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Notices

of the American Mathematical Society

February 2008

Volume 55, Number 2

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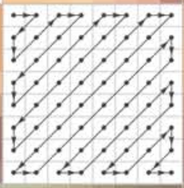

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of the American Mathematical Society

February 2008

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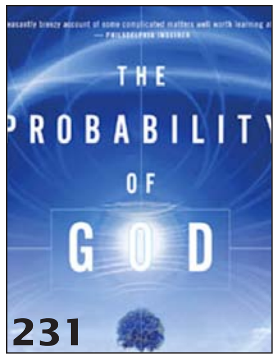
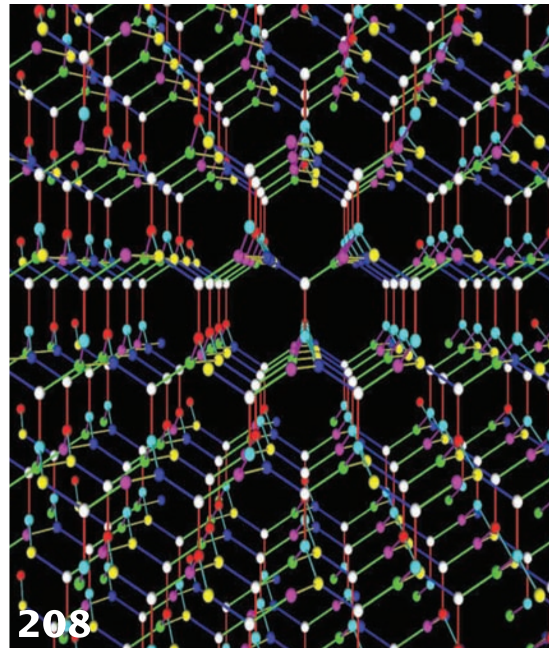
Commentary





Features

Notices
of the American Mathematical Society

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Departments

From the AMS Secretary

Opinion

What Does an AMS Congressional Fellow Do?

I had the honor and pleasure of serving as the 2006–2007 AMS Congressional Fellow. I was one of 32 Science Policy Congressional Fellows in a program run by the American Association for the Advancement of Science (AAAS). Each AAAS Fellowship is funded by a different scientific or engineering society. For example, the American Physical Society funds two fellows each year, the American Institute of Physics funds another, the American Nuclear Society two more, and the American Geophysical Union yet another. The AMS funds the lone fellowship for a mathematician. This is money well spent. The fellowship will pay dividends over the long term (like pure mathematics does), as mathematicians become a regular voice in the policy process in our country.

I served my fellowship with the House of Representatives Committee on Science (renamed Committee on Science and Technology in January 2007), working for the Subcommittee on Research (renamed Subcommittee on Research and Science Education in January 2007). Among the permanent staffers for the Committee are three Ph.D. physicists, all former AAAS Fellows. The Subcommittee has authorization jurisdiction over the National Science Foundation, and the focus of my job was to analyze programs at the NSF, especially those involving education. My fellowship came at an opportune time. Rep. Bart Gordon (D-Tenn), chair of the Committee, introduced a number of bills involving the NSF on January 10, 2007, in the opening days of the 110th Congress. Those bills later became part of the 21st Century Competitiveness Act of 2007, which President Bush signed into law on August 9, 2007, as my fellowship was ending.

Chairman Gordon's legislative agenda for 2007 was in large part to implement the recommendations of an influential National Academies report entitled *Rising Above the Gathering Storm; Energizing and Employing America for a Brighter Economic Future*. This report recommended major increases in national investment in science, technology, engineering, and mathematics. The report was adopted on Capitol Hill by both major political parties as a blueprint for advancing national prosperity, and the current administration's American Competitiveness Initiative picked up on many of the recommendations from the report as well.

The word "competitiveness" is popular on Capitol Hill these days, referring to America's ability to compete with the rapidly advancing third world amid globalization. It is an unfortunate term, in my view. I prefer the word "prosperity", which puts the emphasis on the absolute rather than relative health of our nation.

The 21st Century Competitiveness Act runs several hundred pages. The principal focus in my office was Title 7, a reauthorization of the National Science Foundation. This Title sets policies, priorities, and budgets for the NSF for the next three fiscal years. Although the NSF is a widely admired agency, supported from all corners, the reauthorization legislation was not without controversy. Almost any word in those hundreds of pages can serve as a flashpoint for passionate disagreement. Settling on an annual rate of NSF funding increase of 11% was not easy.

It is important to understand that such increases are merely authorizations, not appropriations. Government agencies are funded in a two-part process. The first part, authorization, is often done several years at a time, but the budget numbers there are merely upper bounds (in theory) for the final numbers. The second part, appropriation, is an annual process (in theory), but appropriated dollars can be smaller than authorized amounts. We can expect annual political fights to appropriate to the NSF the dollars authorized by the 21st Century Competitiveness Act.

My day-to-day tasks around the office included meeting with a variety of interested associations, organizing legislative hearings, publishing hearing reports, drafting talking points, writing scripts for committee mark-ups, composing memos supporting various policy positions, providing support for the bills on the House floor, and assisting with the negotiation of a compromise bill in the House-Senate conference.

Not everything in the final bill was implemented just as the Gathering Storm report envisioned. In particular, the Gathering Storm report recommended that "physical sciences, engineering, mathematics, and information sciences" be areas of special emphasis for government investment. But the legislative language to implement this priority got watered down in several stages. The final bill designates for priority treatment at NSF "physical or natural science, technology, engineering, social sciences, or mathematics, or [areas] that enhance competitiveness, innovation, or safety and security in the United States".

In the end, I came away from the fellowship recognizing the vital role that policy plays for mathematics as well as the important role that mathematics plays in setting policy. If mathematics were just an abstruse study of an unreal world, beautiful but disconnected and irrelevant, then there would be no reason for our government to fund it or our children to learn it. It is imperative that the mathematics community impresses upon policy-makers that mathematics is a tool for solving human problems, for improving the human condition, for advancing national prosperity. Only when this is fully appreciated does supporting mathematics become a critical element of our national competitiveness (or rather, prosperity) policy.

Ask yourself why the administration's FY2007 budget request gave the Division of Mathematical Sciences at NSF a 3.2% increase while the Division of Physics got a 6.6% increase. The answer is that these numbers represented priorities established by policy-makers at that time. Now ask yourself how the mathematics community can influence such priorities. One way is to continue to support the AMS Congressional Fellowship program, so that more people in the business of setting national priorities learn to recognize the value of mathematics and mathematicians.

—Daniel Ullman
George Washington University
`dullman@gwu.edu`

Letters to the Editor

The Pythagoras Game

John Bonaccorsi's letter to the editor in the November 2007 *Notices* asks about a "Pythagoras" game that B. L. van der Waerden had as a child. I think that he refers to the "gadget" (*médaille* in French, but nothing to do with awards) distributed by the Paul Kramer factory based in Neuchâtel, at the beginning of the twentieth century.

