

Mathematics Research Institutes Contact Information—August 2004, p. 810

National Science Board—January 2004, p. 54

New Journals for 2003—June/July 2004, p. 670

NRC Board on Mathematical Sciences and Their Applications—March 2004, p. 350

NRC Mathematical Sciences Education Board—April 2004, p. 446

NSF Mathematical and Physical Sciences Advisory Committee—February 2004, p. 242

Program Officers for Federal Funding Agencies—October 2004, p. 1078 (DoD, DoE); December 2004, p. 1368 (NSF)

December 20, 2004: NSA grants in quantum computing algorithms. See <http://www.nas.gov/msp/msp00002.cfm>.

December 31, 2004: Supporting references for nominations for Alan T. Waterman Award. See "Mathematics Opportunities" in this issue.

January 1, 2005: Entries for *Cryptologia* undergraduate paper competitions. See <http://www.dean.usma.edu/math/pubs/cryptologia/>.

January 5, 2005: Applications for fellowships for the IMA 2005-2006 thematic program. See "Mathematics Opportunities" in this issue.

January 7, 2005: Applications for National Defense Science and Engineering Graduate Fellowships. See "Mathematics Opportunities" in this issue.

January 10, 2005: Applications for AAUW Selected Professions Fellowships. See http://www.aauw.org/fga/fellowships_grants/selected.cfm or contact the AAUW Educational Foundation, 1111 Sixteenth St., N.W., Washington, DC 20036; telephone 800-326-2289 (AAUW); fax 202-872-1425; email: info@aauw.org.

January 31, 2005: Applications for postdoctoral fellowships at the Mittag-Leffler Institute. See "Mathematics Opportunities" in this issue.

February 1, 2005: Applications for AWM Travel Grants and AWM Mentoring Travel Grants. See the AWM website, <http://www.awm-math.org/travelgrants.html>; telephone: 301-405-7892; email: awm@math.umd.edu.

February 15, 2005: Nominations for Clay Mathematics Institute Liffoff Program. See "Mathematics Opportunities" in this issue.

March 1, 2005: Applications for EDGE Summer Program. See "Mathematics Opportunities" in this issue.

March 1, 2005: Applications for New Directions visiting professorships at IMA. See "Mathematics Opportunities" in this issue.

May 1, 2005: Applications for AWM Travel Grants. See the AWM website, <http://www.awm-math.org/travelgrants.html>; telephone: 301-405-7892; email: awm@math.umd.edu.

June 30, 2005: Nominations for the 2005 Fermat Prize. See http://www.ups-tlse.fr/ACTUALITES/Sciences/Prix_Fermat_2004/Areglement.html.

January 1, 2006: Applications for ICM 2006 Travel Grants. See <http://www.icm2006.org> or email: grants@icm2006.org.

NSF Division of Mathematical Sciences

Listed below are names, email addresses, and telephone numbers for the program directors for the coming academic year in the Division of Mathematical Sciences of the National Science Foundation.

Algebra, Number Theory, and Combinatorics

Tomek Bartoszynski
703-292-4885
tbartosz@nsf.gov

Donald James
703-292-4877
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Kathleen O'Hara
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Analysis
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trussell@nsf.gov

Junping Wang
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jwang@nsf.gov

Geometric Analysis, Topology, and Foundations
Tomek Bartoszynski
703-292-4885
tbartosz@nsf.gov

Joanna Kania-Bartoszynska
703-292-4881
jkaniaba@nsf.gov

Benjamin Mann (on leave)
703-292-4867
bmenn@nsf.gov

Stewart Priddy
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Christopher Stark
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cstark@nsf.gov

Infrastructure
John B. Conway
703-292-4872
jconway@nsf.gov

Lloyd Douglas
703-292-4862
ldouglas@nsf.gov

Statistics and Probability
Keith Crank (on leave)
703-292-4880
kcrank@nsf.gov

Shulamith Gross
703-292-4868
sgross@nsf.gov

Xuming He
703-292-4876
xhe@nsf.gov

Wen Masters
703-292-4871
wmasters@nsf.gov

Robert Serfling
703-292-4884
rserfling@nsf.gov

The administrative staff includes:

Division Director
William Rundell
703-292-4850
wrundell@nsf.gov

Executive Officer
Deborah Lockhart
703-292-4858
dlockhar@nsf.gov

Assistant Program Director
Dean Evasius
703-292-8132
devasius@nsf.gov

Administrative Officer
Tyzcer Henson
703-292-4852
thenson@nsf.gov

Division Secretary
Jennifer Connell
703-292-5301
jconnell@nsf.gov

NSF Mathematics Education Staff

The Directorate for Education and Human Resources (EHR) of the National Science Foundation (NSF) sponsors a range of programs that support educational projects in mathematics,

science, and engineering. Listed below is contact information for those EHR program officers whose fields are in the mathematical sciences or mathematics education. These individuals can provide information about the programs they oversee, as well as information about other EHR programs of interest to mathematicians. The postal address is: Directorate for Education and Human Resources, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230. The EHR webpage is <http://www.nsf.gov/ehr>.

Division of Elementary, Secondary, and Informal Education
William Frascella, Division Director
703-292-8628
wfrascel@nsf.gov

John (Spud) Bradley
703-292-8620
jbradley@nsf.gov

Monica Mitchell
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Monica Neagoy
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Mark Saul
703-292-8614
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Division of Research, Evaluation, and Communication
John Cherniavsky
703-292-5136
jchernia@nsf.gov

Finbarr (Barry) Sloane
703-292-5146
fsloane@nsf.gov

Division of Undergraduate Education
John Haddock
(contact information unavailable)

Elizabeth Teles
703-292-4643
eteles@nsf.gov

Lee Zia
703-292-5140
lzia@nsf.gov

Division of Human Resource Development
Roosevelt Johnson
703-292-8640

Math and Science Partnership Program
Diane Spresser
703-292-5188
dspresse@nsf.gov

Office of Assistant Director for Education and Human Resources
James Lightbourne
703-292-4628
jhlightb@nsf.gov

Book List

The Book List highlights books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. When a book has been reviewed in the Notices, a reference is given to the review. Generally the list will contain only books published within the last two years, though exceptions may be made in cases where current events (e.g., the death of a prominent mathematician, coverage of a certain piece of mathematics in the news) warrant drawing readers' attention to older books. 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.

Abel's Proof: An Essay on the Sources and Meaning of Mathematical Unsolvability, by Peter Pesic. MIT Press, May 2003. ISBN 0-262-16216-4. (Reviewed March 2004.)

Across the Board: The Mathematics of Chessboard Problems, by John J. Watkins. Princeton University Press, April 2004. ISBN 0-691-11503-6.

Adam Spencer's Book of Numbers, by Adam Spencer. Four Walls Eight Windows, January 2004. ISBN 1-568-58289-7.

Alan Turing: Life and Legacy of a Great Thinker, edited by Christof

- Teuscher. Springer, 2004. ISBN 3-540-20020-7.
- Alpha & Omega: The Search for the Beginning and End of the Universe*, by Charles Seife. Viking, July 2003. ISBN 0-670-03179-8.
- Automated Reasoning and the Discovery of Missing and Elegant Proofs*, by Larry Wos and Gail Pieper. Rinton Press, December 2003. ISBN 1-58949-023-1.
- Beyond Coincidence*, by Martin Plimmer and Brian King. Icon Books, March 2004. ISBN 1-840-46534-4.
- Beyond the Limit: The Dream of Sofya Kovalevskaya*, by Joan Spicci. Forge, August 2002. ISBN 0-765-30233-0. (Reviewed January 2004.)
- The Changing Shape of Geometry: Celebrating a Century of Geometry and Geometry Teaching*, edited by Chris Pritchard. Cambridge University Press, January 2003. ISBN 0-521-53162-4.
- Cogwheels of the Mind: The Story of Venn Diagrams*, by A. W. F. Edwards. Johns Hopkins University Press, April 2004. ISBN 0-801-87434-3.
- Constantin Carathéodory: Mathematics and Politics in Turbulent Times*, by M. Georgiadou. Springer, September 2004. ISBN 3-540-44258-8.
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- The Mathematical Century: The 30 Greatest Problems of the Last 100 Years*, by Piergiorgio Odifreddi, translated by Arturo Sangalli. Princeton University Press, May 2004. ISBN 0-691-09294-X.
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Predicting Presidential Elections and Other Things, by Ray C. Fair. Stanford University Press, August 2002. ISBN 0-804-74509-9.

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Shooting the Sun, by Max Byrd. Bantam, December 2003. ISBN 0-553-80208-9.

Signs of the Inka Khipu: Binary Coding in the Andean Knotted-String Records, by Gary Urton. University of Texas Press, August 2003. ISBN 0-292-78540-2.

Six Degrees: The Science of a Connected Age, by Duncan J. Watts. W. W. Norton, February 2003. ISBN 0-393-04142-5. (Reviewed February 2004.)

Strange Curves, Counting Rabbits, and Other Mathematical Explorations, by Keith Ball. Princeton University Press, November 2003. ISBN 0-691-11321-1. (Reviewed in this issue.)

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REFERENCE & BOOK LIST

Statistics on Women Mathematicians Compiled by the AMS

At its August 1985 meeting the Council of the AMS approved a motion to regularly assemble and report in the *Notices* information on the relative numbers of men versus women in at least the following categories: membership in the AMS, invited hour addresses at AMS meetings, speakers at Special Sessions at AMS meetings, percentage of women speakers in AMS Special Sessions by gender of organizers, and members of editorial boards of AMS journals.

It was subsequently decided that this information would be gathered by determining the sex of the individuals in the above categories based on name identification if no other means was available and that additional information on the number of Ph.D.'s granted to women would also be collected using the AMS-IMS-MAA Annual Survey. Since name identification was used, the information for some categories necessitated the use of three classifications:

Male: names that were obviously male

Female: names that were obviously female

Unknown: names that could not be identified as clearly male or female (e.g., only initials given, non-gender-specific names, etc.)

The following is the nineteenth reporting of this information. Updated reports will appear annually in the *Notices*.

Invited Hour Address Speakers at AMS Meetings (1994-2003)

Male:	487	87%
Female:	76	13%
Unknown:	0	0%
Total checked:	563	

Speakers at Special Sessions at AMS Meetings (1999-2003)

Male:	10,059	78%
Female:	1,801	14%
Unknown:	1,052	8%
Total checked:	12,912	

Percentage of Women Speakers in AMS Special Sessions by Gender of Organizers (2003)

Special Sessions with at Least One Woman Organizer

Total number of speakers:	604	
Male:	468	77%
Female:	130	22%
Unknown:	6	1%

Special Sessions with No Women Organizers

Total number of speakers:	1,686	
Male:	1,426	85%
Female:	223	13%
Unknown:	37	2%

2003 Members of the AMS Residing in the U.S.

Male:	12,675	68%
Female:	3,305	18%
Unknown:	2,619	14%
Total checked:	18,599	

Trustees and Council Members

	2000	2001	2002	2003
Total:	50	49	47	48
Male:	37 74%	37 76%	33 70%	36 75%
Female:	13 26%	12 24%	14 30%	12 25%

Members of AMS Editorial Committees

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total:	176	194	198	213	213	230	219	224	230	224
Male:	161 91%	175 90%	177 89%	189 89%	182 85%	198 86%	186 85%	190 85%	195 85%	189 84%
Female:	15 9%	19 10%	21 11%	24 11%	31 15%	32 14%	33 15%	34 15%	35 15%	35 16%

Ph.D.'s Granted to U.S. Citizens

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total:	469	567	493	516	586	554	537	494	418	499
Male:	345 74%	426 75%	377 76%	368 71%	423 72%	367 66%	379 71%	343 69%	291 70%	341 68%
Female:	124 26%	141 25%	116 24%	148 29%	163 28%	187 34%	158 29%	151 31%	127 30%	158 32%

Mathematics Calendar

The most comprehensive and up-to-date Mathematics Calendar information is available on e-MATH at <http://www.ams.org/mathcal/>.

December 2004

5-16 **International Workshop on Nonlinear Partial Differential Equations**, IPM, Tehran, Iran. (Aug. 2003, p. 850)

*6-8 **International Conference on Mathematical Inequalities and their Applications, I**, Victoria University, Melbourne, Australia.

Aim: To stimulate researchers from all fields of science to collaborate and present new results and applications in mathematical inequalities.

Information: <http://rgmia.vu.edu.au/conference/>.

*6-8 **OSDI '04 - 6th Symposium on Operating Systems Design and Implementation**, Renaissance Parc 55 Hotel, San Francisco, California.

Description: OSDI brings together professionals from academic and industrial backgrounds in what has become a premier forum for discussing the design, implementation, and implications of systems software.

Information: <http://www.usenix.org/events/osdi04/>.

6-10 **III Joint Meeting Japan-Mexico in Topology and Its Applications**, Oaxaca, Mexico. (Jun/Jul. 2004, p. 690)

6-10 **Compact Moduli Spaces and Birational Geometry**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2004, p. 690)

9-11 **Discrete Mathematics and Its Applications**, Amrita Vishwa Vidyapeetham, Ettimadai, Coimbatore, Tamil Nadu, India. (Aug. 2004, p. 832)

13-15 **Pseudospectra and Structural Dynamics**, University of Bristol, Bristol, UK. (Oct. 2004, p. 1095)

13-17 **The 9th Asian Technology Conference in Mathematics (ATCM2004)**, National Institute of Education, Singapore. (Apr. 2004, p. 461)

13-17 **Recent Advances in Core Model Theory**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2004, p. 690)

13-18 **Joint Conference: The 2004 NZIMA Conference in Combinatorics and Its Applications and The 29th Australasian Conference in Combinatorial Mathematics and Combinatorial Computing (29th ACCMCC)**, Copthornes-Manuels, Lake Taupo, New Zealand. (Jun/Jul. 2004, p. 690)

14-16 **Sixth IMA International Conference on Mathematics in Signal Processing**, The Royal Agricultural College, Cirencester, UK. (Nov. 2004, p. 1263)

15-17 **Arithmetic, Geometry and Topology, Conference on the Occasion of Larry Breen's Sixtieth Birthday**, Institut Galilée, Université Paris 13, France. (Jun/Jul. 2004, p. 690)

16-19 **International Conference on History and Heritage of Mathematical Sciences**, Govt. Model Autonomous Holkar Science College, Indore, India. (Jun/Jul. 2004, p. 690)

17-19 **4th WSEAS International Conference on Signal Processing, Computational Geometry & Artificial Vision (ISCGAV'04)**, Puerto De La Cruz, Tenerife, Canary Islands, Spain. (Jun/Jul. 2004, p. 691)

17-19 **International Conference on Smarandache Algebraic Structures**, Indian Institute of Technology, IIT Madras, Chennai, Tamil Nadu, India. (Aug. 2003, p. 850)

17-22 **The Third International Congress of Chinese Mathematicians**, The Chinese Univ. of Hong Kong, Shatin, Hong Kong,

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 held in North America 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. Meetings held outside the North American area may carry more detailed information. In any case, 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/>.

P. R. China. (Dec. 2003, p. 1443)

18-20 **Recent Advances in Mathematics & Its Applications (ISRAMA 2004)**, Kolkata (Calcutta), India. (Jun/Jul. 2004, p. 691)

20-23 **Sharp Thresholds for Mixing Times**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2004, p. 691)

29-31 **6th WSEAS International Conference on Mathematical Methods and Computational Techniques in Electrical Engineering (MMACTEE 2004)**, Vouliagmeni, Athens, Greece. (Jun/Jul. 2004, p. 691)

January 2005

5-8 **Joint Mathematics Meetings**, Hyatt Regency Atlanta & Atlanta Marriott Marquis, Atlanta, Georgia. (Sept. 2002, p. 1001)

6-9 **24th Nordic and 1st Franco-Nordic Congress of Mathematicians**, University of Iceland, Reykjavik, Iceland. (Nov. 2004, p. 1263)

7-8 **2004-05 ASL Winter Meeting (with Joint Mathematics Meetings)**, Atlanta, Georgia. (Jun/Jul. 2004, p. 691)

8-15 **Geometry: Interactions with Algebra and Analysis**, Napier, New Zealand. (May 2004, p. 576)

9-11 **2005 Hawaii International Conference on Statistics, Mathematics and Related Fields**, Sheraton, Waikiki Hotel, Honolulu, Hawaii. (Aug. 2004, p. 832)

10-14 **4th Symposium on Lévy Processes**, University of Manchester, Manchester, England. (Oct. 2004, p. 1095)

10-14 **Braid Groups, Clusters and Free Probability**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2004, p. 691)

10-14 **International Symposium on "Variational Methods and Nonlinear Differential Equations on the Occasion of the 60th Birthday of Antonio Ambrosetti"**, University of Rome 3, Rome, Italy. (Nov. 2004, p. 1264)

*10-14 **Multiscale Processes in Fusion Plasmas**, IPAM at UCLA, 460 Portola Plaza, Los Angeles, California.

Focus: Multiscale Processes in Fusion Plasmas is a five-day workshop focussing on five physical phenomena in fusion plasmas.

Information: <http://www.ipam.ucla.edu/programs/fus2005/>.

10-14 **Workshop on Topological Strings**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 461)

12-14 **Second Joint IMS/ISBA International Conference**, Bormio, Italy (Italian Alps). (Aug. 2004, p. 833)

17-July 15 **Model Theory and Applications to Algebra and Analysis**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Apr. 2003, p. 500)

*24-28 **IPAM workshop: Probabilistic Models of Cognition-The Mathematics of Mind**, UCLA, Los Angeles, California.

Organizers: Alan Yuille, Josh Tenenbaum.

Information: <http://www.ipam.ucla.edu/programs/cog2005/>.

*24-29 **RTNS2005: Recent Trends in Nonlinear Science 2005 (winter school)**, Castellon, Spain.

Goal: The goal of these winter schools is to train participants to theory and applications in the field of nonlinear science. This will be done in an atmosphere of informal discussion and interchange of ideas. These courses have received official recognition in the doctorate programs of Universitat Autònoma de Barcelona and Universitat Politècnica de Catalunya.

Courses: (<http://www.rtns2005.uji.es/courses.html>).

Registration: (<http://www.rtns2005.uji.es/registration.html>). NOTE: The number of available places in the school is limited. Final admissions will be by the registration order.

Information: Second Winter School of the Spanish Network DANCE (<http://www.dance-net.org/>).

24-July 22 **Developments in Quantitative Finance**, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK. (Aug. 2004, p. 833)

26-30 **Front Propagation and Nonlinear Stochastic PDEs for Combustion and Other Applications**, Centre de Recherches Mathématiques, Université de Montréal, Montréal, Québec, Canada. (Aug. 2004, p. 833)

27-29 **IMAC-XXIII Preconference Courses**, Rosen Plaza Hotel, Orlando, Florida. (May 2004, p. 576)

31-February 1 **DIMACS Workshop on Bounded Rationality**, DIMACS Center, CoRE Bldg, Rutgers University, Piscataway, New Jersey. (Oct. 2004, p. 1095)

*31-February 2 **IPAM Workshop: Mathematics of the Ear and Sound Signal Processing**, UCLA, Los Angeles, California.

Organizers: Jack Xin, Li Deng, Stanley Osher, Yingyong Qi, James Sneyd.

Information: <http://www.ipam.ucla.edu/programs/es2005/>.

31-February 3 **IMAC-XXIII: A Conference on Structural Dynamics**, Rosen Plaza Hotel, Orlando, Florida. (May 2004, p. 576)

February 2005

3-4 (NEW DATE) **DIMACS Workshop on Markets as Predictive Devices (Information Markets)**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Jun/Jul. 2004, p. 691)

7-9 **IMA Tutorial/Workshop: Where Mathematics Meets Industry**, University of Minnesota, Minneapolis, Minnesota. (Jun/Jul. 2004, p. 691)

14-18 **Geometry: Interactions with Algebra and Analysis**, University of Auckland, Auckland, New Zealand. (May 2004, p. 576)

15-17 **International Symposium on Stochastic Models in Reliability, Safety, Security and Logistics (SMRSSL'05)**, Negev Academic College of Engineering (NACE), Beer Sheva, Israel. (Apr. 2004, p. 461)

17-21 **CERM.4 (Fourth Congress of the European Society for Research in Mathematics Education)**, Sant Feliu de Guixols, Spain (Oct. 2004, p. 1095)

*21-26 **Mathematical Methods in Quantum Mechanics**, Casa Della Gioventù, Bressanone, Italy.

Aim: To present the state of the art in some challenging open problems in Quantum Mechanics from the point of view of Mathematical Physics. It is mainly addressed to young people interested in working on the subject.

Topics: Scattering for linear and nonlinear Schrödinger equation, many-body problems, derivation of macroscopic equations from quantum dynamics, Born-Oppenheimer approximation, classical behavior in quantum systems. Three short courses will be given in a series of lectures scheduled in the morning of each day. Some invited talks will be given in the afternoon followed by short contributed talks given by participants.

Courses: M. Pulvirenti (Roma, La Sapienza), Introduction to quantum kinetic theory; G. Velo (Bologna), Basic mathematical aspects of nonlinear Schrödinger equations; J. Yngvason (Wien), The Bose-Einstein condensation.

Invited Speakers: S. Albeverio (Bonn), L. Erdős (Munich), J. Fröhlich* (ETH, Zurich), A. Joye (Grenoble), S. Teufel (Warwick), K. Yajima (Tokyo) * to be confirmed.

Organizers: G. Dell'Antonio (Roma La Sapienza), R. Figari (Napoli), S. Graffi (Bologna), V. Grecchi (Bologna), A. Sacchetti (Modena), A. Teta (L'Aquila).

Information: <http://www.MMQM.unimore.it>; email: info.mmqm@unimo.it.

*22-26 **IPAM Workshop: Mathematical Issues and Challenges in Data Assimilation for Geophysical Systems-Interdisciplinary Perspectives**, UCLA, Los Angeles, California.

Organizers: Christopher Jones, Kayo Ide, Robert Miller, Douglas Nychka.

Information: <http://www.ipam.ucla.edu/programs/da2005/>.

* 23-25 **Graph Asymmetries**, Massey University, Palmerston North, New Zealand.

Topics: The topics to be discussed at the workshop comprise but are not limited to: Endomorphism monoids of classes of graphs such as paths, trees, or bipartite graphs; Graphs whose endomorphism monoids have prescribed properties; Semigroups whose Cayley graphs have prescribed properties; Graphs from other algebraic structures; Aut- and End-vertex transitive Cayley graphs of semigroups; Graph grammars and their relationship to graph morphisms; Asymmetric designs and graph families; Graph asymmetries in computer- or life science.

Deadlines: Abstract submission: January 7, 2005. Author notification: January 28, 2005. Final abstract deadline: February 11, 2005.

Information: Workshop Page: <http://wga.massey.ac.nz/wga05/>; Roland Kaschek, email: R.H.Kaschek@massey.ac.nz; Ulrich Knauer, email: Ulrich.Knauer@uni-oldenburg.de.

March 2005

1-2 **DIMACS Short Course: A Field Guide to GenBank and NCBI Molecular Biology Resources**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Jun/Jul. 2004, p. 692)

2-5 **Representing Unresolved Degrees of Freedom for the Atmosphere and Ocean**, Centre de Recherches Mathématiques, Université de Montréal, Montréal, Québec, Canada. (Aug. 2004, p. 833)

3-5 **International Conference on Environmental Fluid Mechanics (ICEFM'05)**, Indian Institute of Technology Guwahati, Guwahati, India. (Sept. 2004, p. 971)

6-12 **International Conference on Algebras, in Memory of Kostia Beidar**, National Cheng Kung University, Tainan, Taiwan. (Nov. 2004, p. 1264)

7-9 **DIMACS Working Group on Order Theoretic Aspects of Epidemiology**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Jun/Jul. 2004, p. 692)

7-11 **Third International Conference on Pattern Avoiding Permutations**, University of Florida, Gainesville, Florida. (Jun/Jul. 2004, p. 692)

* 7-June 10 **IPAM Long Program: Grand Challenge Problems in Computational Astrophysics**, UCLA, Los Angeles, California.

Description: This long-term program will involve a community of senior and junior researchers. The intent is for long-term participants to have an opportunity to learn about computational astrophysics from the perspectives of many different fields—mathematics, science and astronomy. In addition to these activities, there will be opening tutorials, four workshops, and a culminating workshop at Lake Arrowhead. Full and partial support for long-term participants is available, and those interested are encouraged to fill out an online application at the website above. Support for individual workshops will also be available, and may be applied for through the online application for each workshop. Funding for participants is available at all academic levels, though recent PhD's, graduate students, and researchers in the early stages of their career are especially encouraged to apply.

Organizers: Willy Benz, Philip Colella, Richard Klein, James McWilliams, Joseph Monaghan, Mark Morris, Stanley Osher, Chi-Wang Shu, Harold Yorke.