I received it several years ago as a present, and I went to the factory: the grandson of Paul Kramer was as fascinated as I was.

Unfortunately, they have no archives. I would have liked to see this game distributed in our local high schools… A technican made a prototype for me, but there is no chance of having any re-edition so far.

—Alain M. Robert
Neuchâtel University
`Alain.Robert@unine.ch`

(Received November 12, 2007)

Editor's Note: In adition to Alain Robert, many other readers have written letters to the *Notices* and/or John Bonaccorsi identifying the Pythagoras game and their experiences with it. The two printed here are representative.

In the November 2007 *Notices* there is a letter querying the game "Pythagoras", which came up in an interview of van der Waerden. I have an old game called "Pythagoras", manufactured by Tryne Games Mfg., Inc. (Lindenhurst, L.I., New York), with copyright date 1961. This is a puzzle with seven plastic pieces to be arranged into squares and various shapes, fitting the description given in the letter. The puzzle is in fact precisely the classic Tangrams puzzle.

—Don Chakerian
Davis, CA
`Dmandgd@aol.com`

(Received October 30, 2007)

I also grew up playing the Pythagoras game and my kids play it now. Although the game describes itself as a Greek game it is exactly the same as the Chinese game Tangram. The pieces consist of one square, one parallelogram, and five right isosceles triangles of various sizes (2 large, 1 medium, and 2 small). The set comes with almost a hundred puzzles to solve, which consist of shaded shapes one needs to construct using all seven pieces. I highly recommend Tangrams for all kids 8 and up.

Younger children might prefer versions where the puzzles are the same scale as the pieces. Most popular is fitting the pieces together as a square to put them away in the box.

—Christina Sormani
CUNY GC and Lehman Colleges
`sormanic@member.ams.org`

(Received November 16, 2007)

F. Schur, not I. Schur

Among the authors who developed, about 100 years ago, axiomatic frameworks for geometry, Charles Weibel mentions in his "Survey of non-Desarguesian planes" [*Notices*, November 2007, p. 1294] the name I. Schur. It was not Issai Schur (1875–1941) (who worked in the representation theory of groups, number theory, and analysis, but not in geometry), but Friedrich Schur (1856–1932) who is meant. F. Schur's work on the axiomatic foundation of geometry was summarized in his book *Grundlagen der Geometrie*, Teubner, Leipzig, 1909. He received the Lobachevsky Prize in 1912.

—Victor Pambuccian
Arizona State University—West Campus
`pamb@math.west.asu.edu`

(Received October 31, 2007)

Submitting Letters to the Editor

The *Notices* invites readers to submit letters and opinion pieces on topics related to mathematics. Electronic submissions are preferred (`notices-letters@ams.org`); see the masthead for postal mail addresses. Opinion pieces are usually one printed page in length (about 800 words). Letters are normally less than one page long, and shorter letters are preferred.

Identifications

Affiliations of authors of "Letters to the Editor" are provided for identification purposes only. Opinions expressed in letters are those of the authors and do not necessarily reflect those of their employers or, in the case of American Mathematical Society officers or committee members, policies of the Society. Committee reports to the Council of the Society and official communications of officers of the Society, when published in the *Notices*, appear in the section of the *Notices* "From the AMS Secretary".

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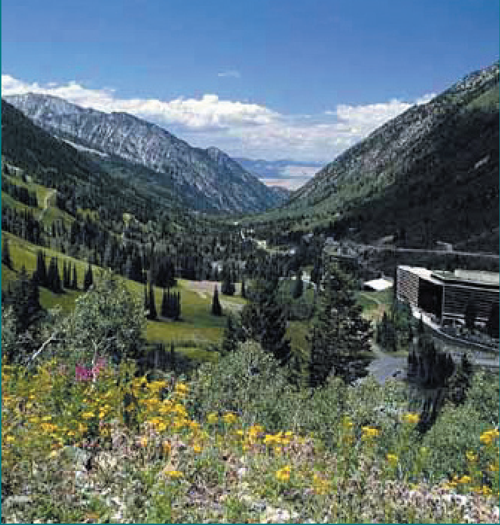
This program is contingent on the receipt of funds under a grant from federal funding agencies.



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- Teichmüller Theory & Low-Dimensional Topology
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Crystals That Nature Might Miss Creating

Toshikazu Sunada

No one should have any objections against the claim that the *diamond crystal*, the most precious gem polished usually with the brilliant cut, casts a spell on us by its stunning beauty. The beauty would be more enhanced and its emotional appeal would be raised to a rational one if we would explore the microscopic structure, say the periodic arrangement of carbon atoms, which is actually responsible for the dazzling glaze caused by the effective refraction and reflection of light. Figure 1, found in many textbooks of solid state physics, illustrates the arrangement of atoms together with the bonding (depicted by thin lines) of atoms provoked by atomic force. A close look at this figure (or its readymade model preferably) reveals that, as a 1-dimensional diagram in space, the diamond crystal is a join of the same hexagonal rings[1] and has "very big" symmetry, thereby being conspicuously distinguished from other crystals by its "microscopic beauty".

The purpose of this article is to provide a *new crystal*[2] having a remarkable mathematical structure similar to that of the diamond crystal. This "crystal", which we prosaically call the K_4 *crystal* with good reason, has valency 3, is a web of the same *decagonal rings*, and has very big symmetry.

Toshikazu Sunada is professor of mathematics at Meiji University, Tama-ku, Kawasaki, Japan. His email address is sunada@math.meiji.ac.jp.

[1] *The chair conformation in chemical terminology. One may observe that 12 hexagonal rings gather at each atom.*

[2] *This is different from the so-called diamond polytypes such as lonsdaleite, a rare stone of pure carbon discovered at Meteor Crater, Arizona, in 1967.*

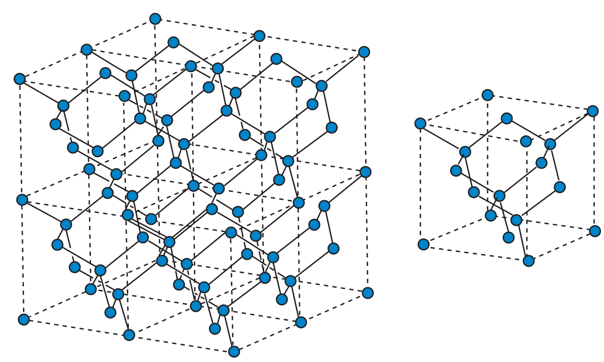

Figure 1. Carbon atoms in the diamond crystal.

A significant difference is that the K_4 crystal has *chirality* while the diamond crystal does not. Since "*nature favors symmetry*" as is justified by plenty of examples, it makes sense to ask if this mathematical object exists in nature as a real crystal, or may be synthesized with some atoms (by allowing double bonds in an appropriate way if necessary).

As mentioned above, a crystal in the mathematical sense is a periodic figure of 1 dimension consisting of *vertices* (points representing positions of atoms) and *edges* (lines representing bonding of atoms), by ignoring the physical characters of atoms and atomic forces which may be different one by one. In other words, a crystal is considered as an *infinite graph* realized periodically in space. This interpretation offers us two distinct notions of symmetry; one is *extrinsic symmetry*, the same as the classical notion bound up directly with beauty of the spatial object, which thus depends on realizations and is described in terms of congruent transformations of space;

another is *intrinsic symmetry*, the notion irrelevant to realizations, solely explained in terms of automorphisms of graphs, and hence somehow denoting beauty enshrined inward. In general, intrinsic symmetry is "bigger than" extrinsic symmetry since congruent transformations leaving the crystal invariant induce automorphisms, but not vice versa.

A special feature of the diamond crystal is that intrinsic symmetry coincides with extrinsic symmetry. Furthermore the diamond crystal has a *strong isotropic property*[3] in the sense that any permutation of 4 edges with a common end point extends to a congruent transformation preserving the diamond crystal. Those observations naturally give rise to the question as to which crystal shares such noteworthy properties. The answer, as we will see in the last section, is that the K_4 crystal (if one ignores its mirror image) is, in this sense, the diamond crystal's only "relative" (Theorem 3).

I would like to point out that the view taken up here is quite a bit different from that of classical crystallography, whose business is also the study of symmetry of crystals. Actually I came across the K_4 crystal when I was studying *discrete geometric analysis*, the field that deals with analysis on graphs by using geometric ideas cultivated in global analysis. In fact, the geometric theory of random walks on crystal lattices, a topic developed recently in [1], [3], played a crucial role in its construction.

Symmetry of the Diamond Crystal

For a start, it is worthwhile to give a precise description of the diamond crystal. Consider a regular tetrahedron $C_1C_2C_3C_4$ together with its barycenter C. The atom at the position C is bound to atoms at C_i so that we shall draw lines joining C and C_i's. We then take the regular tetrahedron $CC_2'C_3'C_4'$ with the barycenter C_1 which is to be *point-symmetrical* with respect to the midpoint A of the segment CC_1 (see Figure 2). We do the

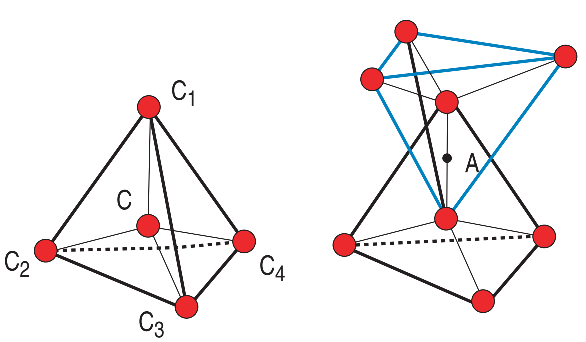

Figure 2. Regular tetrahedron.

[3] *The term "isotropic" is used in a different context in crystallography.*

same for the other three vertices C_2, C_3, C_4, and then continue this process. The 1-dimensional figure obtained in this manner turns out to be the diamond crystal.

There is another way to construct the diamond crystal, which allows us to see the periodicity explicitly. We again begin with the regular tetrahedron $C_1C_2C_3C_4$ and its barycenter C. Consider the parallelepiped P with the edges C_2C_1, C_2C_3, C_2C_4. Regarding P as a building block, we fill space solidly with parallelepipeds which are exactly alike (see Figure 3). Then the diamond crystal is formed by gathering up the copy, in each parallelepiped, of the above-mentioned figure inside P. From this construction, it follows that the additive group

$$L = \{n_1\overrightarrow{C_2C_1} + n_2\overrightarrow{C_2C_3} + n_3\overrightarrow{C_2C_4};\ n_1, n_2, n_3 \in \mathbb{Z}\}$$

leaves the diamond crystal invariant under translations $\mathbf{x} \mapsto \mathbf{x} + \sigma$ $(\sigma \in L)$. This is the periodicity that the diamond crystal possesses. In general, a crystal is characterized as a graph realized in space which is invariant under translations by a lattice group.

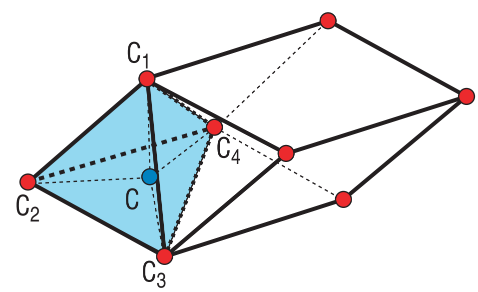

Figure 3. Parallelepiped P.

The following says that the diamond crystal not only has big symmetry, but also has a *strong isotropic property*, which as well as Observation 2 below is easily checked in view of its construction.

Observation 1. *Let p and p' be vertices of the diamond crystal. Let ℓ_1, ℓ_2, ℓ_3, ℓ_4 be the edges with the end point p, and $\ell_1', \ell_2', \ell_3', \ell_4'$ be the edges with the end point p'. Then whatever the order of edges may be, there exists a congruent transformation T leaving the diamond crystal invariant such that $T(p) = p'$ and $T(\ell_i) = \ell_i'$ $(i = 1, 2, 3, 4)$.*

A graph is, in general, an abstract object, having nothing to do with its realization and defined solely by an incidence relation between vertices and edges. When we think of the diamond crystal as an abstract graph, we call it the *diamond lattice*. More generally, a crystal as an abstract graph will be called a *crystal lattice*. Needless to say, there are many ways to realize a given crystal lattice periodically in space. For instance, Figure 4 gives a graphite-like realization of the diamond lattice.

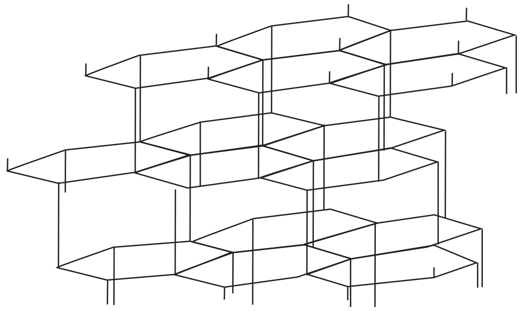

Figure 4. A realization of the diamond lattice of graphite type.

A congruent transformation leaving a crystal invariant induces an automorphism of the corresponding crystal lattice in a natural manner. But every automorphism is not necessarily derived in this way. The following says that among all periodic realizations of the diamond lattice, the diamond crystal is a realization with the biggest extrinsic symmetry.