Information: <http://www.ipam.ucla.edu/programs/pca2005/>.

* 8-11 **IPAM Program in Grand Challenge Problems in Computational Astrophysics—Tutorials**, UCLA, Los Angeles, California.

Program: These are tutorials to introduce mathematicians to the main issues and problems of current interest in astrophysics, and to introduce astrophysicists to the principal mathematical techniques relevant to doing computations in astrophysics.

Information: <http://www.ipam.ucla.edu/programs/pca2005/>.

14-18 **Deterministic and stochastic Navier-Stokes equations**, AIM Research Conference Center, Palo Alto, California. (Oct. 2004, p. 1095)

18-19 **AMS Southeastern Section Meeting**, Western Kentucky University, Bowling Green, Kentucky. (May 2004, p. 576)

19-20 **Twenty-Eighth Annual Texas Partial Differential Equations Conference**, University of Texas, Pan American, Edinburg, Texas. (Oct. 2004, p. 1095)

19-22 **2005 ASL Annual Meeting**, Stanford, California. (Jun/Jul. 2004, p. 692)

21-25 **Extensions of Hilbert's Tenth Problem**, AIM Research Conference Center, Palo Alto, California. (Sept. 2004, p. 970)

21-25 **Workshop on $N=1$ Compactifications**, The Fields Institute, Toronto, Ontario, Canada. (Mar. 2004, p. 361)

22-26 **Conference on Algebra and its Applications, Center of Ring Theory and Its Applications**, Department of Mathematics, Ohio University, Athens, Ohio. (Oct. 2004, p. 1095)

24-27 **Geometric Representation Theory**, University of Arizona, Tucson, Arizona. (Aug. 2004, p. 833)

27-31 **The 3rd International Conference on Sciences of Electronic, Technologies of Information and Telecommunications (SETIT 2005)**, Susa, Tunisia. (Nov. 2004, p. 1264)

28-30 **IMA Tutorial/Workshop: New Paradigms in Computation**, University of Minnesota, Minneapolis, Minnesota. (Jun/Jul. 2004, p. 692)

28-April 1 **Generalized Kostka Polynomials**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2004, p. 692)

* 28-April 1 **Topology and geometry of the moduli space of curves**, AIM Research Conference Center, Palo Alto, California.

Organizers: Ravi Vakil and Ulrike Tillmann.

Workshop topics: This workshop, sponsored by AIM and the NSF, will be devoted to bringing the communities of topologists and algebraic geometers together. The aim is to have an active exchange of results, techniques and ideas on the cohomology of the moduli spaces of curves. Specific topics to be addressed include: Integral cohomology, stable and unstable. Tautological cohomology of the compactified moduli space. Applications to Gromov-Witten theory.

Deadline: December 15, 2004.

Information: <http://aimath.org/ARCC/workshops/modspacecurves.html>.

28-April 1 **Workshop on String Phenomenology**, The Perimeter Institute, Waterloo, Ontario, Canada. (Apr. 2004, p. 461)

29-April 1 **14th International Workshop on Matrices and Statistics**, Massey University, Albany Campus, Auckland, New Zealand. (Nov. 2004, p. 1264)

April 2005

1-July 8 **Special Semester on "Modern Methods of Time-Frequency Analysis"**, Erwin Schroedinger Institute (ESI) for Mathematical Physics, Vienna, Austria. (Apr. 2004, p. 461)

2-3 **AMS Eastern Section Meeting**, University of Delaware, Newark, Delaware. (May 2004, p. 576)

4-8 **Stiff Sources and Numerical Methods for Conservation Laws**, AIM Research Conference Center, Palo Alto, California. (Nov. 2004, p. 1264)

- *4-9 **IPAM Workshop: Astrophysical Fluid Dynamics**, UCLA, Los Angeles, California.
Organizers: Richard Klein, Willy Benz, Philip Colella, James McWilliams, Joseph Monaghan, Michael Norman, Robert Rosner, Chi-Wang Shu, Jim Stone, Marco Velli.
Information: <http://www.ipam.ucla.edu/programs/pcaws1/>.
- 6-10 **Extracting Macroscopic Information from Molecular Dynamics**, Centre de Recherches Mathématiques, Université de Montréal, Montréal, Québec, Canada. (Aug. 2004, p. 833)
- 8-10 **AMS Central Section Meeting**, Texas Tech University, Lubbock, Texas. (May 2004, p. 576)
- *9-10 **Third Annual Graduate Student Topology Conference**, Northwestern University, Evanston, Illinois.
Description: The purpose of this conference is to gather graduate students in topology and provide them the opportunity to give talks, communicate recent advances, exchange new ideas, and meet other students in their field. The schedule will consist of keynote talks by Mike Hopkins (MIT) and Paul Seidel (Univ. Chicago), and many student talks. Talks should be accessible to an audience of graduate students of varying levels and need not be about original research, but simply something the speaker enjoys and wishes to share. We hope to build upon the success of the first conference at Notre Dame University and the second conference at the University of Minnesota.
Keynote Speakers: Mike Hopkins (MIT) and Paul Seidel (Univ. Chicago).
Organizers: Paul Pearson and Valentina Joukhovitski.
Information: <http://www.math.northwestern.edu/~pearson/conference.html>; email: pearsonp@math.northwestern.edu or valka@math.northwestern.edu.
- *10-15 **2005 USENIX Annual Technical Conference**, Marriott Anaheim, Anaheim, California.
Description: USENIX has always been the place to present groundbreaking research and cutting-edge practices in a wide variety of technologies and environments and 2005 is no exception.
Topics: An extensive Training Program; covering crucial topics and led by highly respected instructors; General Session Refereed Papers, discussing original work on topics in modern computing; FREENIX/Open Source Refereed Papers, showcasing the latest developments and interesting applications of open source software; Guru Is In Sessions, where you can ask noted experts your most burning technical questions and get practical solutions.
Information: <http://www.usenix.org/events/usenix05/>.
- 11-15 **IMA Workshop: Atomic Motion to Macroscopic Models: The Problem of Disparate Temporal and Spatial Scales in Matter**, University of Minnesota, Minneapolis, Minnesota. (Jun/Jul. 2004, p. 692)
- 14-15 **DIMACS Workshop on Intellectual Property Protection**, DIMACS Center, Rutgers University, Piscataway, New Jersey. (Jun/Jul. 2004, p. 692)
- 16-17 **AMS Western Section Meeting**, University of California, Santa Barbara, California. (May 2004, p. 576)
- *18-22 **IPAM Workshop: N-body Problems in Astrophysics**, UCLA, Los Angeles, California.
Organizers: Ben Moore, Sverre Aarseth, Willy Benz, Geoff Bryden, Hugh Couchman, Piet Hut, Ben Leimkuhler, Joseph Monaghan, Matthias Steinmetz.
Information: <http://www.ipam.ucla.edu/programs/pcaws2/>.
- 18-July 13 **Time at Work**, Institut Henri Poincaré, Paris, France. (Aug. 2004, p. 833)
- 27-May 1 **Multiscale Modeling in Solids**, Centre de Recherches Mathématiques, Université de Montréal, Montréal, Québec, Canada. (Aug. 2004, p. 834)
- 28-30 **Barrett Lectures: New Developments in Nonlinear Partial Differential Equations**, University of Tennessee, Knoxville, Tennessee. (Sept. 2004, p. 972)
- May 2005**
- 2-6 **IMA Workshop: Experiments in Physical Biology, Part I**, University of Minnesota, Minneapolis, Minnesota. (Jun/Jul. 2004, p. 693)
- *2-6 **IPAM Workshop: Relativistic Astrophysics**, UCLA, Los Angeles, California.
Organizers: Richard Matzner, Curt Cutler, Michael Holst, Richard Klein, Joseph Monaghan, Ewald Mueller, Tsvi Piran, Stuart Shapiro.
Information: <http://www.ipam.ucla.edu/programs/pcaws3/>.
- 2-6 **Workshop on Gravitational Aspects of String Theory**, The Fields Institute, Toronto, Ontario, Canada. (Apr. 2004, p. 461)
- 5-6 **DIMACS Workshop on Security of Web Services and E-Commerce**, DIMACS Center, CoRE Bldg, Rutgers University, Piscataway, New Jersey. (Oct. 2004, p. 1096)
- 6-9 **Statistical Inferences on Shape Manifolds**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2004, p. 693)
- 11-15 **Integrative Multiscale Modeling and Simulation in Materials Science, Fluids and Environmental Science**, Centre de Recherches Mathématiques, Université de Montréal, Montréal, Québec, Canada. (Aug. 2004, p. 834)
- 13-14 **Sixth Mississippi State-UAB Conference on Differential Equations & Computational Simulations**, Mississippi State University, Mississippi State, Mississippi (Oct. 2004, p. 1096)
- 14-15 **Conference in Honor of Heydar Radjavi's 70th Birthday**, Hotel Golf, Bled, Slovenia. (Aug. 2004, p. 834)
- 15-18 **HPCS 2005: The New HPC Culture in Canada, The 19th Annual Symposium on High Performance Computing Systems & Applications**, University of Guelph, Guelph, Ontario, Canada.
- 15-18 **OSCAR'05: The 3rd Annual Symposium on Open Source Cluster Application Resources (OSCAR)**, University of Guelph, Guelph, Ontario, Canada. (Nov. 2004, p. 1264)
- 15-21 **43rd International Symposium on Functional Equations**, Batz-sur Mer, France. (Nov. 2004, p. 1265)
- 15-21 **ICMI Study 15: The Professional Education and Development of Teachers of Mathematics**, Águas de Lindóia, São Paulo, Brazil. (Jun/Jul. 2004, p. 693)
- 16-20 **IMA Workshop: Experiments in Physical Biology, Part II**, University of Minnesota, Minneapolis, Minnesota. (Jun/Jul. 2004, p. 693)
- *16-20 **IPAM Workshop: Transport Phenomena in Computational Astrophysics**, UCLA, Los Angeles, California.
Organizers: Rolf-Peter Kudritzki, Adam Burrows, Jim Morel, Mark Morris, Chi-Wang Shu, William Watson, Harold Yorke
Information: For further information: <http://www.ipam.ucla.edu/programs/pcaws4/>.
- 16-20 **Stability Criteria for Multi-dimensional Waves and Patterns**, AIM Research Conference Center, Palo Alto, California. (Nov. 2004, p. 1265)
- 17-20 **Graph Theory with Altitude**, University of Colorado at Denver, Denver, Colorado. (Jun/Jul. 2004, p. 693)
- 19-21 **CTS Conference on Combinatorics and Its Applications in Honor of Frank K. Hwang's 65th Birthday**, National Chiao Tung University (NCTU), Hsin Chu, Taiwan. (Sept. 2004, p. 973)
- 22-25 **ICCS 2005: International Conference on Computational Science**, Atlanta, Georgia. (Oct. 2004, p. 1096)

23–25 **DIMACS Workshop on The Epidemiology and Evolution of Influenza**, DIMACS Center, CoRE Bldg, Rutgers University, Piscataway, New Jersey. (Oct. 2004, p. 1096)

29–June 3 **5th Conference on Stochastic Analysis, Random Fields and Applications and Minisymposium on Stochastic Methods in Financial Models V**, Centro Stefano Franscini, Ascona, Switzerland. **Confirmed invited speakers:** M. Benaïm (Neuchâtel), T. Komorowski (Lublin), S. Méléard (Paris X), D. Nualart (Barcelone), E. Perkins (Vancouver), B. Prum (Génopole Evry), M. Scheutzow (TU-Berlin), F. Viens (Purdue), N. Bouleau (ENPC Paris), R. Carmona (Princeton), P. Malliavin (Académie des Sciences Paris), W. Schmidt (HfB Frankfurt).

Organizers: R. Dalang (EPF Lausanne), M. Dozzi (Nancy), F. Russo (Paris 13).

Information: Contact: Mrs. E. Gindraux, Institut de Mathématiques, EPFL, CH-1015 Lausanne, Switzerland; email: erika.gindraux@epfl.ch.

June 2005

1–5 **Stochastic Modeling in Financial Mathematics** (joint with SAMSI), Centre de Recherches Mathématiques, Université de Montréal, Montréal, Québec, Canada. (Aug. 2004, p. 834)

4–8 **International Conference on Scientific Computing (ICSC05)**, Nanjing, P. R. China. (Oct. 2004, p. 1096)

6–8 **DIMACS Workshop on Polyhedral Combinatorics of Random Utility**, DIMACS Center, CoRE Bldg, Rutgers University, Piscataway, New Jersey. (Oct. 2004, p. 1096)

6–8 **SEM Annual Conference & Exposition on Experimental and Applied Mechanics**, Marriott Portland Downtown, Portland, Oregon. (May 2004, p. 576)

6–10 **International Mediterranean Congress Of Mathematics Almeria 2005**, Almeria, Spain.

Main Speakers: Fabrizio Catanese (Univ. Bayreuth, Germany), Alfio Quarteroni (E. P. F. Lausanne, Switzerland), Efim Zelmanov (Univ. San Diego, San Francisco, U.S.A.).

Thematic Sessions: Algebras and its Representations, Geometry and Topology, Approximation, Special Functions and Numerical Analysis, Functional Analysis and its Applications, General Topology and its Applications, Probabilistic Spaces, Copulae and T-norms. Applications, Random Models and Design of Experiments, Financial Mathematics and Mathematical Economics, Mathematics Education. **Information:** <http://www.ual.es/congresos/CIMMA2005>.

6–10 **Moduli Spaces of Properly Embedded Minimal Surfaces**, AIM Research Conference Center, Palo Alto, California. (Jun/Jul. 2004, p. 693)

7–10 **SIAM Conference on Mathematical and Computational Issues in the Geosciences**, Palais des Papes, The International Conference Center, Avignon, France. (Nov. 2004, p. 1265)

7–17 **Fields Institute Summer School on Operator Algebras**, University of Ottawa, Ottawa, Ontario, Canada. (Nov. 2004, p. 1265)

* 8–10 **Eleventh Conference on Integer Programming and Combinatorial Optimization (IPCO XI)**, Berlin, Germany.

Deadline: November 15, 2004.

Information: <http://www.math.tu-berlin.de/ipco05>.

8–11 **IMA Workshop: Effective Theories for Materials and Macromolecules**, University of Minnesota, Minneapolis, Minnesota. (Jun/Jul. 2004, p. 693)

12–24 **Foliations 2005**, Lodz, Poland. (Sept. 2004, p. 973)

13–18 **Computational Methods and Function Theory (CMFT 2005)**, Joensuu, Finland. (Feb. 2004, p. 279)

13–25 **CIMPA Summer School AGAHF 2005—Arithmetic and**

Geometry around Hypergeometric Functions, Galatasaray University, Ortakoy, Istanbul, Turkey. (Aug. 2004, p. 834)

16–19 **Second Joint International Meeting with the Deutsche Mathematiker-Vereinigung (DMV) and the Oesterreichische Mathematische Gesellschaft (OMG)**, Mainz, Germany. (May 2004, p. 576)

19–24 **33rd Canadian Operator Symposium (COSy), dedicated to George Elliott's 60th birthday**, University of Ottawa, Ottawa, Ontario, Canada. (Nov. 2004, p. 1265)

19–24 **First Announcement: Conference on Applied Mathematics and Scientific Computing 4: On the occasion of Professor Aganovic's 70th birthday**, Brijuni, Croatia. (Nov. 2004, p. 1265)

19–24 **Conference on Applied Mathematics and Scientific Computing 4: On the occasion of Professor Aganovic's 70th Birthday**, Brijuni, Croatia. (Nov. 2004, p. 1265)

* 20–22 **DIMACS Workshop on Detecting and Processing Regularities in High Throughput Biological Data**, DIMACS Center, CoRE Bldg, Rutgers University, Piscataway, New Jersey.

Description: The biological community is being inundated with a large amount of data and understanding this data is lagging behind the process of acquiring it. It is believed nature has left vital clues hidden in this data and there is a need for techniques and methodologies to work effectively in detecting these. Biological information processing exploits these regularities to gain understanding of the underlying model or phenomenon. The workshop aims to contribute significantly to the research effort by bringing together researchers from the many different groups engaged in biological projects having the study of regularities in the data as an underlying theme.

Organizer: Laxmi Parida, IBM; T. J. Watson Research, email: parida@us.ibm.com.

Local Arrangements: Maria Mercado, DIMACS Center, email: mercado@dimacs.rutgers.edu, 732-445-5928.

Information: <http://dimacs.rutgers.edu/Workshops/Detecting/>.

20–24 **Second Conference on Self-Similarity and Applications**, INSA Toulouse, Toulouse, France. (Aug. 2004, p. 834)

20–25 **Asymptotic and Probabilistic Methods in Geometric Group Theory**, Geneva, Switzerland. (Jun/Jul. 2004, p. 693)

* 20–25 **Title FPSAC'05: 17th Annual Conference on Formal Power Series and Algebraic Combinatorics**, Taormina, Sicily (Italy).

Topics: All aspects of combinatorics and their relations with other parts of mathematics, physics, computer science and biology.

Information: <http://www.unime.it/fpsac05>; email: fpsac05@unime.it.

* 20–26 **Sixth International Conference "Symmetry in Nonlinear Mathematical Physics"**, Institute of Mathematics, National Academy of Sciences of Ukraine, Kyiv (Kiev), Ukraine.

Topics: Symmetries of differential equations, Integrable and super-integrable systems, Symbolic computations in symmetry analysis, Dynamical systems, solitons, Supersymmetry and its generalizations, Quantum field theory, Lie groups and algebras, representation theory and special functions, q-algebras, quantum groups and non-commutative geometry, Gravitation, cosmology, quantum gravity, Condensed matter and statistical physics, Nonlinear phenomena and quantum chaos.

Deadline: May 20, 2005.

Information: Conference address: Anatoly Nikitin; Institute of Mathematics, National Academy of Sciences of Ukraine, 3 Tereshchenkivska Street, Kyiv 4, 01601 Ukraine; <http://www.imath.kiev.ua/~appmath/conf.html>; email: appmath@imath.kiev.ua; fax: +38 044 235 20 10; phone: +38 044 234 63 22 (office); +38 044 250 08 96 (home).

20–July 8 (REVISED) **Random matrices, random processes, and integrable systems (C.R.M. Short Program)**, Centre de recherches mathématiques, Université de Montréal, Montréal. (Nov. 2004, p. 1265)

20–August 15 **Computational Prospects of Infinity**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Jun/Jul. 2004, p. 693)

21–24 **MAM 5—Fifth International Conference on Matrix Analytic Methods in Stochastic Models**, Pisa, Italy. (Sept. 2004, p. 974)

*26–29 **12th International Linear Algebra Society Conference**, Regina Inn Hotel and Conference Centre, Regina, Canada.
Aim and Scope: The 2005 ILAS Conference in Regina will bring together an international group of researchers to present recent accounts of their work, to discuss advances in all aspects of linear algebra and its applications, to promote and foster new directions for research, and to provide a forum to ensure that linear algebra remains a prominent and respected discipline within mathematics.
Deadlines: Abstract submission: May 1, 2005; Registration: May 25, 2005; Accommodation reservation: May 25, 2005.
Organizers: S. Fallat, D. Farenick, C-H. Guo, S. Kirkland. Scientific Organizers: R. Bhatia, R. Guralnick, D. Hershkowitz, S. Kirkland, V. Mehrmann, B-S. Tam, P. van den Driessche, H. Wolkowicz.
Information: <http://www.math.uregina.ca/~ilas2005/>; email: ilas2005@math.uregina.ca.

*26–29 **The Twentieth IEEE Symposium on Logic In Computer Science (LICS 2005): Call for Workshop Proposals**, Chicago, Illinois.

Topic proposals: Researchers and practitioners are invited to submit proposals for workshops on topics relating logic - broadly construed - to computer science or related fields. Typically, LICS workshops feature a number of invited speakers and a smaller number of contributed presentations. Proposals should include: A short scientific summary and justification of the proposed topic. This should include a discussion of the particular benefits of the topic to the LICS community. A discussion of the proposed format and agenda and the proposed duration, which may vary from half a day to two days, and preferred dates. Procedures for selecting participants and papers. Expected number of participants. Potential invited speakers. Plans for dissemination (for example, special issues of journals). Please note that it is expected that LICS workshop organizers should be present to run their workshops. It is also assumed that normally workshop organizers (though not necessarily participants) will register for the LICS conference.
Workshop Dates: June 25, 2005 and June 30–July 1, 2005.
Proposal deadline: November 15, 2004 and should be submitted electronically to: Philip Scott, Workshops Chair, LICS 2005; email: phil@site.uottawa.ca.

26–July 1 **ERLOGOL-2005: Intermediate Problems of Model Theory and Universal Algebra**, State Technical University/Mathematics Institute, Novosibirsk, Russia. (Jun/Jul. 2004, p. 694)

26–July 1 **30th Conference on Stochastic Processes and Their Applications**, University of California at Santa Barbara (UCSB), Santa Barbara, California. (Jun/Jul. 2004, p. 694)

*28–July 1 **DAYS ON DIFFRACTION-2005**, St. Petersburg Branch of Steklov's Math. Inst. and St. Petersburg Univ., St. Petersburg, Russia.
Workshop Topics: All topics related to mathematical aspects of wave propagation, scattering and diffraction.
Organizers: Prof. V. M. Babich (PDMI), Prof. V. S. Buldyrev (SPBU), Euler Int. Math. Inst.
Deadlines: Abstract submission by March 1, 2005.
Information: <http://math.nw.ru/DD/>.

July 2005

2–7 **SRTL-4: The Fourth International Research Forum on Statistical Reasoning, Thinking, and Literacy**, The University of

Auckland, Auckland, New Zealand. (Jun/Jul. 2004, p. 694)

2–9 **Mile High Conference on Quasigroups, Loops and Nonassociative Systems**, University of Denver, Denver, Colorado. (Nov. 2004, p. 1266)

3–9 **XXIVèmes Journées Arithmétiques**, Marseilles, France. (Sept. 2004, p. 975)

*4–8 **8th International Symposium on "Generalized Convexity and Monotonicity"**, Insubria University, Varese, Italy.
Topics: Generalized convexity of functions and sets, generalized monotonicity of maps, and their applications to mathematical programming, economics, management science, engineering, stochastics, variational inequalities, etc.
Program Committee: N. Hadjisavvas (Chair), A. Cambini, R. Cambini, A. Guerraggio, D.T. Luc, L. Martein, J.E. Martinez-Legaz, A. Rubinov, S. Schaible, X.Q. Yang.
Organizing Committee: A. Guerraggio (Chair), N. Hadjisavvas, E. Allevi, M. Bianchi, G. Crespi, G. Giorgi, A. Gnudi, D. La Torre, E. Miglierina, E. Molho, L. Pellegrini, R. Pini, M. Rocca, A. Setti.
Deadlines: Early registration: March 31, 2005. Late registration: May 31, 2005. Title and abstract of talks: May 31, 2005. Submission of manuscripts for publication in the Symposium Proceedings: September 30, 2005.
Information: <http://www.eco.uninsubria.it/gcm8>.

*4–8 **Conference on Universal Algebra and Lattice Theory**, University of Szeged, Szeged, Hungary.

Topics: The program of the conference will consist of 30 minute invited and 20 minute contributed talks within the scope of universal algebra and lattice theory. Presentations on algorithmic aspects such as decidability and complexity questions related to algebras and lattices are especially welcome.
Organizers: Laszlo Zadori, Gabor Czédli Bolyai Institute, University of Szeged.

Invited Speakers: Ralph Freese (University of Hawaii, Honolulu), George Grätzer (University of Manitoba, Winnipeg), Keith A. Kearnes (University of Colorado, Boulder), Emil W. Kiss (Eötvös Loránd University, Budapest), Benoit Larose (Concordia University, Montreal), Ralph N. McKenzie (Vanderbilt University, Nashville), Matthew A. Valeriote (McMaster University, Hamilton), Friedrich Wehrung (Université de Caen, Caen), Ross Willard (University of Waterloo, Waterloo).

Information: <http://www.math.u-szeged.hu/confer/algebra/>.