Observation 2. *Every automorphism of the diamond lattice extends to a congruent transformation leaving the diamond crystal invariant.*

Our concern is the existence of other crystals enjoying the properties stated in these observations.

Crystal Lattices as Abelian Covering Graphs

We need more mathematics to study crystal lattices. The discipline we step into is not classical crystallography, but an elementary part in algebraic topology applied to graphs, a realm apparently unrelated to crystals.

Recall that a crystal has periodicity with respect to the action of a lattice group in space by translations. By identifying vertices (respectively, edges) when they are superposed by such translations, and by inducing the incidence relation of vertices and edges to identified objects, we obtain a finite graph[4] which we call the *fundamental finite graph*. For instance, the fundamental finite graph for the diamond crystal is the graph with 2 vertices joined by 4 multiple edges (Figure 5).

The canonical map from the crystal (lattice) onto the fundamental finite graph is a covering map, that is, a surjective map preserving the local incidence relations. Therefore what we have observed now amounts to the conclusion that a crystal lattice is an *abelian covering graph* over a finite graph with covering transformation group ismorphic to $\mathbb{Z}^3$. Having this view in mind, we give

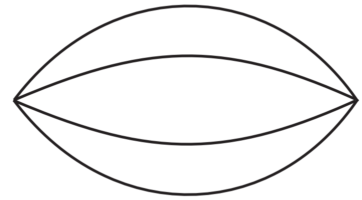

Figure 5. The fundamental finite graph for the diamond crystal.

an abstract definition of d-dimensional crystal lattices.

Definition. *A graph is said to be a d-dimensional crystal lattice if it is an abelian covering graph over a finite graph*[5] *with a covering transformation group isomorphic to $\mathbb{Z}^d$, the free abelian group of rank d.*

Among all abelian covering graphs of a fixed finite graph X_0, there is a "maximal one", whose covering transformation group is $H_1(X_0, \mathbb{Z})$, the first homology group. The diamond lattice is the maximal abelian covering graph over the graph in Figure 5. It is interesting to point out that the *hexagonal lattice* is the maximal abelian covering graph over the graph with 2 vertices joined by 3 multiple edges so that the hexagonal lattice is regarded as the 2-dimensional analogue of the diamond lattice.

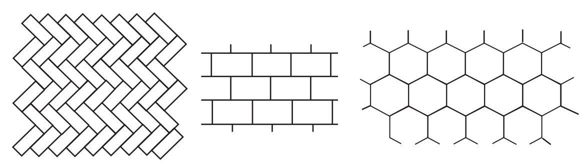

Figure 6. The hexagonal lattice and its various realizations.

If we start from a crystal lattice X with a fundamental finite graph X_0 in the above sense, then a crystal corresponding to X should be understood as a *periodic realization* $\Phi : X \longrightarrow \mathbb{R}^d$. The periodicity of Φ is embodied by the equality $\Phi(\sigma x) = \Phi(x) + \rho(\sigma)$, where σ is a covering transformation, and ρ is an injective homomorphism of the covering transformation group into a lattice group in $\mathbb{R}^d$.

From its nature, a periodic realization is determined uniquely by the image of a finite part of the crystal lattice. To be exact, let E (respectively, E_0) be the set of oriented edges in X (respectively, X_0), and consider a system of vectors $\{\mathbf{v}(e)\}_{e\in E_0}$ defined by

$$\mathbf{v}(e) = \Phi\big(t(e)\big) - \Phi\big(o(e)\big) \quad (e \in E),$$

[4] *In other words, this is the quotient graph by the lattice group action.*

[5] *There are, of course, infinitely many choices of fundamental finite graphs for a fixed crystal lattice.*

where $o(e)$ and $t(e)$ are the origin and terminus of e respectively. We should note that the function $\mathbf{v}$ on E is invariant under the action of the covering transformation group so that it is regarded as a function on E_0. It is easily observed that $\{\mathbf{v}(e)\}_{e\in E_0}$ determines the periodic realization Φ. In this sense, $\{\mathbf{v}(e)\}_{e\in E_0}$ is called a *building block*.

Energy and Standard Realizations

Our mathematical experience suggests that symmetry has strong relevance to a certain *minimum principle*. Leonhard Euler, a pioneer of *calculus of variations*, said "since the fabric of the Universe is most perfect and the work of a most wise creator, nothing at all takes place in the Universe in which some rule of maximum or minimum does not appear".[6] We shall apply this "philosophy" to the problem to look for a periodic realization with biggest extrinsic symmetry.[7]

We think of a crystal as a system of harmonic oscillators, that is, each edge represents a harmonic oscillator whose energy is the square of its length. We shall define the energy of a crystal "per a unit cell" in the following way.[8]

Given a bounded domain D in $\mathbb{R}^d$, denote by $\mathcal{E}(D)$ the sum of the energy of harmonic oscillators whose end points are in D, and normalize it in such a way that

$$\mathcal{E}_0(D) = \frac{\mathcal{E}(D)}{\deg(D)^{1-2/d}\mathrm{vol}(D)^{2/d}},$$

where $\deg(D)$ is the sum of degree (valency) of vertices in D. Roughly $\mathcal{E}(D) \sim \mathrm{vol}(D)$ and $\deg(D) \sim \mathrm{vol}(D)$ as $D \uparrow \mathbb{R}^d$, so that $\mathcal{E}_0(D)$ is bounded from above. If the crystal is transformed by a homothetic transformation T, then, thanks to the term $\mathrm{vol}(D)^{2/d}$, the energy $\mathcal{E}_0(D)$ changes to $\mathcal{E}_0(T^{-1}D)$.

Take an increasing sequence of bounded domains $\{D_i\}_{i=1}^{\infty}$ with $\bigcup_{i=1}^{\infty} D_i = \mathbb{R}^d$ (for example, a family of concentric balls). The energy of the crystal (per unit cell) is defined as the limit

$$E_{ner} = \lim_{i\to\infty} \mathcal{E}_0(D_i).$$

Indeed the limit exists under a mild condition on $\{D_i\}_{i=1}^{\infty}$, and E_{ner} does not depend on choices of $\{D_i\}_{i=1}^{\infty}$. We write $E_{ner}(\Phi)$ for the energy when the crystal is given by a periodic realization Φ. It is easy to observe that $E_{ner}(T\circ\Phi) = E_{ner}(\Phi)$ for every homothetic transformation T.

For a fixed crystal lattice, there exists a unique periodic realization (up to homothetic transformations) which attains the minimum of E_{ner}. Such a realization is said to be the *standard realization* and is characterized by two equalities

$$\sum_{e\in E_x} \mathbf{v}(e) = \mathbf{0},$$
$$\sum_{e\in E_0} \left(\mathbf{x}\cdot\mathbf{v}(e)\right)^2 = c\|\mathbf{x}\|^2 \quad (\mathbf{x}\in\mathbb{R}^d),$$

where E_x denotes the set of oriented edges whose origin is x.

The diamond crystal turns out to be the standard realization of the diamond lattice. One can also check that the honeycomb is the standard realization of the hexagonal lattice. Thus it is not surprising that the standard realization yields a crystal with the biggest symmetry, as the following theorem tells.

Theorem 1. *For the standard realization Φ, there exists a homomorphism $T : \mathrm{Aut}(X) \longrightarrow M(d)$ such that $\Phi(gx) = T(g)\Phi(x)$, where $\mathrm{Aut}(X)$ denotes the automorphism group and $M(d)$ is the group of congruent transformations of $\mathbb{R}^d$.*

The existence and uniqueness of standard realizations are proven along the following line. For the existence, we first fix a fundamental finite graph (in other words, fix a transformation group acting on the crystal lattice). We also fix the volume of a fundamental domain for the lattice group action in $\mathbb{R}^d$ and show that there exists a periodic realization Φ that minimizes $\sum_{e\in E_0}\|\mathbf{v}(e)\|^2$, a more manageable version of energy functional. This is easy indeed, but it is not obvious that this Φ (up to homothetic transformations) does not depend on the choice of a fundamental finite graph.[9] The independence of the choice in full generality is somehow derived from an asymptotic property of the simple random walk on X. At first sight, this might sound mysterious because of the big conceptual discrepancy between "randomness" and "symmetry", or "chance" and "order" in our everyday language. However once we perceive that "laws of randomness" are solidly present in the world, it is no wonder that symmetry favored by the world is naturally connected with randomness, just like the relation between symmetry and minimum principles.

In general, a random walk on a graph X is a stochastic process on the set of vertices characterized by a transition probability, i.e., a function p on E satisfying $p(e) > 0$ and $\sum_{e\in E_x} p(e) = 1$. We think of $p(e)$ as the probability that a particle at $o(e)$ moves in a unit time to $t(e)$ along the edge

[6] *The quotation in* Vector Calculus *by J. E. Marsden and A. J. Tromba.*

[7] *The macroscopic shape of a crystal is also characterized by a certain minimum principle (J. W. Gibbs (1878) and P. Curie (1885)).*

[8] *A real crystal (crystalline solid) is also physically regarded as a system of harmonic oscillators under an appropriate approximation of the equation of motion, but the shape of energy is much more complicated (see* [5]*).*

[9] *If we would know in advance that* $\mathrm{Aut}(X)$ *is isomorphic to a crystallographic group, then it is not difficult to prove this. As a matter of fact, however,* $\mathrm{Aut}(X)$ *is not always isomorphic to a crystallographic group.*

e. If p is constant on E_x, i.e., $p(e) = \big(\deg o(e)\big)^{-1}$, the random walk is said to be *simple*.

The following theorem gives a direct relation between the standard realization and the simple random walk.

Theorem 2. ([1])[10] *Let $p(n,x,y)$ be the n-step transition probability and let Φ be the periodic realization that minimizes $\sum_{e\in E_0}\|\mathbf{v}(e)\|^2$. There exists a positive constant C such that*

(1)
$$C\|\Phi(x)-\Phi(y)\|^2 = \lim_{n\to\infty} 2n\Big\{\frac{p(n,x,x)}{p(n,y,x)}+\frac{p(n,y,y)}{p(n,x,y)}-2\Big\}.$$

This theorem is powerful enough in order to establish immediately what we have mentioned above and eventually leads us to our claim that Φ actually minimizes E_{ner}. Crucial in the argument is the fact that the right hand side of (1) depends only on the graph structure and has nothing to do with realizations. The uniqueness and Theorem 1 are also consequences of this theorem.

Theorem 2 is a byproduct of the asymptotic expansion of $p(n,x,y)$ at $n=\infty$;

$$p(n,x,y)(\deg y)^{-1} \sim (4\pi n)^{-d/2}C(X) \times \big[1 + c_1(x,y)n^{-1} + c_2(x,y)n^{-2} + \cdots\big].$$

Having help from discrete geometric analysis, we may compute explicitly the coefficient $c_1(x,y)$ in geometric terms of graphs. Ignoring the exact shape of irrelevant terms, we find

$$c_1(x,y) = -\frac{C}{4}\|\Phi(x)-\Phi(y)\|^2 + g(x) + g(y) + c$$

with a certain function $g(x)$ and a constant c. Noting that the right hand side of (1) is equal to $c_1(x,x)+c_1(y,y)-2c_1(x,y)$, we get Theorem 2.

As for the constant $C(X)$, we have the following relation to the energy.

$$E_{ner}(\Phi) \geq dC(X)^{-2/d},$$

where the equality holds[11] if and only if Φ is standard. The proof, available at present, of this remarkable inequality is not carried out by finding a direct link between the two quantities, but is based upon a canonical expression of the standard realization, an analogue of *Albanese maps* in algebraic geometry ([1], [2], [3]).

We conclude this section with the case of maximal abelian covering graphs. Let $P : C_1(X_0,\mathbb{R}) \longrightarrow H_1(X_0,\mathbb{R}) (\subset C_1(X_0,\mathbb{R}))$ be the orthogonal projection with respect to the inner product on $C_1(X_0,\mathbb{R})$, the group of 1-chains on X_0, defined by

$$(2)\qquad \langle e,e'\rangle = \begin{cases} 1 & (e=e') \\ -1 & (e=\overline{e'}) \qquad (e,e'\in E_0) \\ 0 & (\text{otherwise}). \end{cases}$$

Identify $H_1(X_0,\mathbb{R})$ with $\mathbb{R}^d$ ($d = \dim H_1(X_0,\mathbb{R})$) by choosing an orthonormal basis for the inner product on $H_1(X_0,\mathbb{R})$ induced from (2). Fixing a reference point $x_0 \in V$, and taking a path $c = (e_1,\dots,e_n)$ in X with $o(e_1)=x_0, t(e_n)=x$, we put

$$\Phi(x) = P(\pi(e_1)) + \cdots + P(\pi(e_n)),$$

where π is the covering map. The map Φ, in which the reader may feel a flavor of Albanese maps, is well-defined and turns out to be the standard realization.

The K_4 Crystal

We mentioned that the diamond crystal has the strong isotropic property. This property leads us to the following general definition in terms of crystal lattices.

Definition. *A crystal lattice X (or a general graph) of degree n is said to be strongly isotropic if, for any $x,y\in V$ and for any permutation σ of $\{1,2,\dots,n\}$, there exists $g\in \mathrm{Aut}(X)$ such that $gx=y$ and $ge_i = f_{\sigma(i)}$ where $E_x=\{e_1,\dots,e_n\}$, $E_y=\{f_1,\dots,f_n\}$.*

In view of Theorem 1, the standard realization of a crystal lattice with this property is strongly isotropic as a crystal.