9–11 **Joint Meeting of the Chinese Society of Probability and Statistics (CSPS) and the Institute of Mathematical Statistics (IMS)**, Beijing, China. (Aug. 2004, p. 834)

10–14 **12th International Conference on Mathematical Modelling and Applications (ICTMA12)**, City University, London, England. (Jan. 2004, p. 64)

10–15 **20th British Combinatorial Conference**, University of Durham, United Kingdom. (Sept. 2004, p. 975)

10–15 **SampTA05 (Sampling Theory and applications)**, Ondokuz Mayıs University Samsun, Turkey. (Nov. 2004, p. 975)

10–16 **Stochastic Modelling of Complex Systems (SMOCS-05)**, Daydream Island resort (Whitsundays, Queensland, Australia). (Nov. 2004, p. 1266)

10–23 **Cornell Summer School in Probability**, Cornell University, Ithaca, New York. (Aug. 2004, p. 834)

*11–14 **Sixth SIAM Conference on Control and its Applications**, Hilton New Orleans Riverside Hotel, New Orleans, Louisiana.
Topics: This conference, which will be held jointly with the 2005 SIAM Annual Meeting, will showcase a wide range of topics in control and systems theory. The topics and applications include real-time optimization and data assimilation, cellular and biological regulation, control techniques for financial mathematics, cooperative control for unmanned autonomous vehicles, biomedical control,

risk sensitive control and filtering, control of smart systems, flow control and quantum control.

Information: <http://www.siam.org/meetings/ct05/>.

11–15 Gravitational Lensing in the Kerr Spacetime Geometry, AIM Research Conference Center, Palo Alto, California. (Nov. 2004, p. 1266)

11–16 Strings 2005, Toronto, University of Toronto, Toronto, Ontario, Canada. (Nov. 2004, p. 1266)

18–22 Algorithms for Approximation V, University College, Chester, UK. (Nov. 2004, p. 1266)

20–27 The 5th International Algebraic Conference in Ukraine, Odessa I. I. Mechnikov National University, Odessa, Ukraine. (Nov. 2004, p. 1266)

24–28 25th European Meeting of Statisticians, University of Oslo, Oslo, Norway.

Scientific Programme: The meeting will cover all areas of methodological, applied and computational statistics, probability theory and applied probability. There will be 8 special lecturers, 23 ordinary invited sessions and one invited discussion session.

Organizer: Arnaldo Frigessi, Chairman of the Local Organising Committee; email: arnaldo.frigessi@medisin.uio.no. The meeting is organised jointly by the University of Oslo and the Norwegian Computing Center.

Scientific Programme Committee: Aad van der Vaart, chair (Amsterdam), Ornulf Borgan (Oslo), Ursula Gather (Dortmund), Sylvia Richardson (London), Gareth Roberts (Lancaster), Tomasz Rolski (Wrocław), Jeffrey Steif (Göteborg).

Registration: Registration to the conference and booking of accommodation must be made via <http://www.ems2005.no>.

Conference Dates and Deadlines: Deadline for grant application is March 1, 2005. Deadline for submission of contributed papers and poster: March 31, 2005. Deadline for early registration: May 1, 2005. Deadline for conference registration: June 30, 2005.

Contact information: EMS 2005, P.O. Box 114 Blindern, N-0314 Oslo, Norway; email: ems2005@nr.no; fax: (+47) 22 69 76 60.

25–29 IMA Workshop: Mixed Integer Programming, University of Minnesota, Minneapolis, Minnesota. (Jun/Jul. 2004, p. 694)

28–August 3 Logic Colloquium '05: ASL European Summer Meeting, Athens, Greece. (Oct. 2004, p. 1097)

August 2005

1–December 23 Pattern Formation in Large Domains, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2004, p. 834)

3–5 DIMACS Workshop on Yield Management and Dynamic Pricing, DIMACS Center, CoRE Bldg, Rutgers University, Piscataway, New Jersey.

Organizers: James Dana, Northwestern University, email: j-dana@kellogg.northwestern.edu; Brenda Dietrich, IBM Watson Labs, email: dietric@watson.ibm.com.

Local Arrangements: Maria Mercado, DIMACS Center, email: mercado@dimacs.rutgers.edu, 732-445-5928.

Information: <http://dimacs.rutgers.edu/Workshops/Yield/>.

7–12 International Conference: Mathematics in Finance, Kruger National Park, South Africa.

Hosts: Hosted jointly by Potchefstroom University for CHE, The University of Pretoria and The University of the Witwatersrand.

Focus: Topics that would be covered include among others: Stochastic models, Modern methods of risk analysis, Quantitative and computational models and methods, Methods of financial mathematics; in particular the role of measure theory, functional analysis and modern stochastics in Finance.

Information: email: mfinance@cam.wits.ac.za.

8–13 XX Nevanlinna Colloquium, ETH Lausanne, Lausanne, Switzerland. (Nov. 2004, p. 1266)

8–December 23 Global Problems in Mathematical Relativity, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2004, p. 834)

October 2005

* **8–9 AMS Eastern Section Meeting**, Bard College, Annandale-on-Hudson, New York.

Information: <http://www.ams.org/amsmtgs/sectional.html>.

* **15–16 AMS Southeastern Section Meeting**, East Tennessee State University, Johnson City, Tennessee.

Information: <http://www.ams.org/amsmtgs/sectional.html>.

* **21–22 AMS Central Section Meeting**, University of Nebraska, Lincoln, Nebraska.

Information: <http://www.ams.org/amsmtgs/sectional.html>.

November 2005

* **12–13 AMS Western Section Meeting**, University of Nebraska, University of Oregon, Eugene, Oregon.

Information: <http://www.ams.org/amsmtgs/sectional.html>.

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.

December 2005

* **14–18 First Joint International Meeting with the Taiwanese Mathematical Society**, Taiwan, Taiwan.

Information: <http://www.ams.org/amsmtgs/internmtgs.html>.

* **15–17 International Conference on Computer & Information Science (ICIS'2005)**, Fort Panhala, Kolhapur, India.

Aim: To provide a platform for academics and professionals in computer science and information technology to meet, communicate, exchange ideas, and establish professional networks.

Sponsors: Technomathematics Research Foundation, India.

Important Dates: Full paper due: April 20, 2005. Proposals for tutorials and sessions due: February 20, 2005. Notification of acceptance: June 15th, 2005. Camera-ready paper with registration fee due: July 20, 2005.

Information: http://pune.sancharnet.in/kpr_tmrf/iccis05.html.

* **15–19 Conference on Low-dimensional Topology**, University of Virginia, Charlottesville, Virginia.

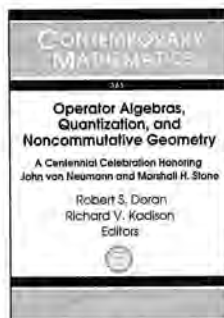
Objective: To bring together researchers working on different aspects of low-dimensional topology, including Floer homology, the Ricci flow program, and more "classical" geometric topology, with the goal of looking for connections and unifying perspectives. A theme in several of these areas is that subtle relationships between a 4-manifold and its boundary constrain and illuminate both 3- and 4-dimensional topology. We propose this as a framework for comparing existing approaches and formulating key problems.

Organizers: Slava Krushkal (Univ. Va), Frank Quinn (Virginia Tech).

Information: <http://www.math.virginia.edu/topology/>.

New Publications Offered by the AMS

Analysis



Operator Algebras, Quantization, and Noncommutative Geometry

A Centennial Celebration Honoring John von Neumann and Marshall H. Stone

Robert S. Doran, *Texas Christian University, Fort Worth, TX*, and Richard V. Kadison, *University of Pennsylvania, Philadelphia, PA*, Editors

John von Neumann and Marshall Stone were two giants of Twentieth Century mathematics. In honor of the 100th anniversary of their births, a mathematical celebration was organized featuring developments in fields where both men were major influences.

This volume contains articles from the AMS Special Session, Operator Algebras, Quantization and Noncommutative Geometry: A Centennial Celebration in Honor of John von Neumann and Marshall H. Stone. Papers range from expository and historical surveys to original research articles. All articles were carefully refereed and cover a broad range of mathematical topics reflecting the fundamental ideas of von Neumann and Stone.

Most contributions are expanded versions of the talks and were written exclusively for this volume. Included, among others, are articles by George W. Mackey, Nigel Higson, and Marc Rieffel. Also featured is a reprint of P.R. Halmos's *The Legend of John von Neumann*.

The book is suitable for graduate students and researchers interested in operator algebras and applications, including noncommutative geometry.

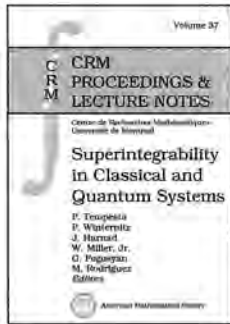
This item will also be of interest to those working in mathematical physics.

Contents: P. R. Halmos, The legend of John von Neumann; *Photo of stone:* G. W. Mackey, Marshall H. Stone: Mathematician, statesman, advisor, and friend; W. Arveson, The universal A -dynamical system; P. Baum, On the index of equivariant elliptic operators; B. Blackadar, The algebraization of dynamics: Amenability, nuclearity, quasidiagonality, and approximate finite dimensionality; D. P. Blecher, Multipliers, C^* -modules, and algebraic structure in spaces of Hilbert space operators; N. Higson, Meromorphic continuation of zeta functions associated to elliptic operators; R. V. Kadison, Noncommutative conditional expectations and their applications; Y. Katayama and M. Takesaki, Outer actions of a discrete amenable group on approximately finite dimensional factors I: General theory; P. S. Muhly and B. Solel, On the curvature of a completely positive map; J. A. Packer, Applications of the work of Stone and von Neumann to wavelets; R. T. Powers, Addition of spatial E_0 -semigroups; G. L. Price, On shifts of minimal index on the hyperfinite II_1 factor; M. A. Rieffel, Compact quantum metric spaces; J. Rosenberg, A selective history of the Stone-von Neumann theorem; M. Junge and Z.-J. Ruan, Decomposable maps on non-commutative L_p -spaces; A. M. Sinclair and R. R. Smith, A survey of Hochschild cohomology for von Neumann algebras; D. P. Williams, From the Stone-von Neumann theorem to the equivariant Brauer group and beyond.

Contemporary Mathematics, Volume 365

December 2004, 422 pages, Softcover, ISBN 0-8218-3402-9, LC 2004054245, 2000 *Mathematics Subject Classification:* 01A70, 19K56, 22D25, 46L05, 46L07, 46L10, 46L53, 46L65, 46L87, 58B34, 58J22, 81R05, All AMS members \$87, List \$109, Order code CONM/365N

Differential Equations



Superintegrability in Classical and Quantum Systems

P. Tempesta, *Scuola Superiore Internazionale, Trieste, Italy*, **P. Winternitz** and **J. Harnad**, *University of Montréal, QC, Canada*, **W. Miller, Jr.**, *University of Minnesota, Minneapolis, MN*, **G. Pogosyan**,

Joint Institute of Theoretical Physics, Moscow, Russia, and **M. Rodríguez**, *Universidad Complutense de Madrid, Spain*, Editors

Superintegrable systems are integrable systems (classical and quantum) that have more integrals of motion than degrees of freedom. Such systems have many interesting properties. This proceedings volume grew out of the Workshop on Superintegrability in Classical and Quantum Systems organized by the Centre de recherches mathématiques in Montréal (Quebec). The meeting brought together scientists working in the area of finite-dimensional integrable systems to discuss new developments in this active field of interest.

Properties possessed by these systems are manifold. In classical mechanics, they have stable periodic orbits (all finite orbits are periodic). In quantum mechanics, all known superintegrable systems have been shown to be exactly solvable. Their energy spectrum is degenerate and can be calculated algebraically. The spectra of superintegrable systems may also have other interesting properties, for example, the saturation of eigenfunction norm bounds.

Articles in this volume cover several (overlapping) areas of research, including:

- Standard superintegrable systems in classical and quantum mechanics.
- Superintegrable systems with higher-order or nonpolynomial integrals.
- New types of superintegrable systems in classical mechanics.
- Superintegrability, exact and quasi-exact solvability in standard and PT-symmetric quantum mechanics.
- Quantum deformation, Nambu dynamics and algebraic perturbation theory of superintegrable systems.
- Computer assisted classification of integrable equations.

The volume is suitable for graduate students and research mathematicians interested in integrable systems.

This item will also be of interest to those working in mathematical physics.

Contents: **Á. Ballesteros**, **F. J. Herranz**, **F. Musso**, and **O. Ragnisco**, Superintegrable deformations of the Smorodinsky–Winternitz Hamiltonian; **F. Calogero** and **J.-P. Francoise**, Isochronous motions galore: Nonlinearly coupled oscillators with lots of isochronous solutions; **T. L. Curtright** and **C. K. Zachos**, Nambu dynamics, deformation quantization, and superintegrability; **C. Gonera**, Maximally superintegrable systems of Winternitz type; **S. Gravel**, Cubic integrals of motion and quantum superintegrability; **J. Harnad** and **O. Yermolayeva**, Superintegrability, Lax matrices and separation of variables; **F. J. Herranz**, **Á. Ballesteros**, **M. Santander**, and **T. Sanz-Gil**, Maximally superintegrable Smorodinsky–Winternitz systems on the N -dimensional sphere and hyperbolic spaces; **A. Kokotov** and **D. Korotkin**, Invariant Wirtinger projective connection and Tau-functions on spaces of branched coverings; **L. G. Mardoyan**, Dyon-oscillator duality. Hidden symmetry of the Yang-Coulomb monopole; **P. Desrosiers**, **L. Lapointe**, and **P. Mathieu**, Supersymmetric Calogero-Moser-Sutherland models: Superintegrability structure and eigenfunctions; **W. Miller, Jr.**, Complete sets of invariants for classical systems; **A. G. Nikitin**, Higher-order symmetry operators for Schrödinger equation; **A. V. Penskoï**, Symmetries and Lagrangian time-discretizations of Euler equations; **L. G. Mardoyan**, **G. S. Pogosyan**, and **A. N. Sissakian**, Two exactly-solvable problems in one-dimensional quantum mechanics on circle; **M. F. Rañada** and **M. Santander**, Higher-order superintegrability of a rational oscillator with inversely quadratic nonlinearities: Euclidean and non-Euclidean cases; **F. Finkel**, **D. Gómez-Ullate**, **A. González-López**, **M. A. Rodríguez**, and **R. Zhdanov**, A survey of quasi-exactly solvable systems and spin Calogero–Sutherland models; **M. Sheftel**, On the classification of third-order integrals of motion in two-dimensional quantum mechanics; **R. G. McLenaghan**, **R. G. Smirnov**, and **D. The**, Towards a classification of cubic integrals of motion; **K. Takasaki**, Integrable systems whose spectral curves are the graph of a function; **P. Tempesta**, On superintegrable systems in E_2 : Algebraic properties and symmetry preserving discretization; **A. V. Turbiner**, Perturbations of integrable systems and Dyson-Mehta integrals; **Y. Uwano**, Separability and the Birkhoff-Gustavson normalization of the perturbed harmonic oscillators with homogeneous polynomial potentials; **J. Bérubé** and **P. Winternitz**, Integrability and superintegrability without separability; **T. Wolf**, Applications of CRACK in the classification of integrable systems; **G. A. Grünbaum** and **M. Yakimov**, The prolate spheroidal phenomenon as a consequence of bispectrality; **O. Yermolayeva**, On a trigonometric analogue of Atiyah-Hitchin bracket; **A. Zhalij** and **R. Zhdanov**, Separation of variables in time-dependent Schrödinger equations; **M. Znojil**, New types of solvability in PT symmetric quantum theory.

CRM Proceedings & Lecture Notes, Volume 37

December 2004, 347 pages, Softcover, ISBN 0-8218-3329-4, 2000 *Mathematics Subject Classification*: 81-06, 81R12, 37J15, 22E70, All AMS members \$87, List \$109, Order code CRMP/37N

General Interest



Combined Membership List 2004-2005

The *Combined Membership List* (CML) is a comprehensive directory of the membership of the American Mathematical Society, the American Mathematical Association of Two-Year Colleges, the Association for Women in Mathematics, the Canadian Mathematical Society, the Mathematical

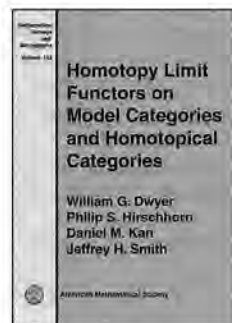
Association of America, and the Society for Industrial and Applied Mathematics.

It includes a complete alphabetical list of all individual members in all six organizations. For each member, the CML provides an address, title, department, institution, telephone number (if available), and electronic address (if provided) and also indicates membership in the six participating societies. In addition, the CML lists academic, institutional, and corporate members of the six participating societies providing addresses and telephone numbers of mathematical sciences departments.

The CML is an invaluable reference for keeping in touch with colleagues and for making connections in the mathematical sciences community in the United States and abroad.

December 2004, 336 pages, Softcover, ISBN 0-8218-3620-X, **Individual member \$42**, List \$70, Institutional member \$56, Order code CML/2004/2005N

Geometry and Topology



Homotopy Limit Functors on Model Categories and Homotopical Categories

William G. Dwyer, *University of Notre Dame, IN*, Philip S. Hirschhorn, *Wellesley College, MA*, Daniel M. Kan, *Massachusetts Institute of Technology, Cambridge, MA*, and Jeffrey H. Smith, *Purdue University, West Lafayette, IN*

The purpose of this monograph, which is aimed at the graduate level and beyond, is to obtain a deeper understanding of Quillen's model categories. A model category is a category together with three distinguished classes of maps, called weak equivalences, cofibrations, and fibrations. Model categories have become a standard tool in algebraic topology and homological algebra and, increasingly, in other fields where

homotopy theoretic ideas are becoming important, such as algebraic K -theory and algebraic geometry.

The authors' approach is to define the notion of a homotopical category, which is more general than that of a model category, and to consider model categories as special cases of this. A homotopical category is a category with only a single distinguished class of maps, called weak equivalences, subject to an appropriate axiom. This enables one to define "homotopical" versions of such basic categorical notions as initial and terminal objects, colimit and limit functors, cocompleteness and completeness, adjunctions, Kan extensions, and universal properties.

There are two essentially self-contained parts, and part II logically precedes part I. Part II defines and develops the notion of a homotopical category and can be considered as the beginnings of a kind of "relative" category theory. The results of part II are used in part I to obtain a deeper understanding of model categories. The authors show in particular that model categories are homotopically cocomplete and complete in a sense stronger than just the requirement of the existence of small homotopy colimit and limit functors.

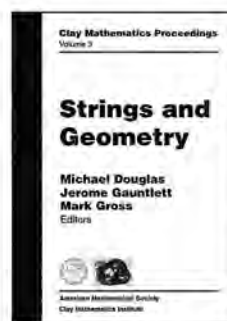
A reader of part II is assumed to have only some familiarity with the above-mentioned categorical notions. Those who read part I, and especially its introductory chapter, should also know something about model categories.

Contents: *Model categories:* An overview; Model categories and their homotopy categories; Quillen functors; Homotopical cocompleteness and completeness of model categories; *Homotopical categories:* Summary of part II; Homotopical categories and homotopical functors; Deformable functors and their approximations; Homotopy colimit and limit functors and homotopical ones; Index; Bibliography.

Mathematical Surveys and Monographs, Volume 113

December 2004, 181 pages, Hardcover, ISBN 0-8218-3703-6, LC 2004059481, 2000 *Mathematics Subject Classification:* 18A99, 18D99, 18G55, 55U35, All AMS members \$47, List \$59, Order code SURV/113N

Mathematical Physics



Strings and Geometry

Michael Douglas, *Rutgers University, Piscataway, NJ*, Jerome Gauntlett, *University of London, England*, and Mark Gross, *University of California San Diego, La Jolla, CA*, Editors

This volume is the proceedings of the 2002 Clay Mathematics Institute School on Geometry and String Theory. This month-long program was held at the Isaac Newton Institute for Mathematical Sciences in Cambridge, England, and was organized by both mathematicians and physicists: A. Corti, R. Dijkgraaf, M. Douglas, J. Gauntlett, M. Gross, C. Hull, A. Jaffe and M. Reid. The early part of the school had many lectures that introduced various concepts of algebraic geometry and string

theory with a focus on improving communication between these two fields. During the latter part of the program there were also a number of research level talks.

This volume contains a selection of expository and research articles by lecturers at the school and highlights some of the current interests of researchers working at the interface between string theory and algebraic geometry. The topics covered include manifolds of special holonomy, supergravity, supersymmetry, D-branes, the McKay correspondence and the Fourier-Mukai transform.

The book is suitable for graduate students and research mathematicians interested in relations between mathematical physics and algebraic geometry.

This item will also be of interest to those working in algebra and algebraic geometry.

Titles in this series are published by the AMS for the Clay Mathematics Institute (Cambridge, MA).

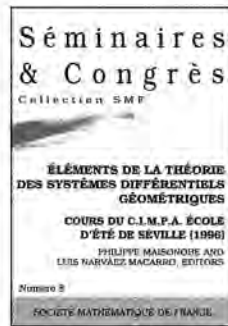
Contents: M. R. Douglas, The geometry of string theory; B. S. Acharya, M theory, G_2 -manifolds and four dimensional physics; S. K. Donaldson, Conjectures in Kähler geometry; J. P. Gauntlett, Branes, calibrations and supergravity; S. Gukov, M-theory on manifolds with exceptional holonomy; N. Hitchin, Special holonomy and beyond; D. Joyce, Constructing compact manifolds with exceptional holonomy; A. Kovalev, From Fano threefolds to compact G_2 -manifolds; A. Craw, An introduction to motivic integration; A. Ishii, Representation moduli of the McKay quiver for finite Abelian subgroups of $SL(3, \mathbb{C})$; F. Kirwan, Moduli spaces of bundles over Riemann surfaces and the Yang-Mills stratification revisited; C. Madonna and V. V. Nikulin, On a classical correspondence between K3 surfaces II; B. Szendrői, Contractions and monodromy in homological mirror symmetry; N. Dorey, Lectures on supersymmetric gauge theory; A. Kapustin, The geometry of A-branes; R. C. Myers, Low energy D-brane actions; List of Participants.

Clay Mathematics Proceedings, Volume 3

January 2005, approximately 384 pages, Softcover, ISBN 0-8218-3715-X, 2000 *Mathematics Subject Classification*: 81T30, 83E30, 53C29, 32Q25, 14J32, 83E50, 14E15, 53C80, 32S45, 14D20. All AMS members \$55. List \$69, Order code CMIP/3N

New AMS-Distributed Publications

Algebra and Algebraic Geometry



Éléments de la théorie des systèmes différentiels géométriques

Cours du C.I.M.P.A. École d'été de Séville (1996)

Philippe Maisonobe,
Université de Nice, France, and
Luis Narváez Macarro,

Universidad de Sevilla, Spain, Editors

The theory of geometric differential systems consists of the study of coherent modules on the ring of differential operators on a complex analytic or algebraic manifold. It is used in various branches of mathematics: algebraic geometry, arithmetic, Lie groups and Lie algebras, algebraic topology of singularities, etc. This book contains articles from lectures given at the Centre International de Mathématiques Pures et Appliquées (C.I.M.P.A.) summer school. It offers a complete survey of the theory, taking into account the most recent advances.

The volume is suitable for graduate students and researchers interested in algebra and algebraic geometry.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Ph. Maisonobe and T. Torrelli, Image inverse en théorie des \mathcal{D} -modules; L. N. Macarro, The local duality theorem in \mathcal{D} -module theory; F. J. Castro-Jiménez and M. Granger, Explicit calculations in rings of differential operators; L. N. Macarro and A. R. León, Continuous division of linear differential operators and faithful flatness of \mathcal{D}_X^n over \mathcal{D}_X ; J. Briançon, Extensions de Deligne pour les croisements normaux; Z. Mebkhout, Le théorème de positivité, le théorème de comparaison et le théorème d'existence de Riemann; Ph. Maisonobe and Z. Mebkhout, Le théorème de comparaison pour les cycles évanescents; B. Malgrange, On irregular holonomic \mathcal{D} -modules; Y. Laurent, Geometric irregularity and \mathcal{D} -modules.

Séminaires et Congrès, Number 8

July 2004, 430 pages, Softcover, ISBN 2-85629-151-1, 2000 *Mathematics Subject Classification*: 12-XX, 13N10, 13P10, 14Bxx, 16S32, 32C38, 32S40, 32S60, 35A27, 35N10, **individual member \$94**, List \$104, Order code SECO/8N

Classified Advertisements

Positions available, items for sale, services available, and more

ALABAMA

UNIVERSITY OF ALABAMA AT BIRMINGHAM Department of Mathematics

Applications are invited for two tenure-track positions at the level of assistant professor or higher to begin August 15, 2005. Applicants should have demonstrated strong potential in research and a commitment to excellent teaching. Post-doc experience is desirable. Candidates whose research is compatible with the department's research expertise - which lies in differential equations, differential geometry, dynamical systems, mathematical physics and topology and includes the computational aspects of these research areas - are encouraged to apply. We are especially interested in applicants with expertise in geometric or harmonic analysis, inverse problems, or numerical analysis. Applications should include a curriculum vita with publication list, a statement of future research plans, and at least three letters of recommendation. The AMS Standard Cover Sheet should be completed online at <http://www.mathjobs.org>. Applicants are encouraged to submit all their materials electronically at <http://www.mathjobs.org>. Review of applications will begin December 1, 2004. For more information about the department please visit

<http://www.math.uab.edu>. UAB is an AA/EO employer.