We wish to list all crystal lattices[12] with the strong isotropic property in dimensions two and three. We thus follow the Greek tradition in geometry that beautiful objects must be classified. Actually the classification of regular polyhedra[13] turns out to have a close connection with our goal.

It is straightforward to check that the hexagonal lattice is a unique 2-dimensional crystal lattice with the strong isotropic property (look at the standard realization). In the 3-dimensional case, we have another crystal lattice with this property besides the diamond lattice. It is the maximal abelian covering graph over the complete graph K_4 with 4 vertices,[14] which we call the K_4 *lattice* in plain words.

Since the graph K_4 has the strong isotropic property, so does its maximal abel cover. The

[10] *To avoid unnecessary complication, we assume that X is non-bipartite so that $p(n,x,y)>0$ for sufficiently large n, where a graph is said to be bipartite if one can paint vertices by two colors in such a way that any adjacent vertices have different colors. We need a minor modification for the bipartite case.*

[11] *This inequality is for non-bipartite crystal lattices. In the bipartite case, the right hand side should be replaced by $d\Big(\dfrac{C(X)}{2}\Big)^{-2/d}$.*

[12] *We restrict ourselves to the class of crystal lattices whose standard realizations are injective on the set vertices.*

[13] *Legend has it that the origin is in their curiosity about the shapes of various crystals.*

[14] *In general, K_n stands for the complete graph with n vertices, that is, the graph such that any two vertices are joined by a single edge.*

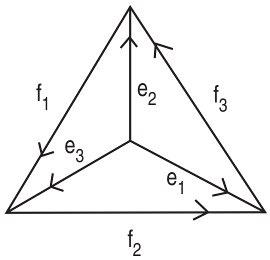

Figure 7. K_4.

K_4 *crystal* is then defined to be the standard realization of the K_4 lattice. The definition as such is quite simple. But its concrete construction is a bit involved and put in practice by following the recipe at the end of the previous section. Consider three closed paths $c_1 = (e_2, f_1, \overline{e_3})$, $c_2 = (e_3, f_2, \overline{e_1})$, $c_3 = (e_1, f_3, \overline{e_2})$ in Figure 7. The cycles c_1, c_2, c_3 constitute a $\mathbb{Z}$-basis of $H_1(K_4, \mathbb{Z})$, and satisfy $\|c_1\|^2 = \|c_2\|^2 = \|c_3\|^2 = 3$, $\langle c_i, c_j \rangle = -1$ $(i \neq j)$ as vectors in $H_1(K_4, \mathbb{R}) = \mathbb{R}^3$ (note that, if $c_i = \overrightarrow{OP_i}$, then P_i's are three vertices of the regular tetrahedron with the barycenter O). Looking at the projections of 1-chains $e_1, e_2, e_3, f_1, f_2, f_3$ onto $H_1(K_4, \mathbb{R})$, and expressing them as linear combinations of c_1, c_2, c_3, we obtain

$$\mathbf{v}(e_1) = -\frac{1}{4}c_2 + \frac{1}{4}c_3, \quad \mathbf{v}(e_2) = \frac{1}{4}c_1 - \frac{1}{4}c_3,$$
$$\mathbf{v}(e_3) = -\frac{1}{4}c_1 + \frac{1}{4}c_2,$$
$$\mathbf{v}(f_1) = \frac{1}{2}c_1 + \frac{1}{4}c_2 + \frac{1}{4}c_3, \quad \mathbf{v}(f_2) = \frac{1}{4}c_1 + \frac{1}{2}c_2 + \frac{1}{4}c_3,$$
$$\mathbf{v}(f_3) = \frac{1}{4}c_1 + \frac{1}{4}c_2 + \frac{1}{2}c_3.$$

Since the vectors $\pm\mathbf{v}(e_1), \pm\mathbf{v}(e_2), \pm\mathbf{v}(e_3), \pm\mathbf{v}(f_1), \pm\mathbf{v}(f_2), \pm\mathbf{v}(f_3)$ give a building block, we get a complete description of the K_4 crystal.

To see how edges are joined mutually, the following observation is more useful. In the K_4 crystal, the terminuses p_1, p_2, p_3 of three edges with a common origin p form an equilat eral triangle with the barycenter p; thus being contained in a plane, say α. If β is the plane containing the equilateral triangle for the origin p_3 (see Figure 9), then the dihedral angle θ between α and β satisfies $\cos\theta = 1/3$; that is, θ is the dihedral angle of the regular tetrahedron.

The K_4 crystal looks no less beautiful than the diamond crystal. Its artistic structure has intrigued me for some time. The reader may agree with my sentiments if he would produce a model