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UNIVERSITY OF ALABAMA IN HUNTSVILLE

Department of Mathematical Sciences

The Department of Mathematical Sciences at the University of Alabama in Huntsville invites applications for a tenure-track position at the rank of assistant professor, beginning spring semester 2005 or fall semester 2005. In exceptional cases, more advanced appointments may be considered. A Ph.D. degree in mathematics or applied mathematics is required. Applicants must have a strong commitment to teaching and show evidence of excellent teaching ability. Applicants should also show evidence of outstanding research potential in an area that matches the interests of the department. Preference will be given to applicants whose research areas are probability/stochastic processes or numerical analysis. Applicants should send a curriculum vita with the AMS standard cover sheet, transcripts, and three letters of recommendation (with at least one letter addressing teaching) to Chairman, Department of Mathematical Sciences, University of Alabama in Huntsville, Huntsville, AL 35899. For more information about the department, visit our web site at <http://www.math.uah.edu>. To ensure full

consideration, all materials should be received by November 1, 2004. Late applications will be reviewed until the position is closed. Women and minorities are encouraged to apply. The University of Alabama in Huntsville is an Affirmative Action, Equal Opportunity Institution.

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CALIFORNIA

CALIFORNIA INSTITUTE OF TECHNOLOGY Department of Mathematics

The Division of Physics, Mathematics and Astronomy at the California Institute of Technology invites applications for a possible tenure-track position in mathematics at the assistant professor level. We are particularly interested in the following research areas: algebraic geometry/number theory, analysis/dynamics, combinatorics, finite and algebraic groups, geometry/topology, logic/set theory, and mathematical physics, but other fields may be considered. The term of the initial appointment is normally four years for a tenure-track assistant professor (with a possible to extension to as much as seven years). Appointment is contingent upon completion of the Ph.D. Exceptional candidates may also be considered at the associate or full professor level. We are

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 2004 rate is \$100 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. 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: January 2005 issue-October 28, 2004; February 2005 issue-November 22, 2004;

March 2005 issue-December 29, 2004; April 2005 issue-January 28, 2005; May 2005 issue-February 25, 2005; June/July 2005 issue-April 27, 2005.

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 02904. Advertisers will be billed upon publication.

seeking highly qualified applicants who are committed to a career in research and teaching. Applicants should write promptly to: SEARCH COMMITTEE, Mathematics 253-37, California Institute of Technology, Pasadena, CA 91125. Please include curriculum vitae, list of publications with those publications appearing in refereed journals so noted, description of research, and ensure that at least three letters of recommendation be sent to the above address. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

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**CALIFORNIA STATE UNIVERSITY
LOS ANGELES
Department of Mathematics**

Inquiries are invited for a possible tenure-track position in mathematics at the level of assistant professor, starting June or September 2005. A Ph.D. in mathematics (algebra/number theory) from an accredited institution of higher education is required. Ability to teach a range of undergraduate mathematics classes is essential. Publications in peer reviewed journals and/or grant activity is required for tenure/promotion. CSULA is on the quarter system. Send letter of application, vita, three letters of recommendation and official transcript from institution awarding doctorate to Dr. P. K. Subramanian, Chair, Department of Mathematics, California State University at Los Angeles, 5151 State University Drive, Los Angeles, CA 90032. An Equal Opportunity, Title IX, Disabled, Employer.

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**CALIFORNIA STATE UNIVERSITY
NORTHRIDGE
Department of Mathematics**

The Department of Mathematics invites applications for a tenure-track appointment at the assistant or associate professor level effective Fall 2005. This position is affiliated with Teachers for a New Era (TNE), an initiative funded in part by the Carnegie Corporation of New York. For more information, please visit <http://tne.csun.edu>.

Qualifications: A doctorate in the mathematical sciences or in education with significant experience in mathematics. We also value experience teaching K-12 mathematics, managing and developing teacher preparation programs, familiarity with issues in mathematical education, including standards and classroom practices, and any other expertise in preparing students to be successful classroom teachers. Potential for publication in mathematical education is expected. At the time of the appointment, the successful applicant, if not a U.S. citizen, must have authorization from the Bureau of Citizenship and

Immigration Services to work in the United States.

Responsibilities: the successful candidate will assume an active role in: (1) Student advisement for prospective teachers; (2) Teaching, designing and collaborating on courses for pre-service teachers; (3) Creating and maintaining partnerships with colleagues in the College of Education and mathematics teachers at local schools, including the new Los Angeles Unified School District high school just opened on the CSUN campus; (4) Grant activities to support K-12 projects in the department; (5) Participating in the Carnegie initiative; (6) Continuing scholarly activities in research and publication in mathematics education; (7) A long-term commitment to K-12 mathematics education. Applicants should send a vita, the AMS standard cover sheet, and three letters of recommendation, one of them addressing the candidate's teaching abilities, to the Hiring Committee, Department of Mathematics, CSUN, Northridge, CA 91330-8313. Review of applications will begin on January 15, 2005, and continue until a candidate is appointed or the search is terminated. Email (inquiries only) math.hiring1@csun.edu. California State University is an Equal Opportunity, Affirmative Action employer.

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**HARVEY MUDD COLLEGE
Department of Mathematics**

Harvey Mudd College invites applications for a tenure-track position in statistics, biostatistics, or related statistical fields. The rank will be at the assistant or associate professor level. Excellence in teaching is essential, as is evidence of a strong and ongoing research program. Preference will be given to candidates familiar with modern data analysis techniques with cross-disciplinary interests. Candidates must be willing to supervise undergraduate research and work with others in departmental programs, such as the recently created mathematical biology major or the industrial projects-based clinic program.

Harvey Mudd College is a highly selective undergraduate institution of science, engineering and mathematics; the median SAT score is about 1470, a quarter of our students are National Merit Scholars, and one year of high school calculus is required for admission. Each year there are about 25 graduates in mathematics, CS/math, and mathematical biology, with approximately half going to graduate school. Over 40% of mathematics alumni from HMC have entered Ph.D. programs. The college enrolls about 700 students and is a member of the Claremont College consortium, which consists of four other undergraduate colleges, the Claremont Graduate University, and the Keck Graduate Institute of Applied Life Sciences, forming together an academic community of about 5,000 students. There is an active and vital research community of over 40

mathematicians and statisticians in the consortium.

Claremont is situated approximately 35 miles east of downtown Los Angeles, at the foot of the San Gabriel Mountains. The community is known for its tree-lined streets and village charm. It is an easy drive from Claremont to the cultural attractions of the greater Los Angeles area, as well as the ocean, mountains, and deserts of Southern California.

Applicants should send a curriculum vitae, a description of their teaching philosophy and experience, a description of their current research program, undergraduate and graduate transcripts, and arrange to have three letters of recommendation sent to the address that appears below. Further information about the college and department may be found at <http://www.math.hmc.edu/>. Preference will be given to applications completed by December 17, 2004.

Harvey Mudd College is an Equal Opportunity Employer and is committed to the recruitment of applicants historically underrepresented on college faculties.

Address for applications:

Professor Francis E. Su
Chair, Search Committee
Department of Mathematics
Harvey Mudd College
Claremont, CA 91711-5990

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**STANFORD UNIVERSITY
Department of Mathematics**

The department expects to make one or more Szegő assistant professor appointments. These appointments are for a term of three years beginning in September 2005. Research fields to be considered are: (1) analysis, (2) algebra, number theory, or logic, (3) geometry or topology, (4) combinatorics, (5) applied mathematics or probability, (6) financial mathematics.

Applicants are expected to show outstanding promise in research as well as strong interest and ability in teaching. They must have received the Ph.D. prior to the start of the appointment, but not before 2003. Candidates should send a letter of application with a curriculum vitae and list of publications, a teaching statement and supporting information including a teaching letter if possible, and three letters of recommendation to Szegő Search Committee, Department of Mathematics, Stanford University, Stanford, CA 94305 by December 15, 2004. Stanford is an Affirmative Action, Equal Opportunity Employer.

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**STANFORD UNIVERSITY
Department of Mathematics**

The department is considering applications for a tenure-track or tenured faculty appointment beginning September 2005. The research fields to be considered are:

(1) analysis, (2) algebra, number theory, or logic, (3) geometry or topology, (4) combinatorics, (5) applied mathematics or probability. There are also possibilities for joint appointments with other departments.

Candidates should send a letter of application with a curriculum vitae, a list of publications, a brief statement of research interest, and a cover sheet clearly stating the following information: name, area of specialization, institution, date of Ph.D., and Ph.D. advisor. Also the candidate should arrange to have at least three letters of recommendation (junior candidates only) or names and addresses of three references (senior candidates only) and evidence of commitment to excellence in teaching sent to Search Committee, Department of Mathematics, Stanford University, Stanford, CA 94305 by January 1, 2005. Stanford is an Affirmative Action, Equal Opportunity Employer.

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**TABULA, INC.
Engineer wanted**

Senior Place & Route Algorithms Engineer, job located in Santa Clara, CA. Tabula, Inc., send resume to: email: hr@tabula.com.

000149

**UNIVERSITY OF CALIFORNIA
LOS ANGELES
Department of Mathematics**

The following positions are available for the 2005–06 academic year, subject to availability of resources and administrative approval.

(1) Tenure-track/tenured faculty positions.

(2) E.R. Hedrick Assistant Professorships. Salary is \$53,200, and appointments are for three years. The teaching load is four quarter courses per year, which may include one advanced course in a successful candidate's field.

(3) Research Assistant Professorships in Computational and Applied Mathematics (CAM). The salary is \$53,200, and appointments are for three years. The teaching load is normally reduced to two or three quarter courses per year by research funding as available and can include one advanced course in a successful candidate's field.

(4) Assistant Adjunct Professorships in the Program in Computing (PIC). Applicants for these positions must show very strong promise in teaching and research in an area related to computing. The teaching load is four one-quarter programming courses each year and one seminar every two years. Initial appointments are for one year and possibly longer, up to a maximum service of four years. The salary is \$56,800.

(5) Assistant Adjunct Professorships and Research Postdocs. Normally appointments are for one year, with the possibility of renewal. Strong research and teach-

ing background required. The salary range is \$48,900–\$53,200. Teaching load for Adjuncts is six quarter courses per year.

(6) Visiting Instructorships.

Applicants should complete the application located on the website at <http://www.math.ucla.edu/~search>.

Preference will be given to applicants whose applications are completed by January 10, 2005.

UCLA is an Equal Opportunity/Affirmative Action Employer. Under federal law, the University of California may employ only individuals who are legally authorized to work in the United States as established by providing documents specified in the Immigration Reform and Control Act of 1986.

000106

CONNECTICUT

**YALE UNIVERSITY
Josiah Willard Gibbs
Instructorships/Assistant
Professorships**

Description: Offered to men and women with the doctorate who show definite promise in research in pure mathematics. Applications from women and members of minority groups are welcome. Appointments are for two/three years. The teaching load is kept light to allow ample time for research. This will consist of 3 one-semester courses. Part of the teaching duties over the term of the appointment may consist of a one-semester course at the graduate level in the general area of the instructor's research. Grant Amount: The 2005–2006 salary will be at least \$53,800. Deadline: January 1, 2005. Application information: Inquiries and applications can be obtained at the following website: <http://www.math.yale.edu>. Inquiries and application-supporting documents should be sent to the Gibbs Committee, Department of Mathematics, Yale University, via email: gibbs.committee@math.yale.edu. Yale University is an Affirmative Action/Equal Opportunity Employer.

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DISTRICT OF COLUMBIA

**THE GEORGE WASHINGTON UNIVERSITY
Department of Mathematics
Washington, DC**

The Department of Mathematics invites applications for a contract faculty position in the area of topology at the assistant professor level beginning fall 2005. The initial appointment is for a three-year term, and there is a possibility of renewal. A strong commitment to research and excellence in teaching are required. Responsibilities include teaching two or three

courses per semester and an engagement with our research group in topology.

The salary is competitive. Review of applications will begin on February 1, 2005, and will continue until the position is filled. Send curriculum vitae, a research summary and plan, and at least three letters of recommendation to:

Daniel Ullman, Chair
Department of Mathematics
The George Washington University
1922 F Street NW, Room 102
Washington, DC 20052

At least one letter of recommendation should comment in some detail about teaching. Applications from women are especially encouraged. The George Washington University is an Equal Opportunity/Affirmative Action employer.

000155

**THE GEORGE WASHINGTON UNIVERSITY
Department of Mathematics
Washington, DC**

The Department of Mathematics invites applications for a tenure-track faculty position in an area of mathematical biology at the assistant professor level beginning fall 2005. A strong commitment to research and excellence in teaching are required. Responsibilities include teaching two courses per semester and an active involvement with the department's doctoral program.

The university is committed to building an interdisciplinary strength in quantitative biological sciences, including hires in various departments (biology, chemistry, physics, computer sciences) in the fall of 2004. The ideal applicant will be able to collaborate with this emerging group, while also fitting into an area of strength within the Department of Mathematics, e.g., combinatorics and graph theory, complexity theory, differential equations, dynamical systems, or topology. See <http://www.gwu.edu/~home> for more information about the department of mathematics, and see <http://www.bioinformatics.gwu> for information on one aspect of GW's research group in quantitative biological sciences.

The salary is competitive. Review of applications will begin on January 15, 2005, and will continue until the position is filled. Send a curriculum vitae, a research summary and plan, a statement of teaching philosophy, and at least three letters of recommendation to:

Daniel Ullman, Chair
Department of Mathematics
The George Washington University
1922 F Street NW, Room 102
Washington, DC 20052

At least one letter of recommendation should comment in some detail about teaching. Applications from women are especially encouraged. The George Washington University is an Equal Opportunity/Affirmative Action employer.

000156

FLORIDA

UNIVERSITY OF WEST FLORIDA
Department of Mathematics and
Statistics

The University of West Florida, Department of Mathematics and Statistics, invites applications for an anticipated tenure-track position at the assistant professor level, beginning August 2005. Ph.D. in mathematics required with preference given to candidates in applied mathematics. Salary competitive. Candidates should have strong commitment to teaching at the undergraduate and master's levels, scholarly activity and service. A police background screening is required.

To apply, please go to <http://jobs.uwf.edu> to create your application. Please be prepared to attach the following documents in digital format: letter of interest and vita. Interested persons should also send transcripts and at least three sealed letters of reference to Dr. Kuyuan Li, Chairperson, Department of Mathematics and Statistics, University of West Florida, 11000 University Parkway, Pensacola, Florida 32514. Active review of candidates' materials will begin January 15, 2005, and will continue until the position is filled. UWF is an Equal Opportunity, Access, Affirmative Action Employer.

000165

GEORGIA

EMORY UNIVERSITY
Department of Mathematics and
Computer Science
Atlanta, Georgia 30322

The Emory University Department of Mathematics and Computer Science invites applications for an anticipated tenure-track assistant professorship, effective 2005-2006. The department seeks candidates with research interests in the areas of differential geometry and geometric analysis. Preference will be given to candidates whose research interests mesh well with those of current faculty. Applicants must have a Ph.D. in mathematics or a closely related field, with demonstrated promise in research and a strong commitment to teaching in a liberal arts environment.

Applications, including a letter of application, a CV, and a brief description of research accomplishments and plans should be sent to:

Screening Committee, Math Search
 Department of Mathematics and
 Computer Science
 Emory University
 Atlanta, Georgia 30322

Applicants should also arrange for at least 3 letters of reference to be sent to this

address. Screening of applications will begin on January 1, 2005.

Informal inquiries are welcome; please see our web page at <http://www.mathcs.emory.edu/News/Ops> for further details. Emory University is an Affirmative Action/Equal Opportunity Employer.

000144

GEORGIA INSTITUTE OF TECHNOLOGY

Beginning with the 2004/05 academic year, the School of Mathematics at Georgia Tech will embark on an ambitious faculty recruitment program, one which will be sustained over the next five years. Building on past successes, this recruiting effort is intended to make rapid advances in the scope and quality of our research and graduate education programs. Candidates will be considered at all ranks, with priority given to those candidates who (1) bring exceptional quality research credentials to Georgia Tech; (2) complement existing strengths in the School of Mathematics; (3) reinforce bridges to programs in engineering and the physical, computing and life sciences; (4) have strong potential for external funding; and (5) have a demonstrated commitment to high quality teaching at both the undergraduate and graduate levels. Consistent with these priorities, candidates will be considered in all areas of pure and applied mathematics and statistics. Candidates for positions at the assistant and associate professor levels should arrange for a résumé, at least three letters of reference, and a summary of future research plans to be sent to the Hiring Committee, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332-0160, USA. Candidates for full professor positions should submit a résumé and a letter outlining their vision for service as a senior faculty member at Georgia Tech. Review of applications will begin in September 2004, and the roster of candidates being considered will be updated on a monthly basis. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

000101

ILLINOIS

SOUTHERN ILLINOIS UNIVERSITY
CARBONDALE
Department of Mathematics
Numerical Analysis Position

Applications are invited for a tenure-track position in numerical analysis at the assistant professor level to begin on August 16, 2005. Applicants must have a research program in numerical analysis, and must demonstrate evidence of, or potential for, excellence both in research and in teaching at both undergraduate and graduate levels. Ph.D. in mathematics required by August 15, 2005. Postdoctoral experience

preferred. Send letter of application, CV, and three letters of recommendation to: Numerical Analysis Position, Department of Mathematics, Southern Illinois University Carbondale, Carbondale, Illinois 62901-4408. Review of applications will begin November 22, 2004, and continue until position is filled. SIUC is an affirmative action/equal opportunity employer that strives to enhance its ability to develop a diverse faculty and staff and to increase its potential to serve a diverse student population. All applications are welcomed and encouraged and will receive consideration.

000145

INDIANA

INDIANA UNIVERSITY SOUTH BEND
Department of Mathematical Sciences

The Department of Mathematical Sciences invites applications for a tenure-track, assistant professor position in applied mathematics starting August 2005. The applicant must have completed all requirements for a Ph.D. in mathematics or a closely related field by the time of appointment. Preferred areas of interest include simulation and stochastic modeling, and applied probability. Responsibilities include teaching undergraduate and graduate courses, research, and service. Salaries and fringe benefits are competitive. For more information, visit the website <http://www.iusb.edu/~sbmath/>.

To apply, send a letter of application, curriculum vitae, copies of graduate school transcripts, a statement of research interests, a statement of teaching philosophy, and arrange for at least three letters of recommendation to be sent to: Applied Mathematics Search Committee, Department of Mathematical Sciences,

IUSB is an Affirmative Action/Equal Opportunity Employer, and encourages applications from underrepresented groups. Applications will be reviewed as they are received, but full consideration will be given to any applications completed by January 31, 2005.

000162

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame, IN 46556
Notre Dame Instructorship in
Mathematics

The Department of Mathematics of the University of Notre Dame invites applications from recent doctorates for the position of Notre Dame Instructor in Mathematics. Candidates in any specialty compatible with the research interests of the department will be considered. The teaching load and salary will be competitive with those of distinguished instructorships at other AMS Group I universities. This position is for a term of three years

beginning August 22, 2005, is non-renewable and non-tenure-track. Applications, including a curriculum vitae, a letter of application, and a completed AMS standard cover sheet, should be sent to: William G. Dwyer, Chair, at the above address. Applicants should also arrange for at least three letters of recommendation to be sent to the chair. These letters should address the applicant's research accomplishments and supply evidence that the applicant has the ability to communicate articulately and teach effectively. Notre Dame is an Equal Opportunity Employer. Women and minorities are urged to apply. The evaluation of candidates will begin December 1, 2004. Information about the department is available at <http://www.science.nd.edu/math/>.

000067

UNIVERSITY OF NOTRE DAME
Department of Mathematics
 Notre Dame, IN 46556
Regular Position in Algebra

The Department of Mathematics of the University of Notre Dame invites applications for a position in algebra, especially number theory, algebraic geometry, the Langlands program, and areas of algebra such as commutative algebra consonant with the research interests of the department. The starting date for the position is August 22, 2005. Candidates at any rank will be considered. The teaching load is one course one semester and two courses the other semester. The salary is competitive. Applications, including a curriculum vitae, a letter of application, and a completed AMS standard cover sheet, should be sent to: William G. Dwyer, Chair, at the above address. Applicants should also arrange for at least three letters of recommendation to be sent to the chair. These letters should address the applicant's research accomplishments and supply evidence that the applicant has the ability to communicate articulately and teach effectively. Notre Dame is an Equal Opportunity Employer. Women and minorities are urged to apply. The evaluation of candidates will begin December 1, 2004. Information about the department is available at <http://www.math.nd.edu/math>.

000068

UNIVERSITY OF NOTRE DAME
Department of Mathematics
 Notre Dame, IN 46556
Regular Position in Numerical Analysis

The Department of Mathematics of the University of Notre Dame invites applications from an applied mathematician with a special interest in numerical analysis. The starting date for the position is August 22, 2005. Candidates at any rank will be considered. The teaching load is one course one semester and two courses the other semester. The salary is competitive. Applications, including a curriculum vitae,

a letter of application, and a completed AMS standard cover sheet, should be sent to: William G. Dwyer, Chair, at the above address. Applicants should also arrange for at least three letters of recommendation to be sent to the chair. These letters should address the applicant's research accomplishments and supply evidence that the applicant has the ability to communicate articulately and teach effectively. Notre Dame is an Equal Opportunity Employer. Women and minorities are urged to apply. The evaluation of candidates will begin December 1, 2004. Information about the department is available at <http://www.science.nd.edu/math>.

000069

IOWA

UNIVERSITY OF IOWA

Actuarial science tenure-track assistant professor starting 8/05. Ph.D. required. Actuarial fellowship or associateship highly preferred. Industrial experience helpful. Duties include teaching and research in actuarial science and/or financial mathematics, involvement in Ph.D. program, and supervision of Ph.D. students. Selection begins 12/01/04. CV, three reference letters, and transcript for recent Ph.D.s to Actuarial Search, Statistics & Actuarial Science, Univ. of Iowa, Iowa City, IA 52242-1409. <http://www.stat.uiowa.edu>.

Women and minorities are encouraged to apply. The University of Iowa is an Affirmative Action, Equal Opportunity Employer.

000132

KANSAS

KANSAS STATE UNIVERSITY
Department of Mathematics

Subject to budgetary approval, applications are invited for tenure-track positions commencing August 14, 2005; rank and salary commensurate with qualifications. The department seeks candidates whose research interests mesh well with current faculty. The department has research groups in the areas of analysis, algebra, geometry/topology, and differential equations. Applicants must have strong research credentials as well as strong accomplishment or promise in teaching. Letter of application, current vita, description of research, and at least three letters of reference evaluating research should be sent to:

Louis Pigno
 Department of Mathematics
 Cardwell Hall 138

Kansas State University
 Manhattan, KS 66506

The department also requires that the candidate arrange for letters to be submitted evaluating teaching accomplishments and potential. Offers may begin by December 1, 2004, but applications for positions will be reviewed until February 1, 2005, or until positions are closed. AA/EOE

000137

KENTUCKY

UNIVERSITY OF LOUISVILLE
Department of Mathematics

The Department of Mathematics at the University of Louisville invites applications for several tenure-track positions at the assistant professor level beginning fall 2005. Minimum qualifications for these positions include a Ph.D. degree, or its equivalent, in the mathematical sciences and promise of excellence in research and teaching. Preference will be given to applicants who strengthen the department's new Ph.D. program in applied and industrial mathematics and who complement the existing strengths in the department. Interested applicants should submit (1) the AMS Standard Coversheet; (2) curriculum vitae; (3) summary of research interest; (4) statement of teaching qualifications; and (5) at least four letters of recommendation, including letters which discuss at length research and teaching qualifications. To receive full consideration, material should be received by December 15, 2004. Applications should be sent to: Search Committee, Department of Mathematics, University of Louisville, Louisville, KY 40292. The Department of Mathematics is committed to building a culturally diverse faculty and strongly encourages women, African Americans, and other minorities to apply. AA/EOE

000148

LOUISIANA

LOUISIANA STATE UNIVERSITY
Department of Mathematics

As part of the Louisiana State University National Flagship Agenda, the Department of Mathematics is engaged in a major expansion of its professorial faculty. To help guide this expansion, applications are invited for a distinguished mathematician who will take a leadership role in advancing the national reputation of the Mathematics Department. This anticipated full professor position will have a substantial salary and a teaching load of one class each semester. Some additional junior positions may be available for the appointee to fill. The department will consider

applicants in algebra, analysis, topology, applied mathematics and combinatorics.

Applicants are expected to have a Ph.D. or equivalent degree in mathematics (or a related area), a record of leadership in research and a record of excellence in teaching. Applicants should send a curriculum vitae and the names and addresses of four references. Letters of support are welcome but not required for the initial application.

Applications will be reviewed beginning January 3, 2005. We request that applicants use the secure AMS online application system at <http://www.mathjobs.org/jobs>. Applicants may also write to the address below. Minorities and women are encouraged to apply. LSU is an equal opportunity/equal access employer. Submit to:

Hiring Committee
Ref: Log #0172
Department of Mathematics
Louisiana State University
Baton Rouge, LA 70803
email: profjobs@math.lsu.edu

000154

MARYLAND

JOHNS HOPKINS UNIVERSITY Department of Mathematics

Subject to availability of resources and administrative approval, the following positions are available for the 2005–06 academic year.

1. One tenure-track or tenured positions in all areas of pure mathematics.
2. One non-tenure-track J. J. Sylvester Assistant Professor.
3. One FRG postdoc position: This is open to mathematicians who have recently completed or will soon complete a doctorate in mathematics and whose research interests concern Eigenfunctions of the Laplacian.

For questions, send an email to math@math.jhu.edu. Applications should be sent to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218-2689, and should include a complete curriculum vitae, at least four letters of recommendation (including a letter concerning teaching), and a description of current and planned research. Applications received by November 1, 2004, will be given priority. Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply. See our ad online at <http://www.mathematics.jhu.edu/mathnew/jobs.html>.

000058

TOWSON UNIVERSITY Tenure-Track Assistant Professor Position in Mathematics

Applicants are invited to apply for a tenure-track position in pure mathematics at the rank of assistant professor beginning 2005 Fall Semester. The salary is competitive. Applicants must have an earned doctorate in mathematics. Applicants must possess a commitment to teaching, an active research program, and the ability to teach a variety of courses, some of which require the use of technology.

Applicants should submit a letter of application, a resume, a description of research, a statement of teaching experience and philosophy, and a copy of both the undergraduate and graduate transcripts. They should arrange to have three letters of recommendation, addressing both teaching and research sent to:

Dr. Leonid Stern, Chairperson
Mathematics Search Committee
Mathematics Department
Towson University
8000 York Road
Towson, MD 21252-0001

Applications or material sent by e-mail or facsimile will not be considered. Priority will be given to applications received on or before January 20, 2005.

The Mathematics Department <http://www.towson.edu/math/> offers bachelor's degree programs in pure mathematics, applied mathematics, actuarial science and risk management, and mathematics education. Master's degree programs are offered in applied and industrial mathematics, and mathematics education (at both the secondary school and middle school levels).

Towson University is an equal opportunity/affirmative action employer and has a strong institutional commitment to diversity. Women, minorities, persons with disabilities, and veterans are encouraged to apply.

000141

MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY Department of Mathematics Applied Mathematics

The applied mathematics group at MIT is seeking to fill possible positions at the level of instructor, assistant professor, or higher, beginning September 2005. Appointments will be made based on demonstrated outstanding research qualifications. Candidates in all areas of applied mathematics, including physical applied mathematics, computational molecular biology, numerical analysis and scientific computation, will be considered. Current activities of the group include: combina-

torics, operations research, theory of algorithms, numerical analysis, astrophysics, condensed matter physics, computational physics, fluid dynamics, geophysics, nonlinear waves, theoretical and computational molecular biology, quantum computing, quantum field theory and material science, but new hiring may involve other areas. Please send curriculum vitae, research description, along with three letters of recommendation by January 10, 2005, to: Committee on Applied Mathematics, Room 2-345, Department of Mathematics, M.I.T., 77 Massachusetts Ave., Cambridge, MA 02139-4307. M.I.T. is an Equal Opportunity/Affirmative Action Employer. (For more information about the position and institution: <http://www-math.mit.edu>.)

000126

MASSACHUSETTS INSTITUTE OF TECHNOLOGY Department of Mathematics

The Department of Mathematics may make appointments, at the level of lecturer and assistant professor or higher, in pure mathematics for the year 2005–2006. The teaching load will be nine hours for the academic year (eight hours for assistant professor appointments). These positions are open to mathematicians with doctorates who show definite promise in research. Applications should be complete by January 10, 2005. Applicants should arrange to have sent (a) vita, (b) three letters of reference, (c) a description of their most recent research, and (d) a research plan for the immediate future to: Pure Mathematics Committee, Massachusetts Institute of Technology, Room 2-263, 77 Massachusetts Ave., Cambridge, MA 02139-4307. M.I.T. is an Equal Opportunity Affirmative Action Employer. (For more information about the position or institution: <http://www-math.mit.edu>.)

000127

MASSACHUSETTS INSTITUTE OF TECHNOLOGY Department of Mathematics C.I.E. Moore Instructorships in Mathematics

These positions are open to mathematicians with doctorates who show definite promise in research. The teaching load will be nine hours for the academic year. Applications should be complete by January 10, 2005. Applicants should arrange to have sent (a) a vita, (b) three letters of reference, (c) a description of the research in their thesis, and (d) a research plan for the next year to: Pure Mathematics Committee, Massachusetts Institute of Technology, Room 2-263, Cambridge, MA 02139-4307. M.I.T. is an Equal Opportunity/Affirmative Action Employer. (For more information about the position or institution: <http://www-math.mit.edu>.)

000128

**UNIVERSITY OF MASSACHUSETTS
AMHERST**
Department of Mathematics & Statistics

The Department of Mathematics & Statistics (<http://www.math.umass.edu>) invites applications for tenure-track positions at the assistant professor level. The search will encompass the following areas: analysis and partial differential equations, applied and computational mathematics, algebraic geometry, differential geometry and topology, representation theory and Lie theory, number theory, probability, and statistics. Exceptional promise in research and teaching (at all levels of the curriculum) is required. Although this search focuses on junior level appointments, candidates for more senior level appointments will be considered. In addition, visiting assistant professor/lecturer positions might be available. Applicants should send a curriculum vita, and arrange to have at least three letters of recommendation sent to: Search Committee, Department of Mathematics & Statistics, University of Massachusetts Amherst, Lederle Graduate Research Center, 710 North Pleasant St., Amherst, MA 01003-9305. Review of applications will begin on November 1. Applications will continue to be accepted until all positions are filled. Please include the AMS Application Cover Sheet. Women and members of minority groups are encouraged to apply. The University of Massachusetts is an Affirmative Action/Equal Opportunity Employer.

000133

WILLIAMS COLLEGE
Department of Mathematics

The Williams College Department of Mathematics and Statistics invites applications for one tenure-track position in mathematics, beginning fall 2005, at the rank of assistant professor (in an exceptional case, a more advanced appointment may be considered). We are seeking a highly qualified candidate who has demonstrated excellence in teaching and research, and who will have a Ph.D. by the time of appointment.

Williams College is a private, residential, highly selective liberal arts college with an undergraduate enrollment of approximately 2,000 students. The teaching load is two courses per 12-week semester and a winter term course every other January. In addition to excellence in teaching, an active and successful research program is expected.

To apply, please send a vita and have three letters of recommendation on teaching and research sent to the Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluations of applications will begin on or after November 15 and will continue until the position is filled. Williams College is dedicated to providing a welcoming intellectual

environment for all of its faculty, staff and students; as an EEO/AA employer, Williams especially encourages applications from women and minorities. For more information on the Department of Mathematics and Statistics, visit <http://www.williams.edu/Mathematics>.

000151

WILLIAMS COLLEGE
Department of Mathematics

The Williams College Department of Mathematics and Statistics invites applications for one tenure-track position in statistics, beginning fall 2005, at the rank of assistant professor (in an exceptional case, a more advanced appointment may be considered). We are seeking a highly qualified candidate who has demonstrated excellence in teaching and research, and who will have a Ph.D. by the time of appointment.

Williams College is a private, residential, highly selective liberal arts college with an undergraduate enrollment of approximately 2,000 students. The teaching load is two courses per 12-week semester and a winter term course every other January. In addition to excellence in teaching, an active and successful research program is expected.

To apply, please send a vita and have three letters of recommendation on teaching and research sent to the Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluations of applications will begin on or after November 15 and will continue until the position is filled. Williams College is dedicated to providing a welcoming intellectual environment for all of its faculty, staff and students; as an EEO/AA employer, Williams especially encourages applications from women and minorities. For more information on the Department of Mathematics and Statistics, visit <http://www.williams.edu/Mathematics>.

000152

MICHIGAN

MICHIGAN STATE UNIVERSITY
East Lansing, MI 48824
proMSc Program in
Industrial Mathematics

Direct your students toward one of the professional M.Sc. programs. Industry needs business-savvy mathematicians. See <http://www.sciencemasters.com/>.

000001

NEW HAMPSHIRE

DARTMOUTH COLLEGE
John Wesley Young Research
Instructorship

The John Wesley Young Instructorship is a postdoctoral two-year appointment intended for promising Ph.D. graduates with strong interests in both research and teaching and whose research interests overlap a department member's. Current research areas include applied mathematics, combinatorics, geometry, logic, noncommutative geometry, number theory, operator algebras, probability, set theory and topology. Instructors teach four 10-week courses distributed over three terms, though one of these terms in residence may be free of teaching. The assignments normally include introductory, advanced undergraduate, and graduate courses. Instructors usually teach at least one course in their own specialty. This appointment is for 26 months with a monthly salary of \$4,350.00 and is not renewable. Salary includes 2-month research stipend for instructors in residence during two of the three summer months in 2006 and 2007. To be eligible for a 2005-2007 Instructorship, candidate must be able to complete all requirements for the Ph.D. degree before September 2005.

Applications may be obtained at <http://www.math.dartmouth.edu/recruiting/>. Or submit a letter of application, curriculum vitae, graduate school transcript, thesis abstract, statement of research plans and interests, and at least three, preferably four, letters of recommendation to Donna Black, Department of Mathematics, Dartmouth College, 6188 Bradley Hall, Hanover, NH 03755-3551. At least one referee should comment on applicant's teaching ability; at least two referees should write about applicant's research ability. Applications received by January 5, 2005, receive first consideration; applications will be accepted until position is filled. Dartmouth College is committed to diversity and strongly encourages applications from women and minorities.

000103

DARTMOUTH COLLEGE
Department of Mathematics

The Department of Mathematics anticipates a tenure-track opening with initial appointment in the 2005-2006 academic year. The position is for an applied mathematician at the rank of assistant professor. In extraordinary cases, an appointment at a higher rank is possible. Successful candidate should have demonstrated ability to work across disciplines; particularly, it is expected that he or she seek out and strike up collaborations across campus with departments such as biology, physics, computer science; he/she should also aggressively seek funding in his/her area of research. Current applied

interests include (but are not limited to) imaging, signal processing, computational number theory, statistical physics, stochastic processes, quantum computing, and computational biology and are receiving funding from various sources including NSF and NIH. Candidates for the position must be committed to outstanding teaching and interaction with students at all levels of undergraduate and graduate study.

To create an atmosphere supportive of research, Dartmouth offers new faculty members grants for research-related expenses, a quarter of sabbatical leave for each three academic years in residence, and flexible scheduling of teaching responsibilities. The teaching responsibility in mathematics is three courses spread over three of four 10-week terms. To apply for the position, applications may be obtained at <http://www.math.dartmouth.edu/recruiting/>. Or send a letter of application, curriculum vitae, and a brief statement of research results and interests, and arrange for four letters of reference, at least one of which specifically addresses teaching, to be sent to Donna Black, Recruiting Secretary, Department of Mathematics, Dartmouth College, 6188 Bradley Hall, Hanover, NH 03755-3551. Applications received by December 15, 2004, will receive first consideration. Dartmouth College is committed to diversity and strongly encourages applications from women and minorities. Inquiries about the progress of the selection process may be directed to Dan Rockmore, Recruiting Chair.

000104

DARTMOUTH COLLEGE Department of Mathematics

The Department of Mathematics anticipates a tenure-track opening with initial appointment in the 2005-2006 academic year. In extraordinary cases, an appointment at a higher rank is possible. Preference given to candidates working in either set theory/logic or areas of algebra with connections to existing research interests in the department, including computational algebra, algebraic and arithmetic geometry, representation theory, coding theory and algebraic combinatorics. Candidates for the position must also be committed to outstanding teaching and interaction with students at all levels of undergraduate and graduate study.

To create an atmosphere supportive of research, Dartmouth offers new faculty members grants for research-related expenses, a quarter of sabbatical leave for each three academic years in residence, and flexible scheduling of teaching responsibilities. The teaching responsibility in mathematics is three courses spread over three of four 10-week terms. To apply for the position, applications may be obtained at <http://www.math.dartmouth.edu/recruiting/>. Or send a letter of application, curriculum vitae, and a brief statement of research results and interests,

and arrange for four letters of reference, at least one of which specifically addresses teaching, to be sent to Donna Black, Recruiting Secretary, Department of Mathematics, Dartmouth College, 6188 Bradley Hall, Hanover, NH 03755-3551. Applications received by December 15, 2004, will receive first consideration. Dartmouth College is committed to diversity and strongly encourages applications from women and minorities. Inquiries about the progress of the selection process may be directed to Dan Rockmore, Recruiting Chair.

000105

NORTH CAROLINA

NORTH CAROLINA STATE UNIVERSITY Department of Mathematics

We invite applications for an anticipated tenure track position at the assistant professor level in probability and applications beginning fall 2005. Applicants must have a doctorate in mathematics or a closely related area, a strong ongoing research program, and a commitment to effective teaching at the undergraduate and graduate levels. Candidates in all areas of probability theory and related applications who have had at least one year of postdoctoral experience will be considered. The department has strong research programs in both pure and applied mathematics, and significant collaborations with other departments, institutions, and industry. The successful candidate will have the opportunity to participate in the programs of the Statistical and Applied Mathematical Sciences Institute (SAMSI), the Center for Research in Scientific computation, and our affiliated programs in biomathematics and financial mathematics. Information about the department may be found at <http://www.math.ncsu.edu>. Applicants should send a vita, research plan, and three letters of recommendation to Stochastics Search Committee, Department of Mathematics, NC State University, Box 8205, Raleigh, NC 27695-8205. North Carolina State University is an Equal Opportunity and Affirmative Action Employer. In addition, NC State welcomes all persons without regard to sexual orientation. ADA Accommodations: Dr. Jean-Pierre Fouque, fouque@math.ncsu.edu, (919) 515-2382. Complete applications received before December 31, 2004, will receive full consideration.

000130

OHIO

CASE WESTERN RESERVE UNIVERSITY Department of Mathematics Cleveland, Ohio

One or more tenure-track appointments. Open rank, however, appointment at the rank of assistant professor is strongly

preferred. We especially emphasize coordination with department, college and university goals, including undergraduate teaching in the university's SAGES Program. Areas of preference have been identified to meet department priorities. For more information and instructions, see <http://www.case.edu/artsci/dean/searches/mathematics05.html>. Indicate in which area you wish to be considered. The successful candidate will hold the Ph.D. or equivalent and have, relative to career stage, a distinguished record of publication, research, service, and teaching. Compensation commensurate with qualifications. Electronic applications only, to: James Alexander, math-faculty-position@cwru.edu, consisting of a letter of application, which indicates in which area of preference you wish to be considered, AMS cover sheet, a c.v., and the names and contact information for four referees to whom we may write. Visiting positions/instructorships/lectureships may also be open. Evaluation of applications will begin December 15, 2004. Case is a recipient of an NSF ADVANCE institutional transformation grant to increase the participation of women in science and engineering. Case Western Reserve University is committed to diversity and is an Affirmative Action, Equal Opportunity Employer. Applications from women or minorities are especially encouraged.

000131

OREGON

UNIVERSITY OF OREGON Department of Mathematics

Applications are invited for three positions in the department of mathematics:

1. Assistant or associate professor in any area of pure or applied mathematics, statistics or mathematics education. This is a tenure related position.
2. Assistant or associate professor in probability, statistics or related area. This is a tenure related position.
3. Paul Olum Visiting Assistant Professor. This is a two-year postdoctoral position named in honor of former University of Oregon President Paul Olum. This position is not tenure related.

Specific descriptions and qualifications for these positions, and application instructions, can be found at: <http://uoregon.edu/~math/employment.html>. Application materials may NOT be submitted electronically.

Closing date for all positions is January 5, 2005. Women and minorities are encouraged to apply. The University of Oregon is an EO/AA/ADA Institution committed to diversity

000150

PENNSYLVANIA

**CARNEGIE MELLON UNIVERSITY
CENTER FOR NONLINEAR ANALYSIS
Department of Mathematical Sciences**

The Center for Nonlinear Analysis expects to make several Post-Doctoral appointments for 2005-06 in applied analysis, and potential focus areas include materials science, systems biology, and fluid flow. These will be one- or two-year joint appointments by the Center and the Department of Mathematical Sciences. Recipients will teach at most two courses per year. Applicants should send a vita, list of publications, a statement describing current and planned research, and arrange to have at least three letters of recommendation sent to:

Post-Doctoral Appointments Committee
Center for Nonlinear Analysis
Department of Mathematical Sciences
Carnegie Mellon University
Pittsburgh, PA 15213-3890

The deadline for applications is December 15, 2004.

000164

**LEHIGH UNIVERSITY
Department of Mathematics**

The Lehigh Department of Mathematics seeks to build on its strengths in pure mathematics by hiring at the assistant professor level in analysis with a preference for fields which complement our existing areas of research.

A successful candidate will demonstrate great research potential and have a record of successful teaching commensurate with the position. Applications from new and recent Ph.D.'s are welcome.

As part of their application, candidates should submit: (a) an AMS cover sheet; (b) a complete vita, including a list of publications; (c) a research plan; and (d) at least four letters of recommendation, at least one of which addresses the candidate's teaching.

Applications received by November 15 will be assured of full consideration. Application materials should be sent to:

Analysis Hiring Committee
Department of Mathematics
Lehigh University
Bethlehem, PA 18015-3174

For detailed information see the department website: <http://www.lehigh.edu/~math>.

Lehigh University is an Equal Opportunity/Affirmative Action employer.

000138

**LEHIGH UNIVERSITY
Department of Mathematics**

The Lehigh Department of Mathematics seeks to build on its strengths in

probability and statistics by hiring at the assistant professor level in statistics, including biostatistics.

A successful candidate will demonstrate great research potential, and have a record of successful teaching commensurate with the position. Applications from new and recent Ph.D.'s are welcome.

As part of their application, candidates should submit: (a) an AMS cover sheet; (b) a complete vita, including a list of publications; (c) a research plan; and (d) at least four letters of recommendation, at least one of which addresses the candidate's teaching.

Applications received by November 15 will be assured of full consideration. Application materials should be sent to:

Statistics Hiring Committee
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Lehigh University
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For detailed information see the department website: <http://www.lehigh.edu/~math>.

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**LEHIGH UNIVERSITY
Department of Mathematics**

The Lehigh Department of Mathematics seeks to fill two visiting positions. These are one-year, non-tenure-track positions that carry a four course per year teaching load.

The department welcomes applicants in any fields of pure and applied mathematics, including statistics, which complement our existing areas of research.

As part of their application, candidates should submit: (a) an AMS cover sheet; (b) a complete vita, including a list of publications; (c) a research plan; and (d) at least four letters of recommendation, at least one of which addresses the applicant's teaching.

Applications received by November 15 will be assured of full consideration. Application materials should be sent to:

Visiting Faculty Hiring Committee
Department of Mathematics
Lehigh University
Bethlehem, PA 18015-3174

For detailed information see the department website: <http://www.lehigh.edu/~math>.

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000140

SOUTH CAROLINA

**CLEMSON UNIVERSITY
Department of Mathematical Sciences**

The Department of Mathematical Sciences at Clemson University invites applications for expected tenure-track faculty positions

starting with the fall 2005 semester. The department includes the areas of algebra and discrete mathematics; analysis; computational mathematics; mathematics education; operations research; and probability and statistics. Targeted recruiting is for the assistant professor rank, but applicants for all ranks will be considered. Desirable attributes for candidates include an interdisciplinary research orientation in the mathematical sciences; post-doctoral, industrial, or practical experience; collaborative possibilities with faculty members in the department and related disciplines; and an interest in innovative applications. Candidates should have strong potential or demonstrated capability for effective research and teaching. An earned doctorate or equivalent is required for the tenure-track positions. Review of applications will begin on November 1, 2004, and will continue until the positions are filled. Applications received by December 1, 2004, will receive full consideration. Applicants should indicate their research specialties and interests in their cover letter. Vita and three reference letters should be sent to the address below. For further information regarding the department and its programs, please visit the web site <http://www.math.clemson.edu>. CU is an AA/EO employer and encourages applications from women and minorities.

Send applications to: Faculty Search Committee, Department of Mathematical Sciences, Box 340975, File N, Clemson University, Clemson, SC 29634-0975.

000163

TENNESSEE

**VANDERBILT UNIVERSITY
Department of Mathematics**

We invite applications for a non-tenure-track assistant professor position beginning fall 2005. This position is to be filled in the area of analysis such as operator theory and holomorphic spaces. It is a two-year appointment at the non-tenure-track assistant professor level with a 2-2 teaching load, normally renewable for a third year. This position is intended for a recent Ph.D. with demonstrated research potential and a strong commitment to excellence in teaching. Submit your application and supporting materials to the attention of the "Analysis Hiring Committee." These materials should include a vita, a publication list, a research summary, and the American Mathematical Society Cover Sheet. Please include an email address and fax number if available. Applicants should also arrange to have four letters of recommendation sent to the hiring committee, including one that discusses the candidate's teaching qualifications. Evaluation of the applications will commence on

November 1, 2004, and continue until the position is filled.

Vanderbilt University is an Affirmative Action/Equal Opportunity Employer.

000135

VANDERBILT UNIVERSITY
Department of Mathematics
1326 Stevenson Center
Nashville, TN 37240

We invite applications for two non-tenure-track assistant professor positions in the areas of noncommutative geometry/topology and operator algebras beginning fall 2005. These are three-year appointments at the non-tenure-track assistant professor level with a 1-1 teaching load, a summer stipend, and an award for research related travel. The positions are supported by a Research Training Group (RTG) grant from the National Science Foundation. They are intended for recent Ph.D.'s who are U.S. citizens or residents with demonstrated research potential and a strong commitment to excellence in teaching.

Submit your application and supporting materials to the attention of the "Noncommutative Geometry Hiring Committee". These materials should include a vita, a publication list, a research summary and the American Mathematical Society Cover Sheet. Please include an email address and fax number if available. Applicants should also arrange to have four letters of recommendation sent to the hiring committee, including one that discusses the candidate's teaching qualifications. Evaluation of the applications will commence on November 1, 2004, and will continue until the position is filled. For information about the research group in noncommutative geometry and operator algebras at Vanderbilt University, please consult the Web at <http://www.math.vanderbilt.edu/~ncgoa/>. Vanderbilt University is an Affirmative Action/Equal Opportunity Employer.

000049

VANDERBILT UNIVERSITY
Department of Mathematics
1326 Stevenson Center
Nashville, TN 37240

We invite applications for two non-tenure-track assistant professor positions in the areas of noncommutative geometry/topology and operator algebras beginning fall 2005. These are three-year appointments at the non-tenure-track assistant professor level with a 1-1 teaching load, a summer stipend, and an award for research related travel. The positions are supported by a Research Training Group (RTG) grant from the National Science Foundation. They are intended for recent Ph.D.'s who are U.S. citizens or residents with demonstrated research potential and a strong commitment to excellence in teaching.

Submit your application and supporting materials to the attention of the "Noncommutative Geometry Hiring Committee".

These materials should include a vita, a publication list, a research summary and the American Mathematical Society Cover Sheet. Please include an email address and fax number if available. Applicants should also arrange to have four letters of recommendation sent to the hiring committee, including one that discusses the candidate's teaching qualifications. Evaluation of the applications will commence on November 1, 2004, and will continue until the position is filled. For information about the research group in noncommutative geometry and operator algebras at Vanderbilt University, please consult the Web at <http://www.math.vanderbilt.edu/~ncgoa/>. Vanderbilt University is an Affirmative Action/Equal Opportunity Employer.

000161

TEXAS

RICE UNIVERSITY
Department of Mathematics
Postdoctorate

Griffith Conrad Evans Instructorships Postdoctoral appointments for two to three years for promising research mathematicians with research interests in common with the active research areas at Rice, particularly geometric topology, geometric analysis, differential geometry, combinatorics, analysis, algebraic geometry, and ergodic theory. Duties will include research and classroom teaching. Applications received by December 15, 2004, will receive full consideration. Rice University is an Equal Opportunity Affirmative Action Employer and strongly encourages applications from women and minority group members. Inquiries and applications should be addressed to Chair, Evans Committee, Department of Mathematics, Rice University, P.O. Box 1892, Houston, TX 77251-1892. Submitting the AMS Application Cover Sheet (available in *Notices*, *EMS*, or on the AMS website) would be greatly appreciated.