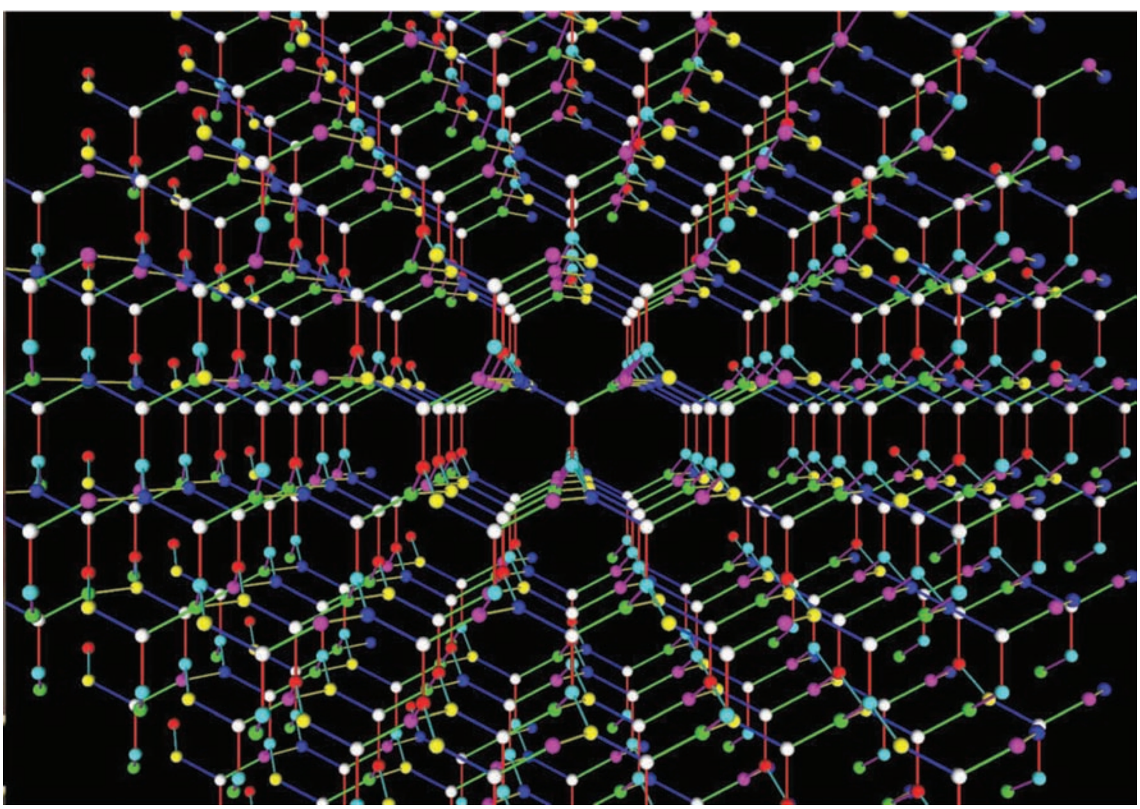

Figure 8. K_4 **crystal (created by Hisashi Naito).**

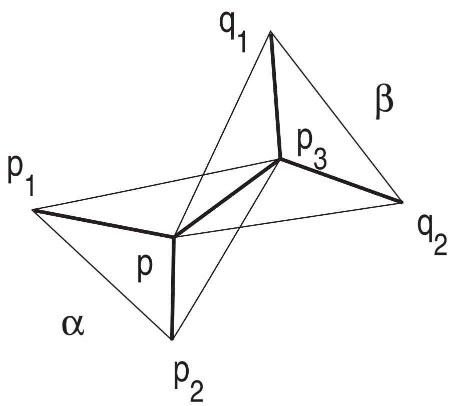

Figure 9. Configuration of edges in the K_4 crystal.

by himself by using a chemical kit.[15] An interesting feature observed in this model is that non-planar decagons all of which are congruent form together the K_4 crystal.[16] Figure 10 exhibits a decagonal ring projected onto two particular planes[17] which is obtained from the closed path[18] $(e_1, f_3, \overline{e_2}, e_3, f_2, \overline{e_1}, e_2, \overline{f_3}, \overline{f_2}, \overline{e_3})$ of length 10. More interestingly, the K_4 crystal has *chirality*; namely, its mirror image cannot be superposed on the original one by a rigid motion. This is quickly checked by taking a look at a decagonal ring that itself has chirality. In contrast, the diamond crystal has no chirality.

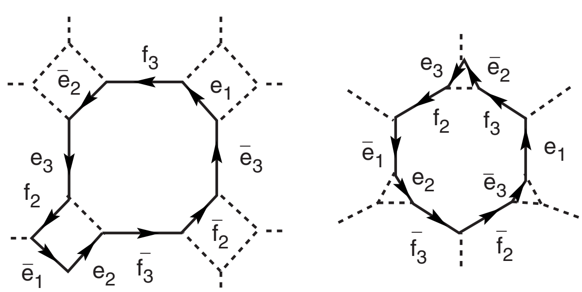

Figure 10. Decagonal ring projected onto planes.

At present, the K_4 crystal is purely a mathematical object. Because of its beauty, however, we are tempted to ask if the K_4 crystal exists in nature, or if it is possible to synthesize the K_4 crystal. More specifically, one may ask whether it is possible to synthesize it by using only carbon atoms. In connection with this question, it should be pointed out that, just like the *Fullerene* C_{60}, a compound of carbon atoms,[19] whose model is (the 1-skeleton of) the *truncated icosahedron* with suitably arranged double bonds,[20] we may arrange double bonds, at least theoretically, in such a way that every atom has valency 4. Indeed the lifting of double bonds in K_4 as in Figure 11 yields such an arrangement in the K_4 crystal.

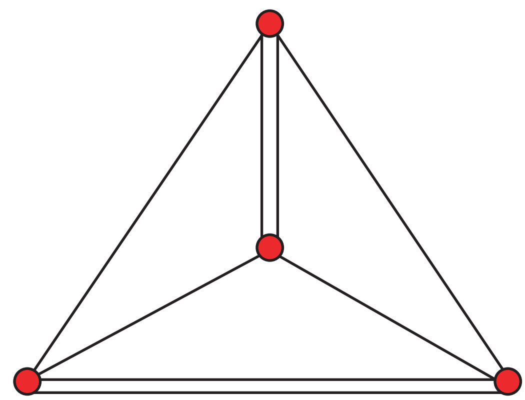

Figure 11. K_4 with double bonds.

Strongly Isotropic Crystals

Leaving the non-mathematical question aside, we go back to our primary problem. The following theorem states that there are no 3-dimensional crystal lattices with the strong isotropic property other than the diamond and K_4 lattices.

Theorem 3. *The degree of a 3-dimensional crystal lattice with the strong isotropic property is three or four. The one with degree four is the diamond lattice, and the one with degree three is the K_4 lattice.*

The proof runs roughly as follows. For a d-dimensional crystal lattice X with the strong isotropic property, one can easily show that its degree n is less than or equal to $d + 1$ (use the standard realization). In particular, for $d = 3$, we conclude that $n = 3$ or 4 (the case $n = 2$ is excluded since a crystal lattice of degree two is the 1-dimensional standard lattice).

First take a look at the case $n = 4$. Let Φ be the standard realization of X, and let $T : \mathrm{Aut}(X) \longrightarrow M(3)$ be the injective homomorphism induced from Φ (Theorem 1). Put $O = \Phi(x)$, and

[15] *As a matter of fact, there are no readymade models of the K_4 crystal so that one must put existing pieces in a kit together by oneself.*

[16] *The number of decagonal rings passing through each vertex is 15.*

[17] *These projections give covering maps of the K_4 lattice onto the 2-dimensional lattices in Figure 10.*

[18] *This closed path is homologous to zero, so that its lifting to the K_4 lattice is also closed. There are 6 decagonal rings such that every decagonal ring is a translation of one of them.*

[19] *Its existence was confirmed in 1990.*

[20] *A double bond should be thought of representing a chemical characteristic of bonding, and hence does not mean a multiple edge.*

let P_1, P_2, P_3, P_4 be the points determined by $\overrightarrow{OP_i} = \mathbf{v}(e_i)$ $(E_x = \{e_1, e_2, e_3, e_4\})$. Then $K = P_1P_2P_3P_4$ is a regular tetrahedron with the barycenter O. The strong isotropic property leads us to the following alternatives:

(1) the point symmetry S_i with respect to the midpoint of OP_i $(i = 1, 2, 3, 4)$ belongs to $T(\mathrm{Aut}(X))$, or

(2) the reflection R_i with respect to the plane going vertically through the midpoint of OP_i $(i = 1, 2, 3, 4)$ belongs to $T(\mathrm{Aut}(X))$.