000111

SOUTHERN METHODIST UNIVERSITY
Dedman College
Department of Mathematics

Applications are invited for one tenure-track assistant professor position to begin in the fall semester of 2005. Applicants must have a Ph.D., provide evidence of outstanding research, and have a strong commitment to teaching at all levels. The Department of Mathematics' active doctoral program is in computational and applied mathematics. Current research includes numerical analysis of ordinary and partial differential equations, mathematical software, dynamical systems, fluid dynamics, nonlinear optics, and mathematical biology. Applications in all areas of computational and applied mathematics are encouraged. Visit <http://www.smu.edu/math> for more information about the department.

edu/math for more information about the department.

To apply, send a letter of application with a curriculum vitae, a list of publications, and a research and teaching statement to: The Faculty Search Committee, Department of Mathematics, Southern Methodist University, P.O. Box 750156, Dallas, Texas 75275-0156. Applicants must also arrange for three letters of recommendation to be forwarded to the Faculty Search Committee. The Search Committee can be contacted by sending e-mail to mathsearch@mail1.smu.edu. [Tel: (214) 768-2452; Fax: (214) 768-2355]

To ensure full consideration for the position, the application must be postmarked by January 7, 2005, but the committee will continue to accept applications until the position is filled. The committee will notify applicants of its employment decision after the position is filled.

SMU will not discriminate on the basis of race, color, religion, national origin, sex, age, disability or veteran status. SMU is also committed to nondiscrimination on the basis of sexual orientation.

000142

UNIVERSITY OF HOUSTON-CLEAR LAKE
School of Science and
Computer Engineering
Faculty Search

The UHCL School of Science and Computer Engineering is conducting a search to fill the faculty position listed below. Interview by appointment only. If an accommodation is needed during an interview, please notify the search committee at least one week prior to the scheduled interview.

Position Description: Assistant Professor for Mathematics

The Department of Mathematical Sciences of the University of Houston-Clear Lake invites applications for a tenure-track opening for an assistant professor or higher to begin August 2005. The department seeks candidates whose mathematical interests complement those of current faculty. A Ph.D. in mathematics by August 2005 is expected. The successful candidate will be expected to teach undergraduate and graduate courses in mathematics, to conduct mathematical research, and to perform university service.

The University of Houston-Clear Lake is an upper-level institution with an enrollment of 7,500 located adjacent to the Johnson Space Center. It offers degree programs at the bachelor and master's level. The mathematical sciences area offers bachelor and master's degrees in mathematics, master's degrees in statistics, courses supporting the natural and applied sciences, and courses in support of the certification of elementary and secondary school teachers.

Apply on-line at <http://jobs.uhc1.edu/>. Please send three letters of recommendation from the references to Chair of Mathematical Sciences Search Committee,

University of Houston-Clear Lake, 2700 Bay Area Blvd. MC-167, Houston, TX, 77058. Preliminary interviews will be held at the Joint Winter Meetings in Atlanta (January 2005) but applications will be accepted until the position is filled.

The University of Houston-Clear Lake is an Affirmative Action/Equal Opportunity Employer supporting workforce diversity and does not discriminate on the basis of race, sex, age, religion, national origin, disability, or veteran status. The university hires only individuals authorized to work in the United States and does not observe hiring practices that will result in the displacement of qualified United States citizens or permanent residents. We reserve the right to extend searches or not fill positions.

000136

VIRGINIA

CHRISTOPHER NEWPORT UNIVERSITY
Department of Mathematics

Two tenure-track positions at assistant professor level to begin August 2005. Must have Ph.D. in mathematics or related field, with expertise in any area of mathematics/statistics & qualifications compatible with needs of department, faculty & students. Effective language communication skills essential. Applicants should show interest in student-faculty research & obtaining grants. Further details (Search #8275) at <http://www.cnu.edu/admin/hr>. Deadline: 2/1/05. EOE.

000157

WYOMING

UNIVERSITY OF WYOMING
Department of Mathematics
Tenure-Track Position in
Computational Fluid Dynamics

Applications are invited for an assistant professor tenure-track position starting August 2005. A higher rank is possible for persons with outstanding research qualifications. The minimum qualifications are an earned Ph.D., significant record of accomplishments in research, evidence of a strong commitment to teaching, and appropriate level of communication skills. Candidates with research emphasis in areas such as computational multiphase flow (modeling, simulation, parameter estimation, optimization and control) as well as computational methods for free boundaries and fluid discontinuities (e.g., fluid interfaces, shock waves, etc.) will be preferred. The position requires the ability and interest to advise undergraduates and supervise master's and doctoral students; to teach a variety of undergraduate, graduate and outreach courses; to collaborate with colleagues in

the math department and faculty in related disciplines; and to develop a competitive, externally funded research program. Review of completed applications will begin December 15, 2004.

A complete application will consist of a letter of application, a complete CV, a statement of research interests and accomplishments, and a statement of teaching philosophy. Please forward applications to: Search Committee on Computational Multiphase Flow, Department of Mathematics, University of Wyoming, Laramie, WY 82071-3036. Please have at least three letters of recommendation, one of which should address the candidate's teaching, sent directly to the search committee. For further information please refer to: <http://math.uwo.edu>. UW is an EO/AA Employer.

000097

PORTUGAL

INSTITUTO SUPERIOR TÉCNICO
Center for Mathematical Analysis
Geometry, and Dynamical Systems
Departamento de Matemática
Av. Rovisco Pais
1049-001 Lisboa, Portugal
Postdoctoral Positions

The Center for Mathematical Analysis, Geometry, and Dynamical Systems of the Department of Mathematics of Instituto Superior Técnico, Lisbon, Portugal, invites applications for postdoctoral positions for research in mathematics, subject to budgetary approval. Positions are for one year, with the possibility of extension for a second year upon mutual agreement. Selected candidates will be able to take up their position between September 1, 2005, and January 1, 2006.

Applicants should have a Ph.D. in mathematics preferably obtained after December 31, 2002. They must show very strong research promise in one of the areas in which the mathematics faculty of the center is currently active. There are no teaching duties associated with these positions.

Applicants should send a curriculum vitae; reprints, preprints and/or dissertation abstract; description of research project (of no more than 1,000 words); and three letters of reference directly to the director at the above address.

To insure full consideration, complete application packages should be received by **January 15, 2005**. Additional information about the Center and the positions is available at <http://www.math.ist.utl.pt/cam/>.

000154

TAIWAN

NATIONAL CHIAO TUNG UNIVERSITY
Department of Applied Mathematics

Applications invited for regular or visiting positions at all levels (assistant professors and above) beginning August 2005. All areas of pure and applied mathematics considered. Applicant should hold Ph.D. (by August 2005) in mathematics or related field, with strong research potential. Usual language of instruction is Mandarin.

Send letter of application, curriculum vitae, research plans, three recommendation letters, transcripts of graduate works (for recent graduates) to:

Hiring Committee
Department of Applied Mathematics
National Chiao Tung University
Hsinchu 300, Taiwan

Full consideration to applications received by February 20, 2005.

The department is one of the leading research centers in Taiwan, with 24 faculty members in combinatorics, differential equations, differential geometry, dynamical systems, financial mathematics, functional analysis, Lie theory, mathematical physics, number theory, operator theory, probability theory, and scientific computation. Visit website <http://www.math.nctu.edu/tw/> for details.

000115

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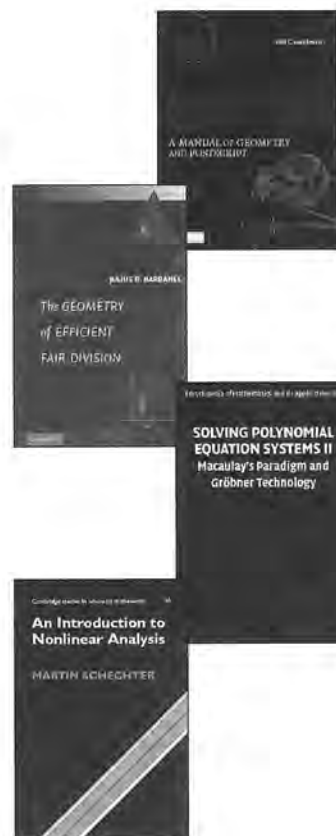
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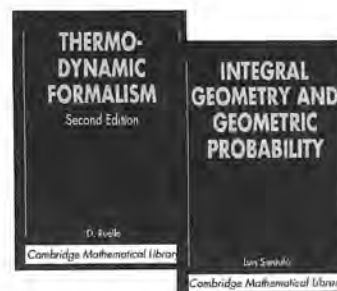
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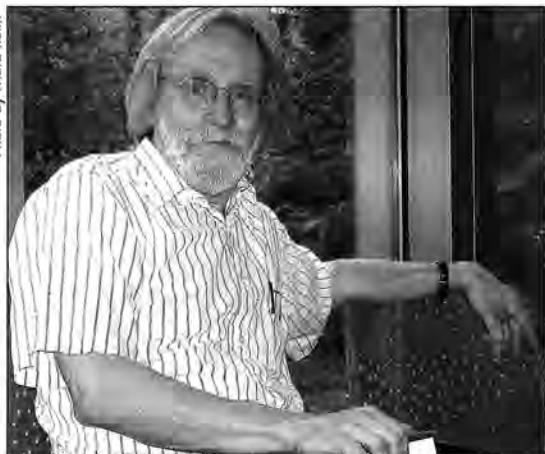
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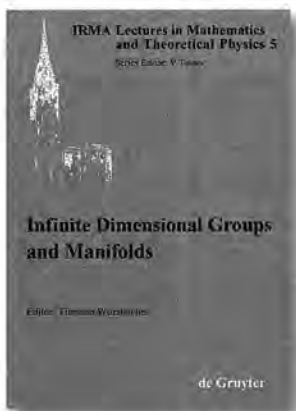
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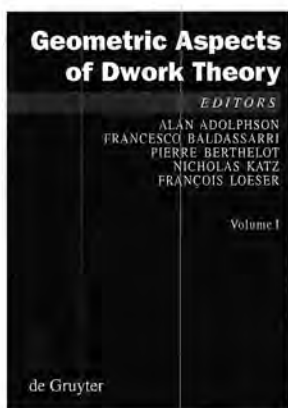
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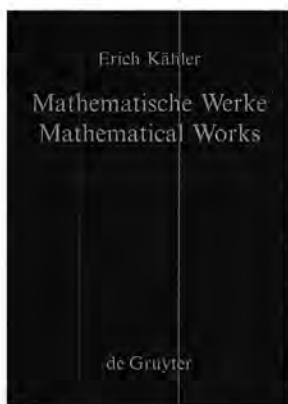
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 Differential Equations
 of Mathematical
 Physics**

I. S. Krasil'shchik and
 A. M. Vinogradov, Editors
 Translations of Mathematical
 Monographs, Volume 182; 1999;
 333 pages; Hardcover; ISBN
 0-8218-0958-X; List \$129;
 Individual member \$77; **Sale
 Price:** **\$32**; Order code
 MMONO/182N

**Hyperbolic Equations
 and Frequency
 Interactions**

Luis Caffarelli and
 Weinan E, Editors
 Members of the Mathematical
 Association of America (MAA) and
 the National Council of Teachers
 of Mathematics (NCTM) receive
 a 20% discount from list price.
 IAS/Park City Mathematics
 Series, Volume 5; 1999; 466
 pages; Hardcover; ISBN

0-8218-0592-4; List \$72; All AMS
 members \$58; **Sale Price:** **\$29**;
 Order code PCMS/5N

**Discrete
 Mathematics and
 Combinatorics**

**Advances in Switching
 Networks**

Ding-Zhu Du and
 Frank K. Hwang, Editors
 DIMACS: Series in Discrete
 Mathematics and Theoretical
 Computer Science, Volume 42;
 1998; 333 pages; Hardcover;
 ISBN 0-8218-0831-1; List \$74;
 All AMS members \$59; **Sale
 Price:** **\$30**; Order code
 DIMACS/42N

**Qualitative Topics in
 Integer Linear
 Programming**

V. N. Shevchenko
 Translations of Mathematical
 Monographs, Volume 156; 1997;
 146 pages; Hardcover; ISBN
 0-8218-0535-5; List \$72;
 Individual member \$43; **Sale
 Price:** **\$29**; Order code
 MMONO/156N

**A Tribute to Emil
 Grosswald: Number
 Theory and Related
 Analysis**

Marvin Knopp and
 Mark Sheingorn, Editors
 Contemporary Mathematics,
 Volume 143; 1993; 612 pages;
 Softcover; ISBN 0-8218-5155-1;
 List \$83; Individual member \$50;
Sale Price: **\$25**; Order code
 CONM/143N

**Combinatorial
 Rigidity**

Jack Graver,
 Brigitte Servatius,
 and Herman Servatius
 Graduate Studies in Mathematics,
 Volume 2; 1993; 172 pages;
 Hardcover; ISBN 0-8218-3801-6;
 List \$34; All AMS members \$27;
Sale Price: **\$17**; Order code
 GSM/2N

Discounts apply to limited quantities. Sale prices are not subject to further discounts and are subject to change without notice. Direct sales only. Not available to bookstores or agents. Sale ends December 15, 2004.

General and Interdisciplinary

World Directory of Mathematicians 2002

Published by the International Mathematical Union.

2002; 1,248 pages; Softcover; List \$70; **Sale Price: \$35**; Order code WRLDIR/12N

Prospects in Mathematics

Invited Talks on the Occasion of the 250th Anniversary of Princeton University

Hugo Rossi, Editor

1999; 162 pages; Hardcover; ISBN 0-8218-0975-X; List \$30; All AMS members \$24; **Sale Price: \$15**; Order code PIMN

C. G. J. Jacobi's Collected Works

C. G. J. Jacobi

1969; 3,913 pages; Hardcover; ISBN 0-8218-0554-1; List \$168; Individual member \$101; **Sale Price: \$42**; Order code JACOBISETN

A Century of Mathematical Meetings

Betty Anne Case, Editor

1996; 332 pages; Hardcover; ISBN 0-8218-0465-0; List \$79; Individual member \$47; **Sale Price: \$32**; Order code MTGMN

Geometry and Topology

Differential Geometry and Control

G. Ferreyra, R. Gardner, H. Hermes, and H. Sussmann, Editors

Proceedings of Symposia in Pure Mathematics, Volume 64; 1999; 341 pages; Hardcover; ISBN 0-8218-0887-7; List \$83; Individual member \$50; **Sale Price: \$33**; Order code PSPUM/64N

Mirror Symmetry III

Duong H. Phong, Luc Vinet, and Shing-Tung Yau, Editors

Titles in this series are copublished with International Press, Cambridge, MA.

AMS/IP Studies in Advanced

Mathematics, Volume 10; 1999; 312 pages; Hardcover; ISBN 0-8218-1193-2; List \$44; All AMS members \$35; **Sale Price: \$22**; Order code AMSIP/10N

Four-Dimensional Integrable Hamiltonian Systems with Simple Singular Points (Topological Aspects)

L. M. Lerman and Ya. L. Umanskiy

Translations of Mathematical Monographs, Volume 176; 1998; 177 pages; Hardcover; ISBN 0-8218-0375-1; List \$83; Individual member \$50; **Sale Price: \$33**; Order code MMONO/176N

Equivariant Homotopy and Cohomology Theory

J. P. May

CBMS Regional Conference Series in Mathematics, Number 91; 1996; 366 pages; Softcover; ISBN 0-8218-0319-0; List \$51; All individuals \$41; **Sale Price: \$23**; Order code CBMS/91N

The General Topology of Dynamical Systems

Ethan Akin

Graduate Studies in Mathematics, Volume 1; 1993; 261 pages; Hardcover; ISBN 0-8218-3800-8; List \$38; All AMS members \$30; **Sale Price: \$19**; Order code GSM/1N

Logic and Foundations

Consequences of the Axiom of Choice

Paul Howard and Jean E. Rubin

Mathematical Surveys and Monographs, Volume 59; 1998; 432 pages; Hardcover; ISBN 0-8218-0977-6; List \$93; Individual member \$56; **Sale Price: \$37**; Order code SURV/59N

The Collected Works of Julia Robinson

Solomon Feferman, Editor

Collected Works, Volume 6; 1996; 338 pages; Hardcover; ISBN 0-8218-0575-4; List \$72; Individual member \$43; **Sale Price: \$29**; Order code CWORKS/6N

Complexity of Proofs and Their Transformations in Axiomatic Theories

V. P. Orevkov

Translations of Mathematical Monographs, Volume 128; 1993; 153 pages; Hardcover; ISBN 0-8218-4576-4; List \$90; Individual member \$54; **Sale Price: \$26**; Order code MMONO/128N

Logic and Combinatorics

Stephen G. Simpson, Editor

Contemporary Mathematics, Volume 65; 1987; 394 pages; Softcover; ISBN 0-8218-5052-0; List \$48; Individual member \$29; **Sale Price: \$14**; Order code CONM/65N

Mathematical Physics

Lectures on Representation Theory and Knizhnik-Zamolodchikov Equations

Pavel I. Etingof, Igor B. Frenkel, and Alexander A. Kirillov, Jr.

Mathematical Surveys and Monographs, Volume 58; 1998; 198 pages; Hardcover; ISBN 0-8218-0496-0; List \$51; All AMS members \$41; **Sale Price: \$23**; Order code SURV/58N

Selected Papers of Walter E. Thirring with Commentaries

Walter E. Thirring

Collected Works, Volume 8; 1997; 729 pages; Hardcover; ISBN 0-8218-0812-5; List \$142; Individual member \$85; **Sale Price: \$36**; Order code CWORKS/8N

Quantization, Nonlinear Partial Differential Equations, and Operator Algebra

William Arveson, Thomas Branson, and Irving Segal, Editors

Proceedings of Symposia in Pure Mathematics, Volume 59; 1996; 224 pages; Hardcover; ISBN 0-8218-0381-6; List \$57; Individual member \$34; **Sale Price: \$26**; Order code PSPUM/59N

Mathematical Quantum Theory I: Field Theory and Many-Body Theory

J. Feldman, R. Froese, and L. Rosen, Editors

CRM Proceedings & Lecture Notes, Volume 7; 1994; 234 pages; Softcover; ISBN 0-8218-0365-4; List \$60; Individual member \$36; **Sale Price: \$27**; Order code CRMP/7N

Number Theory

Number Theory

V. Kumar Murty and Michel Waldschmidt, Editors

Contemporary Mathematics, Volume 210; 1998; 399 pages; Softcover; ISBN 0-8218-0606-8; List \$72; Individual member \$43; **Sale Price: \$22**; Order code CONM/210N

Multiplicative Galois Module Structure

A. Weiss

Fields Institute Monographs, Volume 5; 1996; 95 pages; Hardcover; ISBN 0-8218-0265-8; List \$41; Individual member \$25; **Sale Price: \$21**; Order code FIM/5N

Representations of Groups

Bruce N. Allison and Gerald H. Cliff, Editors

Members of the Canadian Mathematical Society may order at the AMS member price.

Conference Proceedings, Canadian Mathematical Society, Volume 16; 1995; 385 pages; Softcover; ISBN 0-8218-0311-5; List \$116; Individual member \$70; **Sale Price: \$29**; Order code CMSAMS/16N

The Unreasonable Effectiveness of Number Theory

Stefan A. Burr, Editor

Proceedings of Symposia in Applied Mathematics, Volume 46; 1992; 125 pages; Softcover; ISBN 0-8218-5501-8; List \$29; All AMS members \$23; **Sale Price: \$15**; Order code PSAPM/46N

Probability

Probability Theory and Applications

Elton P. Hsu and S. R. S. Varadhan, Editors

Members of the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM) receive a 20% discount from list price.

IAS/Park City Mathematics Series, Volume 6; 1999; 374 pages; Hardcover; ISBN 0-8218-0590-8; List \$56; All AMS members \$45; **Sale Price: \$25**; Order code PCMS/6N

Stochastic Partial Differential Equations: Six Perspectives

Rene A. Carmona and Boris Rozovskii, Editors

Mathematical Surveys and Monographs, Volume 64; 1999; 334 pages; Hardcover; ISBN 0-8218-0806-0; List \$49; All AMS members \$39; **Sale Price: \$25**; Order code SURV/64N

Gaussian Measures

Vladimir I. Bogachev

Mathematical Surveys and Monographs, Volume 62; 1998; 433 pages; Hardcover; ISBN 0-8218-1054-5; List \$100; Individual member \$60; **Sale Price: \$25**; Order code SURV/62N

Local Properties of Distributions of Stochastic Functionals

Yu. A. Davydov, M. A. Lifshits, and N. V. Smorodina

Translations of Mathematical Monographs, Volume 173; 1998; 184 pages; Hardcover; ISBN 0-8218-0584-3; List \$79; Individual member \$47; **Sale Price: \$32**; Order code MMONO/173N



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CMS WINTER MEETING 2004
December 11 – 13 décembre
Université McGill University, Montréal, Québec

The Department of Mathematics and Statistics, McGill University is happy to announce the provisional outline for the Canadian Mathematical Society Winter Meeting 2004, to be held at the Hilton Bonaventure in downtown Montreal. Look for the First Announcement in the September 2004 issue of the *CMS Notes* and at www.cms.math.ca/Events/winter04/ for the latest updates.

Le département de mathématiques et statistiques de l'Université McGill est heureux d'annoncer les détails provisoires pour la Réunion d'hiver 2004 de la SMC, qui se tiendra au Hilton Bonaventure au centre-ville de Montréal. Veuillez consulter la première annonce officielle dans le numéro de septembre des *Notes de la SMC* ainsi que notre site web www.cms.math.ca/Reunions/hiver04/ pour les informations les plus à jour.

PLENARY LECTURERS / CONFÉRENCIERS PRINCIPAUX

Michael Bennett (UBC) **Persi Diaconis** (York) **Rainer Steinwandt** (Karlsruhe) **Rostislav Grigorchuk** (Texas A&M)

PRIZES / PRIX

Conférencier Coxeter-James Lecture: **Izabella Laba** (UBC)
Prix de doctorat / Doctoral Prize Lecture: **Nicolaas Spronk** (Waterloo)
Prix pour service méritoire de la SMC / CMS Distinguished Service Award: **Edgar Goodaire** (Memorial)
Prix Adrien Pouliot Prize: to be announced / à venir
Prix G. de B. Robinson Award: to be announced / à venir

SESSIONS

Algebraic Combinatorics: François Bergeron, Riccardo Biagioli, Peter McNamara, and Christophe Reutenauer (UQAM)
Approximation Theory: Richard Fournier and Paul Gauthier (Montreal)
Arithmetic Geometry: Eyal Goren and Adrian Iovita (McGill)
Combinatorial and Geometric Group Theory: Inna Bumagin (Carleton) and Dani Wise (McGill)
Commutative Algebra: Sara Faridi (UQAM), Sindi Sabourin (York), Will Traves (UQAM) and Adam van Tuyl (Lakehead)
Discrete Geometry: Karoly Bezdek (Calgary) and Bob Erdahl (Queen's)
Dynamical Systems: Michael A. Radin (RIT)
Groups, Equations, non-commutative Algebraic Geometry: Olga Kharlampovich and Alexei Myasnikov (McGill)
Harmonic Analysis: Galia Dafni (Concordia)
History of Mathematics: Thomas Archibald (Acadia), Rich O'Lander, Ron Sklar (St. John's) and Alexei Volkov (McGill)

Interactions between Algebra and Computer Science: Alexei Myasnikov (McGill) and Vladimir Shpilrain (CUNY)
Mathematical Methods in Statistics: Russell Steele, Alain Vandal and David Wolfson (McGill)
Mathematics for Future Teachers: Leo Jonker (Queen's)
Number Theory: Andrew Granville (Montreal)
Special Metrics and Submanifolds in Riemannian Geometry: Gordon Craig (McGill) and Spiro Karigiannis (McMaster)
Universal Algebra and Complexity: J. Hyndman (McGill), B. Larose (Concordia), and Denis Therien (McGill)
Contributed Papers: William Brown (McGill)

Meeting Director: Olga Kharlampovich (McGill)
Local Arrangements: William Brown (McGill)

SYMPOSIUMS

Combinatoire algébrique : François Bergeron, Riccardo Biagioli, Peter McNamara, et Christophe Reutenauer (UQAM)
Théorie d'approximation : Richard Fournier et Paul Gauthier (Montreal)
Géométrie arithmétique : Eyal Goren et Adrian Iovita (McGill)
Théorie des groupes combinatoire et géométrie : Inna Bumagin (Carleton) et Dani Wise (McGill)
Algèbre commutative : Sara Faridi (UQAM), Sindi Sabourin (York), Will Traves (UQAM) et Adam van Tuyl (Lakehead)
Géométrie discrète : Karoly Bezdek (Calgary) et Bob Erdahl (Queen's)
Systèmes dynamiques : Michael A. Radin (RIT)
Groupes, Équations, géométrie algébrique non-commutative : Olga Kharlampovich et Alexei Myasnikov (McGill)
Analyse harmonique : Galia Dafni (Concordia)
Histoire des mathématiques : Thomas Archibald (Acadia), Rich O'Lander, Ron Sklar (St. John's) et Alexei Volkov (McGill)

Intéactions entre la science informatique et l'algèbre : Alexei Myasnikov (McGill) et Vladimir Shpilrain (CUNY)
Méthodes mathématiques en statistique : Russell Steele, Alain Vandal et David Wolfson (McGill)
Mathématiques pour futur professeur(e)s : Leo Jonker (Queen's)
Théorie des nombres : Andrew Granville (Montreal)
Distances et sous-variétés spéciales de la géométrie Riemannienne : Gordon Craig (McGill) et Spiro Karigiannis (McMaster)
Algèbre universelle et complexité : J. Hyndman (McGill), B. Larose (Concordia), et Denis Therien (McGill)
Communications libres : William Brown (McGill)

Directrice de réunion: Olga Kharlampovich (McGill)
Logistique locale: William Brown (McGill)

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/>. Programs and abstracts will continue to be displayed on the AMS website in the Meetings and Conferences section until about three weeks after the meeting is over. Final programs for Sectional Meetings will be archived on the AMS website in an electronic issue of the *Notices* as noted below for each meeting.

Atlanta, Georgia

Atlanta Marriott Marquis and Hyatt
Regency Atlanta

January 5–8, 2005

Wednesday – Saturday



Meeting #1003

Joint Mathematics Meetings, including the 111th Annual Meeting of the AMS, 88th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association of Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Lesley M. Sibner

Announcement issue of *Notices*: October 2004

Program first available on AMS website: November 1, 2004

Program issue of electronic *Notices*: January 2005

Issue of *Abstracts*: Volume 26, Issue 1

Deadlines

For organizers: Expired

For consideration of contributed papers in Special Sessions:
Expired

For abstracts: Expired

For summaries of papers to MAA organizers: Expired

For the latest information on this meeting, see www.ams.org/amsmtgs/2091_intro.html.

Joint AMS-MAA Sessions

The AMS Committee on Science Policy-MAA Science Policy Committee Government Speaker has been cancelled on Friday afternoon.

AMS Program Updates

The **Invited Address** by **Steven Zelditch**, Friday, 10:05 to 10:55 a.m., is titled Random Complex Geometry, or How to count universes in string theory.

The Panel, Friday, 9:30 a.m. to 10:55 a.m. This one act play is set in Ballston VA, at the headquarters of mathematicians' favorite federal agency. It is an historical drama based on, and accurately adhering to, actual events, but typical of the genre, it also seeks to entertain while penetrating facets of the human (and, of course, mathematical) condition. The audience will be challenged to reflect on the realities presented and will have a sense of *deja vu* at the characters portrayed. The work is written and produced by the National Science Foundation, Division of Mathematical Sciences; the staff and the cast will consist of well-known mathematical thespians at this world premier performance. This presentation will be moderated by **William Rundell**, National Science Foundation.

AMS Workshop

Department Chairs Workshop, Tuesday, 8:00 a.m. to 6:30 p.m. This workshop is intended to stimulate discussion among attending chairs and workshop leaders. Sharing ideas and experiences with peers provides a form of

department chair therapy, creating an environment that enables attending chairs to address departmental matters from new perspectives. Workshop leaders will be **Krishnaswami Alladi**, Department Chair of Mathematics, University of Florida; **Deanna Caveny**, Department Chair of Mathematics, College of Charleston; **Peter March**, Department Chair of Mathematics, The Ohio State University; and **Robert Olin**, Dean of Arts and Sciences, University of Alabama-Tuscaloosa. Past workshop sessions have focused on a range of issues facing departments today, including personnel issues (staff and faculty), long range planning, hiring, promotion and tenure, budget management, assessments, outreach, stewardship, junior faculty development, communication, and departmental leadership. There is a registration fee for the workshop of \$75, which includes lunch and a post-workshop reception. This is separate from the Joint Mathematics Meetings registration fee. If you would like to attend the workshop, please complete the RSVP form located at <http://www.ams.org/government/ChairsWorkshop2005.RSVForm.pdf> and return it along with your check as outlined on the form. The RSVP form also includes space for your input in helping to identify important and timely topics that should be addressed at this workshop. Agenda, materials, and location information will be sent to all registered attendees prior to the meeting.

MAA Program Updates

SIGMAA on Research in Undergraduate Mathematics Education Business Meeting and Guest Lecture, Thursday, 5:45 p.m. to 7:45 p.m., organized by **Barbara E. Edwards**, Oregon State University.

MAA Student Research Programs, Friday, 9:00 to 10:30 a.m., organized by **William Hawkins Jr.**, MAA and the University of the District of Columbia and **Robert E. Megginson**, MSRI and the University of Michigan. The MAA supported undergraduate minority student research at six sites in the summer of 2004 as part of its National Research Experiences for Undergraduates Program (NREUP). NREUP has funding from the NSF and NSA. Presenters will discuss how their projects were organized and the work of their students. There will be ample time for discussion and questions. Panelists will include **Nathaniel Dean**, Texas Southern University, and **David L. Housman**, Goshen College. The MAA expects to support another six sites in the summer of 2005. The session is sponsored by the MAA-SUMMA (Strengthening Underrepresented Minority Mathematics Achievement) Program. The deadline for proposals is January 31, 2005. More information can be found at <http://www.maa.org/nreup>.

Session for Chairs: Using the CUPM Curriculum Guide 2004 to Guide Curricula and Pedagogy in the 'Right' Direction, Friday, 9:00 a.m. to 10:20 a.m., organized by **Daniel P. Maki**, Indiana University, and **Catherine M. Murphy**, Purdue University Calumet. **David M. Bressoud**, Macalester University, and **Amy Cohen**, Rutgers University, will provide an overview of the *Guide* and accompanying resources as well as sharing their experiences in leading change. Presentations will be followed by a period for questions and discussions.

Morgan Prize Session, Friday, 10:00 a.m. to 10:50 a.m. The winner and honorable mention recipients of the AMS-MAA-SIAM Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student will speak about their research: **Reid W. Barton** (winner), Massachusetts Institute of Technology, and **Po-Shen Loh** (honorable mention), California Institute of Technology and Cambridge University.

SIGMAA on the Philosophy of Mathematics Invited Speaker, Business Meeting, and Reception, Friday, 5:00 p.m. to 6:30 p.m., organized by **Bonnie Gold**, Monmouth University, and **Satish C. Bhatnagar**, University of Nevada, Las Vegas. **Jonathan Borwein**, Dalhousie University, will speak on Philosophical Implications of Experimental Mathematics.

SIGMAA on Quantitative Literacy Board Meeting and Reception, Friday, 5:15 p.m. to 7:00 p.m., organized by **Judy Moran**, Trinity College, and **Caren Diefenderfer**, Hollins University.

Other Organizations

Blumenthal Session, Friday, 9:00 a.m. to 9:45 a.m. The Leonard M. and Eleanor M. Blumenthal Award for the Advancement of Research in Pure Mathematics will be given at the Joint Prize Session on Thursday afternoon. The winner of this award, **Manjul Bhargava**, Princeton University, will speak on his research at this Friday morning session.

Social Events

University of Illinois at Urbana-Champaign Reception, Thursday, 6:00 p.m. to 7:30 p.m.

Michigan Alumni Get-Together, Friday, 5:00 p.m. to 7:00 p.m. This reception is sponsored by the University of Michigan Department of Mathematics Alumni, who are invited for hors d'oeuvres and a cash bar.

The Ohio State University Friends and Alumni Reception, Friday, 6:00 p.m. to 8:00 p.m.

Association of Christians in the Mathematical Sciences (ACMS) Banquet, Friday, 6:30 p.m. This annual dinner will feature a talk by **Thomas Banchoff**, Brown University, on *Dali: The Christian Dimension*. Tickets are \$35 (\$25 for ACMS members and students) and may be purchased by sending a check payable to ACMS to Dr. Robert Brabenec, Dept. of Mathematics, Wheaton College, Wheaton, IL 60187.

Bowling Green, Kentucky

Western Kentucky University

March 18-19, 2005

Friday - Saturday

Meeting #1004

Southeastern Section

Associate secretary: John L. Bryant

Announcement issue of *Notices*: January 2005
 Program first available on AMS website: February 3, 2005
 Program issue of electronic *Notices*: March 2005
 Issue of *Abstracts*: Volume 26, Issue 2

Deadlines

For organizers: Expired
 For consideration of contributed papers in Special Sessions:
 November 30, 2004
 For abstracts: January 25, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Bennett Chow, University of California, San Diego, *Title to be announced.*

Robert McCann, University of Toronto, *Title to be announced.*

M. Susan Montgomery, University of Southern California, *Title to be announced.*

James J. Zhang, University of Washington, *Title to be announced.*

Special Sessions

Advances in the Study of Wavelets and Multiwavelets (Code: SS 5A), **Douglas P. Hardin**, Vanderbilt University, and **Bruce Kessler**, Western Kentucky University.

Commutative Ring Theory (Code: SS 11A), **Michael C. Axte**, Wabash College, and **Joe Alyn Stickles Jr.**, University of Evansville.

Dynamic Equations on Time Scales and Applications (Code: SS 3A), **Ferhan M. Atici** and **Daniel C. Biles**, Western Kentucky University, and **Billur Kaymakcalan**, Georgia Southern University.

Geometric Topology and Group Theory (Code: SS 14A), **Jens E. Harlander**, Western Kentucky University.

Graph Theory (Code: SS 2A), **Mustafa Atici**, Western Kentucky University.

Hopf Algebras and Related Topics (Code: SS 10A), **David E. Radford**, University of Illinois at Chicago, and **Bettina Richmond**, Western Kentucky University.

Knot Theory and Its Applications (Code: SS 4A), **Yuanan Diao**, University of North Carolina Charlotte, and **Claus Ernst**, Western Kentucky University.

L-Functions (Code: SS 9A), **Heather Russell**, **Nilabh Sanat**, and **Dominic Lanphier**, Western Kentucky University.

Nonlinear Analysis and Applied Mathematics (Code: SS 13A), **Robert J. McCann**, University of Toronto, and **Daniel P. Spirn**, University of Minnesota.

Numerical Analysis, Approximation, and Computational Complexity: Interdisciplinary Aspects (Code: SS 1A), **David Benko**, Western Kentucky University, and **Steven B. Damelin**, Georgia Southern University.

Partial Differential Equations and Their Applications (Code: SS 12A), **Zhongwei Shen** and **Changyou Wang**, University of Kentucky.

Representation Theory (Code: SS 6A), **Markus Hunziker**, University of Georgia.

Semigroups of Operators and Applications (Code: SS 7A), **Khristo Boyadzhiev**, Ohio Northern University, **Lan Nguyen**, Western Kentucky University, and **Quoc-Phong Vu**, Ohio University.

Topology, Convergence, and Order, in Honor of Darrell Kent (Code: SS 8A), **Gary Richardson**, University of Central Florida, and **Thomas A. Richmond**, Western Kentucky University.

Newark, Delaware

University of Delaware

April 2-3, 2005

Saturday - Sunday

Meeting #1005

Eastern Section

Associate secretary: Lesley M. Sibner

Announcement issue of *Notices*: February 2005

Program first available on AMS website: February 17, 2005

Program issue of electronic *Notices*: April 2005

Issue of *Abstracts*: Volume 26, Issue 2

Deadlines

For organizers: Expired

For consideration of contributed papers in Special Sessions:
 December 14, 2004

For abstracts: February 8, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Xiu Xiong Chen, University of Wisconsin, *Title to be announced.*

Anna Gilbert, AT&T Labs-Research, *Title to be announced.*

Alex Lubotzky, Hebrew University of Jerusalem, *Title to be announced.*

Lorenz Schwachhoefer, University of Dortmund, *Title to be announced.*

Special Sessions

Arithmetic Groups and Related Topics (Code: SS 9A), **Alex Lubotzky**, Hebrew University of Jerusalem, and **Andrei Rapinchuk**, University of Virginia.

Asymptotic Behavior of Evolution Equations (Code: SS 4A), **Gaston M. N'Guerekata**, Morgan State University, and **Nguyen Van Minh**, James Madison University.

Designs, Codes, and Geometries (Code: SS 5A), **James A. Davis**, University of Richmond, **Keith E. Mellinger**, University of Mary Washington, and **Qing Xiang**, University of Delaware.

Frontiers on Complex Fluid Flows: Analytic and Computational Methods (Code: SS 7A), **L. Pamela Cook** and **Louis F. Rossi**, University of Delaware.

Geometric Analysis (Code: SS 12A), **Xiuxiong Chen**, University of Wisconsin, Madison, **Pengfei Guan**, McMaster University, **Zhiqin Lu**, University of California Irvine, and **Jeff A. Viaclovsky**, Massachusetts Institute of Technology.

High Dimensional Probability (Code: SS 6A), **Wenbo Li**, University of Delaware, and **Joel Zinn**, Texas A&M University.

Homotopy Theory (in Honor of Donald M. Davis's and Martin Bendersky's 60th Birthdays) (Code: SS 1A), **Kenneth G. Monks**, University of Scranton, and **W. Stephen Wilson**, Johns Hopkins University.

Integral and Operator Equations (Code: SS 13A), **Charles W. Groetsch**, University of Cincinnati, and **M. Zuhair Nashed**, University of Central Florida.

Mathematical Biology (Code: SS 8A), **David A. Edwards**, University of Delaware.

Mathematical Methods for Efficient Simulation of Stochastic Nonlinear Optical Systems (Code: SS 15A), **Richard O. Moore**, New Jersey Institute of Technology, and **Tobin A. Driscoll**, University of Delaware.

Mathematical Methods in Electromagnetic Wave Propagation (Code: SS 3A), **Fioralba Cakoni** and **Peter B. Monk**, University of Delaware.

Recent Progress in Thin Fluid Flows (Code: SS 11A), **Richard J. Braun**, University of Delaware.

Singular Analysis and Spectral Theory of Partial Differential Equations (Code: SS 2A), **Juan B. Gil**, Pennsylvania State University, Altoona, and **Gerardo A. Mendoza**, Temple University.

Spectral and High-Order Discretization Methods for Partial Differential Equations (Code: SS 14A), **Tobin A. Driscoll**, University of Delaware.

Symmetry Methods for Partial Differential Equations (Code: SS 10A), **Philip Broadbridge**, University of Delaware, and **Danny Arrigo**, University of Central Arkansas.

Program issue of electronic *Notices*: April 2005
Issue of *Abstracts*: Volume 26, Issue 3

Deadlines

For organizers: Expired

For consideration of contributed papers in Special Sessions:
December 21, 2004

For abstracts: February 15, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Nikolai Ivanov, Michigan State University, *Title to be announced.*

Mattias Jonsson, University of Michigan, *Title to be announced.*

Nicolas Monod, University of Chicago, *Title to be announced.*

Hee Oh, California Institute of Technology, *Title to be announced.*

Special Sessions

Classical and Differential Galois Theory (Code: SS 3A), **Lourdes Juan** and **Arne Ledet**, Texas Tech University, and **Andy R. Magid**, University of Oklahoma.

Differential Geometry and Its Applications (Code: SS 2A), **Josef F. Dorfmeister**, Munich University of Technology, **Magdalena D. Toda**, Texas Tech University, and **Hongyou Wu**, Northern Illinois University.

Discrete Groups, Homogeneous Spaces, Rigidity (Code: SS 15A), **Alex Gorodnik**, University of Michigan Ann Arbor, **Hee Oh**, California Institute of Technology, and **Nicolas Monod**, University of Chicago.

Extinction, Periodicity, and Chaos in Population and Epidemic Models (Code: SS 10A), **Linda J. S. Allen**, Texas Tech University, **Sophia Ruey-Jen Jang**, University of Louisiana at Lafayette, and **Lih-Ing W. Roeger**, Texas Tech University.

Future Directions in Mathematical Systems and Control Theory (Code: SS 11A), **David Gilliam** and **W. P. Dayawansa**, Texas Tech University.

Graph Theory (Code: SS 12A), **John C. George**, Eastern New Mexico University, and **Walter D. Wallis**, Southern Illinois University at Carbondale.

Homological Algebra and Its Applications (Code: SS 4A), **Alex Martsinkovsky**, Northeastern University, and **Mara D. Neusel**, Texas Tech University.

Invariants of Links and 3-Manifolds (Code: SS 8A), **Mieczyslaw Krzysztof Dabkowski**, University of Texas at Dallas, **Razvan Gelca**, Texas Tech University, and **Jozef Henryk Przytycki**, George Washington University.

Partial Differential Equations and Its Application in Biomedical Study (Code: SS 16A), **Jay R. Walton**, Texas A&M University, **Padmanabhan Seshaiyer** and **Akif Ibragimov**, Texas Tech University.

Lubbock, Texas

Texas Tech University

April 8–10, 2005

Friday – Sunday

Meeting #1006

Central Section

Associate secretary: Susan J. Friedlander

Announcement issue of *Notices*: February 2005

Program first available on AMS website: February 24, 2005

Real Algebraic Geometry (Code: SS 6A), **Anatoly Korcha-**
gin and **David Weinberg**, Texas Tech University.

Recent Advances in Complex Function Theory (Code: SS 5A),
Brock Williams, **Roger W. Barnard**, and **Kent Pearce**, Texas
Tech University.

Statistical Image Processing and Analysis and Applications
(Code: SS 13A), **Victor Patrangenaru**, Texas Tech Univer-
sity.

Theory and Application of Stochastic Differential Equa-
tions (Code: SS 9A), **Edward J. Allen**, Texas Tech Univer-
sity, and **Armando Arciniega**, University of Texas at San
Antonio.

Topology of Continua (Code: SS 1A), **Wayne Lewis**, Texas
Tech University.

Topology of Dynamical Systems (Code: SS 7A), **Brian Raines**,
Baylor University.

Undergraduate and Graduate Student Research (Code: SS
14A), **Ali Khoujmane**, **Edward W. Swim**, **Edward J. Allen**,
and **Padmanabhan Seshaiyer**, Texas Tech University.

Santa Barbara, California

University of California Santa Barbara

April 16–17, 2005

Saturday – Sunday

Meeting #1007

Western Section

Associate secretary: Michel L. Lapidus

Announcement issue of *Notices*: February 2005

Program first available on AMS website: March 3, 2005

Program issue of electronic *Notices*: April 2005

Issue of *Abstracts*: Volume 26, Issue 3

Deadlines

For organizers: Expired

For consideration of contributed papers in Special Sessions:
December 28, 2004

For abstracts: February 22, 2005

*The scientific information listed below may be dated. For
the latest information, see [www.ams.org/amsmtgs/
sectional.html](http://www.ams.org/amsmtgs/sectional.html).*

Invited Addresses

Mei-Chu Chang, University of California Riverside, *Title to
be announced.*

Mischa Kapovich, University of California Davis, *Title to
be announced.*

Mihai Putinar, University of California Santa Barbara, *Pos-
itive Polynomials.*

James Sethian, University of California Berkeley, *Title to
be announced.*

Special Sessions

Algebraic Geometry and Combinatorics (Code: SS 14A),
Alexander Yong and **Allen Knutson**, University of Cali-
fornia Berkeley.

Arithmetic Geometry (Code: SS 13A), **Adebisi Agboola**,
University of California Santa Barbara, and **Cristian Du-
mitru Popescu**, University of California San Diego.

Automorphisms of Surfaces (Code: SS 4A), **Anthony
Weaver**, Bronx Community College of the City University
of New York, and **Peter Turbek**, Purdue University Calumet.

Complexity of Computation and Algorithms (Code: SS 10A),
Mark Burgin, University of California Los Angeles.

Curvature in Group Theory and Combinatorics (Code: SS
11A), **Laura M. Anderson**, State University of New York at
Binghamton, **Noel Patrick Brady**, University of Oklahoma,
Robin Forman, Rice University, and **Jonathan P. McCam-
mond**, University of California Santa Barbara.

Dynamical Systems in Neuroscience (Code: SS 1A), **Eugene
M. Izhikevich**, The Neurosciences Institute.

Function Theory (Code: SS 12A), **Mihai Putinar** and **Stephan
R. Garcia**, University of California Santa Barbara.

Geometric Methods in Three Dimensions (Code: SS 6A),
Daryl Cooper, **David Darren Long**, and **Martin G. Scharle-
mann**, University of California Santa Barbara.

Geometry and Physics (Code: SS 8A), **Xianzhe Dai**, University
of California Santa Barbara, and **Zhiqin Lu**, University of
California Irvine.

History of Mathematics (Code: SS 2A), **Shawnee L. Mc-
Murrin**, California State University San Bernardino, and
James J. Tattersall, Providence College.

Noncommutative Geometry and Algebra (Code: SS 5A),
Kenneth R. Goodearl, University of California Santa Bar-
bara, **J. T. Stafford**, University of Michigan, and **J. J. Zhang**,
University of Washington.

Recent Advances in Combinatorial Number Theory (Code:
SS 3A), **Mei-Chu Chang**, University of California Riverside,
and **Van Ha Vu**, University of California San Diego.

Representation Theory of Algebras (Code: SS 7A), **Ed Green**,
Virginia Polytechnic Institute and State University, **Alex
Martsinkovsky**, Northeastern University, **Dan Zacharia**,
Syracuse University, and **Birge K. Huisgen-Zimmermann**,
University of California Santa Barbara.

Ricci Flow/Riemannian Geometry (Code: SS 9A), **Guofang
Wei** and **Rugang Ye**, University of California Santa Barbara.

Mainz, Germany

June 16–19, 2005

Thursday – Sunday

Meeting #1008

*Joint International Meeting with the Deutsche Mathematiker-
Vereinigung (DMV) and the Oesterreichische Mathematis-
che Gesellschaft (OMG)*

Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2005
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/sectional.html.

Invited Addresses

Helène Esnault, University of Essen, *Title to be announced.*
Richard Hamilton, Columbia University, *Title to be announced.*
Michael J. Hopkins, Massachusetts Institute of Technology, *Title to be announced.*
Christian Krattenthaler, University of Lyon-I, *Title to be announced.*
Frank Natterer, University of Muenster, *Title to be announced.*
Hong-Tzer Yau, New York University and Stanford University, *Title to be announced.*

Special Sessions

Affine Algebraic Geometry, **Shreeram Abhyankar**, Purdue University, **Hubert Flenner**, Fakultät für Mathematik, and **Makar Limanov**, Wayne State University.
Algebraic Combinatorics, **Patricia Hersh**, University of Michigan, **Christian Krattenthaler**, University of Lyon-I, and **Volkmar Welker**, Philipps University Marburg.
Algebraic Cryptography, **Dorian Goldfeld**, Columbia University, **Martin Kreuzer** and **Gerhard Rosenberger**, Universität Dortmund, and **Vladimir Shpilrain**, City College of New York.
Algebraic Cycles, **Eric Friedlander** and **Marc Levine**, Northwestern University, and **Fabien Morel**, Université Paris.
Algebraic Geometry, **Yuri Tschinkel**, Georg-August-Universität Göttingen, and **Brendan E. Hassett**, Rice University.
Dirac Operators, Clifford Analysis and Applications, **Klaus Gürlebeck**, University of Weimar, **Mircea Martin**, Baker University, **John Ryan**, University of Arkansas, and **Michael Shapiro**, IPN Mexico.
Discrete Geometry, **Jacob Eli Goodman**, The City College of New York (CUNY), **Emo Welzl**, Eidgen Technische Hochschule, and **Gunter M. Ziegler**, Technical University of Berlin.
Function Spaces and Their Operators, **Ernst Albrecht**, Universität des Saarlandes, **Raymond Mortini**, Université de Metz, and **William Ross**, University of Richmond.

Functional Analytic and Complex Analytic Methods in Linear Partial Differential Equations, **R. Meise**, University of Dusseldorf, **B. A. Taylor**, University of Michigan, and **Dieter Vogt**, University of Wuppertal.

Geometric Analysis, **Victor Nistor**, Pennsylvania State University, and **Elamr Schrohe**, Universität Hannover.

Geometric Topology and Group Theory, **Cameron McA. Gordon**, The University of Texas at Austin, **Cynthia Hog- Angeloni**, Johann Wolfgang Goethe-Universität, and **Wolfgang Metzler**, University of Frankfurt.

Group Theory, **Luise-Charlotte Kappe**, Universität Freiburg, **Robert Fitzgerald Morse**, University of Evansville, and **Gerhard Rosenberger**, University of Dortmund.

Hilbert Functions and Syzygies, **Uwe Nagel**, University of Kentucky, **Irena Peeva**, Cornell University, and **Tim Römer**, Universität Osnabrück.

History of Mathematics: Mathematics and War, **Thomas W. Archibald**, Acadia University, **John H. McCleary**, Vassar College, **Moritz Epple**, University of Stuttgart, and **Norbert Schappacher**, Technische Universität Darmstadt.

Homotopy Theory, **Paul G. Goerss**, Northwestern University, **Hans-Werner Henn**, Institut de Recherche Mathématique Avancée, Strasbourg, and **Stefan Schwede**, Universität Bonn.

Hopf Algebras and Quantum Groups, **Susan Montgomery**, University of Southern California, and **Hans-Jürgen Schneider**, University of Munich.

Mathematics Education, **Gunter Torner**, Universität Duisburg-Essen, and **Alan Schoenfeld**, School of Education, Berkeley.

Modules and Comodules, **Sergio López-Permouth**, Ohio University, and **Robert Wisbauer**, University of Düsseldorf.

Multiplicative Arithmetic of Integral Domains and Monoids, **Scott Chapman**, Trinity University, San Antonio, **Franz Halter-Koch**, University of Graz, and **Ulrich Krause**, Universität Bremen.

Nonlinear Elliptic Boundary Value Problems, **Thomas Bartsch**, Universität Giessen, and **Zhi-Qiang Wang**, Utah State University.

Nonlinear Waves, **Herbert Koch**, University of Dortmund, and **Daniel I. Tataru**, University of California Berkeley.

Ordinary Differential, Difference, and Dynamic Equations, **Werner Balser**, Universität Ulm, **Martin Bohner**, University of Missouri-Rolla, and **Donald Lutz**, San Diego State University.

Quantum Knot Invariants, **Anna Beliakova**, Universität Zürich, and **Uwe Kaiser**, Boise State University.

Representations and Cohomology of Groups and Algebras, **Dave Benson**, University of Georgia, and **Henning Krause**, Universität Paderborn.

Set Theory, **Joel Hamkins**, City University New York, **Peter Koepke**, Universität Bonn, and **Benedikt Löwe**, Universiteit van Amsterdam.

Spectral Analysis of Differential and Difference Operators, **Evgeni Korotyaev**, Humboldt-University Berlin, **Boris**

Mityagin, The Ohio State University, and **Gerald Teschl**, University of Vienna.

Stochastic Analysis on Metric Spaces, **Laurent Saloff-Coste**, Cornell University, **Karl-Theodor Sturm**, University of Bonn, and **Wolfgang Woess**, Graz Technical University.

Topics in Applied Mathematics and Mechanics: Mathematical Control Theory and Numerical Methods, **Peter Benner**, Fakultät für Mathematik.

Topics in Applied Mathematics and Mechanics: Mechanics, **Friedrich Pfeiffer**, Technical University of Munich.

Topics in Applied Mathematics and Mechanics: Multiscale Problems, Oscillations in PDEs, and Homogenization, **Alexander Mielke**, University of Hannover.

Topics in Applied Mathematics and Mechanics: Numerical PDEs, Equations with Inherent Conditions, **Rolf Jeltsch**, Eidgen Technische Hochschule, **Maria Lukacova**, Technical University of Brno, and **Mac Hyman**, Los Alamos National Laboratory.

Topics in Applied Mechanics: Algebraic Approaches to Preconditioning, **Heike Fassbender**, Technical University of Braunschweig, and **Andreas Frommer**, University of Wuppertal.

Topology of Manifolds, **Matthias Kreck**, University of Heidelberg, and **Andrew Ranicki**, University of Edinburgh.

Annandale-on-Hudson, New York

Bard College

October 8–9, 2005

Saturday – Sunday

Meeting #1009

Eastern Section

Associate secretary: Lesley M. Sibner

Announcement issue of *Notices*: August 2005

Program first available on AMS website: August 25, 2005

Program issue of electronic *Notices*: October 2005

Issue of *Abstracts*: Volume 26, Issue 4

Deadlines

For organizers: March 8, 2005

For consideration of contributed papers in Special Sessions:
June 21, 2005

For abstracts: August 16, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Persi Diaconis, Stanford University, *Title to be announced* (Erdős Memorial Lecture).

Special Sessions

Geometric Group Theory (Code: SS 1A), **Sean Cleary**, The City College of New York, and **Melanie I. Stein**, Trinity College.

The History of Mathematics (Code: SS 2A), **Patricia R. Allaire**, Queensborough Community College, CUNY, **Robert E. Bradley**, Adelphi University, and **Jeff Suzuki**, Bard College.

Johnson City, Tennessee

East Tennessee State University

October 15–16, 2005

Saturday – Sunday

Meeting #1010

Southeastern Section

Associate secretary: John L. Bryant

Announcement issue of *Notices*: August 2005

Program first available on AMS website: September 1, 2005

Program issue of electronic *Notices*: October 2005

Issue of *Abstracts*: Volume 26, Issue 4

Deadlines

For organizers: March 15, 2005

For consideration of contributed papers in Special Sessions:
June 28, 2005

For abstracts: August 23, 2005

Lincoln, Nebraska

University of Nebraska in Lincoln

October 21–23, 2005

Friday – Sunday

Meeting #1011

Central Section

Associate secretary: Susan J. Friedlander

Announcement issue of *Notices*: August 2005

Program first available on AMS website: September 8, 2005

Program issue of electronic *Notices*: October 2005

Issue of *Abstracts*: Volume 26, Issue 4

Deadlines

For organizers: March 22, 2005

For consideration of contributed papers in Special Sessions:
July 5, 2005

For abstracts: August 30, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Howard Masur, University of Illinois at Chicago, *Title to be announced.*

Alejandro Uribe, University of Michigan, *Title to be announced.*

Judy Walker, University of Nebraska, *Title to be announced.*

Jack Xin, University of Texas, *Title to be announced.*

Special Sessions

Algebraic Geometry (Code: SS 1A), **Brian Harbourne**, University of Nebraska-Lincoln, and **Bangere P. Purnaprajna**, University of Kansas.

Eugene, Oregon

University of Oregon

November 12–13, 2005

Saturday – Sunday

Meeting #1012

Western Section

Associate secretary: Michel L. Lapidus

Announcement issue of *Notices*: September 2005

Program first available on AMS website: September 29, 2005

Program issue of electronic *Notices*: November 2005

Issue of *Abstracts*: Volume 26, Issue 4

Deadlines

For organizers: April 12, 2005

For consideration of contributed papers in Special Sessions:
July 26, 2005

For abstracts: September 20, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtg/sectional.html.

Invited Addresses

Matthew Foreman, University of California Irvine, *Title to be announced.*

Mark Haiman, University of California Berkeley, *Title to be announced.*

Wilhelm Schlag, California Institute of Technology, *Title to be announced.*

Hart H. Smith, University of Washington, *Title to be announced.*

Taiwan

December 14–18, 2005

Wednesday – Sunday

Meeting #1013

First Joint International Meeting between the AMS and the Taiwanese Mathematical Society.

Associate secretary: John L. Bryant

Announcement issue of *Notices*: May 2005

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

January 12–15, 2006

Thursday – Sunday

Joint Mathematics Meetings, including the 112th Annual Meeting of the AMS, 89th 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), the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: John L. Bryant

Announcement issue of *Notices*: October 2005

Program first available on AMS website: To be announced

Program issue of electronic *Notices*: January 2006

Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 12, 2005

For consideration of contributed papers in Special Sessions:
To be announced

For abstracts: To be announced

For summaries of papers to MAA organizers: To be announced

Durham, New Hampshire

University of New Hampshire

April 22–23, 2006

Saturday – Sunday

Eastern Section

Associate secretary: Lesley M. Sibner

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 22, 2005

For consideration of contributed papers in Special Sessions:
To be announced

For abstracts: To be announced

San Francisco, California

San Francisco State University

April 29–30, 2006

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: 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/sectional.html.

Special Sessions

History of Mathematics (Code: SS 1A), **Shawnee L. McMurran**, California State University San Bernardino, and **James J. Tattersall**, Providence College.

Fayetteville, Arkansas

University of Arkansas

November 3–4, 2006

Friday – Saturday

Southeastern Section

Associate secretary: John L. Bryant

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: April 3, 2006

For consideration of contributed papers in Special Sessions:
To be announced

For abstracts: To be announced

New Orleans, Louisiana

New Orleans Marriott and Sheraton

New Orleans Hotel

January 4–7, 2007

Thursday – Sunday

Joint Mathematics Meetings, including the 113th Annual Meeting of the AMS, 90th 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: Susan J. Friedlander

Announcement issue of *Notices*: October 2006

Program first available on AMS website: To be announced

Program issue of electronic *Notices*: January 2007

Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 4, 2006

For consideration of contributed papers in Special Sessions:
To be announced

For abstracts: To be announced

For summaries of papers to MAA organizers: To be announced

San Diego, California

San Diego Convention Center

January 6–9, 2008

Sunday – Wednesday

Joint Mathematics Meetings, including the 114th Annual Meeting of the AMS, 91st 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).

Associate secretary: Michel L. Lapidus

Announcement issue of *Notices*: October 2007

Program first available on AMS website: November 1, 2007

Program issue of electronic *Notices*: January 2008

Issue of *Abstracts*: Volume 29, Issue 1

Deadlines

For organizers: April 6, 2007

For consideration of contributed papers in Special Sessions:
To be announced

For abstracts: To be announced

For summaries of papers to MAA organizers: To be announced

Washington, District of Columbia

Marriott Wardman Park Hotel and Omni Shoreham Hotel

January 7–10, 2009

Wednesday – Saturday

Joint Mathematics Meetings, including the 115th Annual Meeting of the AMS, 92nd 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).

Associate secretary: Lesley M. Sibner

Announcement issue of *Notices*: October 2008

Program first available on AMS website: November 1, 2008

Program issue of electronic *Notices*: January 2009

Issue of *Abstracts*: Volume 30, Issue 1

Deadlines

For organizers: April 7, 2008

For consideration of contributed papers in Special Sessions:
To be announced

For abstracts: To be announced

For summaries of papers to MAA organizers: To be announced

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 6–9, 2010

Wednesday – Saturday

Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd 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).

Associate secretary: John L. Bryant

Announcement issue of *Notices*: October 2009

Program first available on AMS website: November 1, 2009

Program issue of electronic *Notices*: January 2010

Issue of *Abstracts*: Volume 31, Issue 1

Deadlines

For organizers: April 5, 2009

For consideration of contributed papers in Special Sessions:
To be announced

For abstracts: To be announced

For summaries of papers to MAA organizers: To be announced

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011

Wednesday – Saturday

Joint Mathematics Meetings, including the 117th Annual Meeting of the AMS, 94th 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 for Symbolic Logic (ASL).

Associate secretary: Susan J. Friedlander

Announcement issue of *Notices*: October 2010

Program first available on AMS website: November 1, 2010

Program issue of electronic *Notices*: January 2011

Issue of *Abstracts*: Volume 32, Issue 1

Deadlines

For organizers: April 2, 2010

For consideration of contributed papers in Special Sessions:
To be announced

For abstracts: To be announced

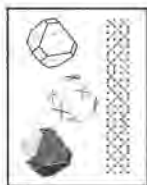
For summaries of papers to MAA organizers: To be announced

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AAAS Meeting to Offer Strong Mathematics Program

The 2005 Annual Meeting of the American Association for the Advancement of Science, February 17–21, in Washington, DC, will feature many outstanding expository talks by prominent mathematicians. These include the following three-hour symposia (and organizers) sponsored by Section A (Mathematics) of the AAAS:

- Mathematical Oncology: Bridging the Scientific Divide (Kristin Swanson, University of Washington)
- Understanding the Interaction of Noise in Complex Systems (Rachel Kruske, University of British Columbia)
- Mapping the Human Brain from Infancy to Old Age (Paul Thompson, UCLA School of Medicine)
- Finding and Keeping Graduate Students in the Mathematical Sciences (Amy Cohen, Rutgers University)

Other symposia that will be of interest to the mathematical community include:

Mathematics and Human Infectious Disease
Something from Nothing? Scientific Inference and Missing Data
Complex Adaptive Systems: Advances in Theory and Practice
Mathematics and Biology 2010: Linking Undergraduate Disciplines
Einstein in Historical and Philosophical Perspective
Astrotomography
Continuing to Learn from TIMSS and Now Also from PISA

The above symposia are only a few of the 150 or so AAAS program offerings in the physical, life, social, and biological sciences. For further details about the 2005 AAAS program, see the October 8, 2004, issue of *Science*.

AAAS annual meetings are the showcases of American science, and they encourage participation by mathematicians and mathematics educators. (AAAS acknowledges

the generous contributions of AMS for travel support and SIAM for support of media awareness.) In presenting mathematics-related themes to the AAAS Program Committee, I have found the committee to be genuinely interested in offering symposia on mathematical topics of current interest. Thus, Section A's committee seeks organizers and speakers who can present substantial new material in an accessible manner to a large scientific audience. Toward this end, I invite you to attend our Section A Committee business meeting 7:45 p.m.–10:45 p.m. Friday, February 18, 2005, at the Marriott Wardman park Hotel (room to be determined). I invite you also to send me, and encourage your colleagues to send me, symposia proposals for future AAAS annual meetings.

—Warren Page, secretary of Section A of the AAAS
wxpny@ao1.com

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Sproul Hall, Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 909-787-3113.

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Eastern Section: Lesley M. Sibner, Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@duke.poly.edu; telephone: 718-260-3505.

Southeastern Section: John L. Bryant, Department of Mathematics, Florida State University, Tallahassee, FL 32306-4510; e-mail: bryant@math.fsu.edu; telephone: 850-644-5805.

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:

2005		
January 5-8	Atlanta, Georgia Annual Meeting	p. 1403
March 18-19	Bowling Green, Kentucky	p. 1404
April 2-3	Newark, Delaware	p. 1405
April 8-10	Lubbock, Texas	p. 1406
April 16-17	Santa Barbara, California	p. 1407
June 16-19	Mainz, Germany	p. 1407
October 8-9	Annandale-on-Hudson, New York	p. 1409
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October 21-22	Lincoln, Nebraska	p. 1409
November 12-13	Eugene, Oregon	p. 1410
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2006		
January 12-15	San Antonio, Texas Annual Meeting	p. 1410
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April 29-30	San Francisco, California	p. 1411
November 3-4	Fayetteville, Arkansas	p. 1411
2007		
January 4-7	New Orleans, Louisiana Annual Meeting	p. 1411

2008		
January 6-9	San Diego, California Annual Meeting	p. 1412
2009		
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2010		
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2011		
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Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 84 in the January 2004 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Several options are available for speakers submitting abstracts, including an 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 similarly coded material (such as accent marks in text) must be typeset in \LaTeX . To see descriptions of the forms available, visit <http://www.ams.org/abstracts/instructions.html>, or send mail to abs-submit@ams.org, typing help as the subject line; descriptions and instructions on how to get the template of your choice will be e-mailed to you.

Completed email abstracts should be sent to abs-submit@ams.org, typing submission as the subject line. Questions about abstracts may be sent to abs-info@ams.org.

Paper abstract forms may be sent to Meetings & Conferences Department, AMS, P.O. Box 6887, Providence, RI 02940. There is a \$20 processing fee for each paper abstract. There is no charge for electronic abstracts. Note that all abstract deadlines are strictly enforced.

Conferences: (see <http://www.ams.org/meetings/> for the most up-to-date information on these conferences.)

June 5-July 21, 2005: Joint Summer Research Conferences in the Mathematical Sciences, Snowbird, Utah (see November 2004 *Notices*, page 1294).

July 25-August 12, 2005: Summer Research Institute on Algebraic Geometry, Seattle, Washington (see November 2004 *Notices*, page 1293).

Co-sponsored conference: June 2006: Fifth Conference on Poisson Geometry, Tokyo, Japan (watch <http://tmugs.math.metro-u.ac.jp/general.html> for future information).



Joint Meetings Advance Registration/Housing Form

Name _____
(please write name as you would like it to appear on your badge)

Mailing Address _____

Telephone _____ Fax: _____

In case of emergency at the meeting, call: Daytime # _____ Evening #: _____

Email Address _____

(Acknowledgment of this registration will be sent to the email address given here, unless you check this box: *Send by U.S. Mail*)

Badge Information:

Affiliation for badge _____

Nonmathematician guest badge name _____
(please note charge below)

I DO NOT want my program and badge to be mailed to me on 12/10/04.

Registration Fees

Joint Meetings	by Dec 10	at mtg	Subtotal
<input type="checkbox"/> Member AMS, ASL, CMS, MAA, SIAM	\$ 199	\$ 259	
<input type="checkbox"/> Nonmember	\$ 308	\$ 401	
<input type="checkbox"/> Graduate Student	\$ 39	\$ 49	
<input type="checkbox"/> Undergraduate Student	\$ 21	\$ 27	
<input type="checkbox"/> High School Student	\$ 2	\$ 5	
<input type="checkbox"/> Unemployed	\$ 39	\$ 49	
<input type="checkbox"/> Temporarily Employed	\$ 158	\$ 181	
<input type="checkbox"/> Developing Countries Special Rate	\$ 39	\$ 49	
<input type="checkbox"/> Emeritus Member of AMS or MAA	\$ 39	\$ 49	
<input type="checkbox"/> High School Teacher	\$ 39	\$ 49	
<input type="checkbox"/> Librarian	\$ 39	\$ 49	
<input type="checkbox"/> Nonmathematician Guest	\$ 10	\$ 10	

\$ _____

AMS Short Course: The Radon Transform and Applications to Inverse Problems (1/3-1/4)

<input type="checkbox"/> Member of AMS or MAA	\$ 85	\$ 115
<input type="checkbox"/> Nonmember	\$ 108	\$ 140
<input type="checkbox"/> Student, Unemployed, Emeritus	\$ 37	\$ 55

\$ _____

MAA Short Course: Seven Lectures on Random Graphs (1/3-1/4)

<input type="checkbox"/> Member of MAA or AMS	\$ 125	\$ 140
<input type="checkbox"/> Nonmember	\$ 175	\$ 190
<input type="checkbox"/> Student, Unemployed, Emeritus	\$ 50	\$ 60

\$ _____

MAA Minicourses (see listing in text)

I would like to attend: One Minicourse Two Minicourses
Please enroll me in MAA Minicourse(s) # _____ and/or # _____
In order of preference, my alternatives are: # _____ and/or # _____
Prices: \$95 for Minicourses #1-6; \$60 for #7-12, #14-16; \$70 for #13

\$ _____

Employment Center

Applicant résumé forms and employer job listing forms will be on the AMS website and in *Notices* in September and October.

Employer—First Table \$ 225 \$ 305

Regular Self-scheduled

Employer—Each Additional Table \$ 75 \$ 105

Regular Self-scheduled

Employer—Posting Only \$ 50 N/A

Applicant (all services) \$ 42 \$ 80

Applicant (Winter List & Message Ctr only) \$ 21 \$ 21

\$ _____

Events with Tickets

MER Banquet (1/6) \$45 # _____Regular # _____Veg # _____Kosher

NAM Banquet (1/7) \$48 # _____Regular # _____Veg # _____Kosher

AMS Banquet (1/8) \$44 # _____Regular # _____Veg # _____Kosher

\$ _____

Other Events

Graduate Student Reception (1/5) (no charge)

AMS Workshop *TA Development Using Case Studies* \$ 20 \$ _____

Total for Registrations and Events

\$ _____

Registration for the Joint Meetings is not required for the Short Courses, but it is required for the Minicourses and the Employment Center

Payment

Registration & Event Total (total from column on left) \$ _____

Hotel Deposit (only if paying by check) \$ _____

Total Amount To Be Paid \$ _____

(Note: A \$5 processing fee will be charged for each returned check or invalid credit card. Debit cards are not accepted.)

Method of Payment

Check. Make checks payable to the AMS. Checks drawn on foreign banks must be in equivalent foreign currency at current exchange rates.

Credit Card. VISA, MasterCard, AMEX, Discover (no others accepted)

Card number: _____

Exp. date: _____ Zipcode of credit card billing address: _____

Signature: _____

Name on card: _____

Purchase order # _____ (please enclose copy)

Other Information

Mathematical Reviews field of interest # _____

How did you hear about this meeting? Check one: Colleague(s) Notices


Focus Internet

This is my first Joint Mathematics Meeting.

I am a mathematics department chair.

For planning purposes for the MAA Two-year College Reception, please check if you are a faculty member at a two-year college.

Please do not include my name on any promotional mailing list.

Please this box if you have a disability requiring special services. 

Mail to:

Mathematics Meetings Service Bureau (MMSB)

P. O. Box 6887

Providence, RI 02940-6887 Fax: 401-455-4004

Questions/changes call: 401-455-4143 or 1-800-321-4267 x4143; mmsb@ams.org

Deadlines Please register by the following dates for:

Résumés/job descriptions printed in the *Winter Lists* **Oct. 25, 2004**

To be eligible for the room lottery: **Oct. 29, 2004**

For housing reservations, badges/programs mailed: **Nov. 5, 2004**

For housing changes/cancellations through MMSB: **Dec. 3, 2004**

For advance registration for the Joint Meetings, Employment Center, Short Courses, MAA Minicourses, & Tickets: **Dec. 10, 2004**

For 50% refund on banquets, cancel by: **Dec. 27, 2004***

For 50% refund on advance registration, Minicourses & Short Courses, cancel by: **Dec. 31, 2004***

***no refunds after this date**

Atlanta Joint Meetings Hotel Reservations

To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc., in the column on the left and by circling the requested room type and rate. If the rate or the hotel requested is no longer available, you will be assigned a room at a ranked or unranked hotel at a comparable rate. Participants are urged to call the hotels directly for details on suite configurations, sizes, and availability; however, suite reservations can be made only through the MMSB to receive the convention rates listed. Reservations at the following hotels must be made through the MMSB to receive the convention rates listed. Reservations made directly with the hotels may be changed to a higher rate. All rates are subject to a 14% sales tax.

Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.

Deposit enclosed (see front of form) Hold with my credit card Card Number _____ Exp. Date _____
 Signature _____

Date and Time of Arrival _____ **Date and Time of Departure** _____ **Child (give age(s))** _____
Name of Other Room Occupant _____ **Arrival Date** _____ **Departure Date** _____ **Child (give age(s))** _____
Name of Other Room Occupant _____ **Arrival Date** _____ **Departure Date** _____ **Child (give age(s))** _____

Order of choice	Hotel	Single	Double 1 bed	Double 2 beds	Triple 2 beds	Triple 2 beds w/cot	Triple King w/cot	Quad 2 beds	Quad 2 beds w/cot	Suites Starting rates
	Hyatt Regency Atlanta (co-hqtrs) - Regular Rooms	\$144	\$144	\$144	\$164	N/A	\$164	\$174	N/A	\$550
	Club Level	\$179	\$179	\$179	\$199	N/A	\$199	N/A	N/A	N/A
	Student	\$116	\$116	\$116	\$126	N/A	\$126	\$136	N/A	N/A
	Atlanta Marriott Marquis (co-hqtrs) - Regular Rooms	\$144	\$144	\$144	\$164	N/A	\$164	\$184	N/A	\$255
	Concierge Level	\$184	\$184	\$184	\$204	N/A	\$204	N/A	N/A	N/A
	Student	\$116	\$116	\$116	\$136	N/A	\$136	\$156	N/A	N/A
	AmeriSuites	\$99	\$99	\$99	\$109 (Double/double or King with sleeper)	N/A	N/A	\$119	N/A	(all suites)
	Holiday Inn Atlanta Downtown	\$99	\$99	\$99	\$99	N/A	\$109 (queen w/cot)	\$99	N/A	N/A
	Days Inn Atlanta Downtown	\$99	\$99	\$99	\$109	\$119	\$119	\$119	\$129	N/A
	Best Western Inn at the Peachtree	\$89	\$89	\$89	\$99	\$109	\$109	\$109	\$119	N/A

Special Housing Requests:

- I have disabilities as defined by the ADA that require a sleeping room that is accessible to the physically challenged. My needs are: _____
- Other requests: _____
- I am a member of a hotel frequent-travel club and would like to receive appropriate credit. The hotel chain and card number are: _____

If you are not making a reservation, please check off one of the following:

- I plan to make a reservation at a later date.
- I will be making my own reservations at a hotel not listed. Name of hotel: _____
- I live in the area or will be staying privately with family or friends.
- I plan to share a room with _____, who is making the reservations.

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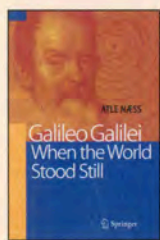
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