If the case (2) occurs, then, say R_1R_2 is the rotation whose angle is twice the dihedral angle θ of the regular tetrahedron so that the crystallographic group $T(\mathrm{Aut}(X))$ must contain a rotation of infinite order since θ/π is irrational, thereby leading to a contradiction. We thus have (1), which implies that the standard realization of X is the diamond crystal. Therefore X is the diamond lattice.

The proof for the claim that X with $n = 3$ is the K_4 lattice is also elementary, although demanding more care in chasing down the cases of the relation between $\Phi(E_x)$ and $\Phi(E_y)$ for adjacent vertices x, y. The key is to verify that the factor group K of $\mathrm{Aut}(X)$ by the maximal abelian subgroup is a finite subgroup of the rotation group $SO(3)$ which is reflected in the chilarity of the K_4 crystal and allows us to employ the classification of finite subgroups of $SO(3)$. On the other hand, the group K acts transitively on V_0 in a natural manner. In view of the fact that the possible order of elements in K is $1, 2, 3, 4$, or 6, we may prove that K is isomorphic to the octahedral group,[21] from which it follows that $|V_0| = 4$, and hence $X_0 = K_4$. An easy argument leads to the conclusion that X is the maximal abel cover of K_4.

We are now at the final stage. It is checked that a realization of the diamond lattice with maximal symmetry is the diamond crystal. We can also demonstrate, again in an ad-hoc manner, that a realization of the K_4 lattice with maximal symmetry is the K_4 crystal or its mirror image.[22] To sum up, we have found out that *there are only three kinds of crystal structures in space with maximal symmetry and the strong isotropic property, that is, the diamond crystal, the K_4 crystal, and its mirror image.* This is what we primarily aimed to observe in this article.

It is a challenging problem to list all crystal lattices with the strong isotropic property in general dimension. A typical example is the d-dimensional diamond lattice, a generalization of the hexagonal and diamond lattices, defined as the maximal abelian covering graph over the finite graph with two vertices and $d + 1$ multiple edges joining them. The maximal abelian covering graph over the complete graph K_n also gives an example, whose dimension is $(n - 1)(n - 2)/2$.

Acknowledgements

The author is grateful to Hisashi Naito for producing the beautiful figure of the K_4 crystal, and is indebted to Peter Kuchment, Uzy Smilansky, Andrzej Zuk, Alexander Gamburd, and Motoko Kotani for their comments and suggestions. Thanks are also due to the Issac Newton Institute where the final version of this paper was completed.

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[21] *Note that the octahedral group is isomorphic to the symmetry group S_4, which is also identified with the automorphism group of K_4.*

[22] *In general, a realization with maximal symmetry is not necessarily standard.*

Irving Kaplansky's Role in Mid-Twentieth Century Functional Analysis

Richard V. Kadison

The mathematical work of Irving Kaplansky, who passed away in June 2006, is largely devoted to algebra. Irving's base camp in mathematics was undeniably algebra. But all of us in functional analysis classify Irving as a *mathematician*—someone capable of working in and drawing inspiration from all areas of mathematics. He is considered by all my coworkers in operator algebra theory to be one of the greatest figures of the early days of the subject.

The role of algebra in functional analysis is mainly one of formulation—but it's a crucial role. Any analyst who hasn't understood that fact has not understood the large picture. The *idea* of what we are doing is often synonymous with the *formulation*. Algebraic formulation gets us to consider certain constructs and to ask provocative questions in functional analysis: Is such-and-such an algebra simple or semi-simple? Can we describe the ideals? Are the four or five sensible ways of viewing semi-simplicity the same (as they are known to be in the finite-dimensional case) or to what extent do they differ? What are the automorphisms and derivations like? The methods and arguments for what we are doing in functional analysis come mostly from analysis (in the broadest sense), but algebra often provides us with clever "tricks".

At this point, an account of Kap's specific contributions to functional analysis with references to his bibliography might be most appropriate. However, those contributions are numerous and basic; so much so, that anything but a dry recital would surely exceed reasonable space limitations.

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In addition, we have Irv's "Selecta" [IKa1] with his "afterthoughts", which contains a few of the articles that constitute his *published* contribution to functional analysis. Some of the articles that had a profound influence on functional analysis do not appear in his Selecta. My guess is that Kap considered those articles as "routine" (that is, not having caused him particular difficulties in completing) and was only dimly aware (if at all) of the great stir and large amount of further research they stimulated. He probably also felt that he could not append a sufficiently authoritative "afterthought"; all this, of course, in the context of Irv's true humility and complete honesty.

Let me touch on just a few items—doing some of the mathematics only for those that do not appear in the Selecta. First, and foremost in technical utility, is the celebrated "Kaplansky Density Theorem". In an "afterthought", Kap quotes G. K. Pedersen's book [GKP1, p.25], "The density theorem is Kaplansky's great gift to mankind. It can be used everyday, and twice on Sunday[s]." It was reported to me that when Arveson heard that quote, he remarked, "I use it twice on Saturdays, too." The title of my lecture at the memorial conference for Irv at the Mathematical Sciences Research Institute in Berkeley was "And Twice on Sundays". The two great density theorems, von Neumann's "Double Commutant Theorem" [JvN1], the first theorem of the subject of operator algebras, and Kap's density theorem were discussed along with my "transitivity theorem" [RKa3] (also a density theorem), which relies heavily on the Kaplansky Density Theorem. I was happy to note that the proof of the transitivity theorem has at its heart a Picard-successive-approximation argument that uses Kaplansky Density at each one of its countably (infinite) many stages—and there it was, only Friday! Another of Kap's "afterthoughts" on his density theorem includes the observation, “the applicability of a piece of mathematics is hard to predict,” to which I shall add, “Amen.” So much mathematics has been applied in vital and totally unanticipated ways.

Irv was plagued by people who asked, “Why did you do this or that mathematics?” He appropriated a famed mountaineer’s answer to the question, “Why do you want to climb Everest?” namely, “Because it is there.” From early observation, I concluded that Irv was driven by internal beauty in mathematics. Again from observation, Irv was quite tolerant of “applicability driven” researchers. Gert Pedersen was also driven by the beauty in mathematics (again, from extended observation). He is quoted in another of Irv’s “afterthoughts” [IKa1, p.86] as saying during a lecture at UC Berkeley, about Irv’s introduction of AW*-algebras, “the subject refuses to die.” In this same “afterthought”, a Godement review is paraphrased as saying, “What is the point of this generalization from W* to AW*, except, perhaps, to offer simplified proofs?” To which Irv replies, “I am pleased that he noticed the simplified proofs.” Irv also adds, “As for the main charge, I plead guilty and throw myself on the mercy of the court.” Why “guilty”? Well, such “charges” are not easy to defend against by yourself. Anything you say in your own defense seems to be coming from the very deep hole of self-serving self-interest. Many of us deal with it as Irv did, in essence, sometimes with the comment, so popular these days, “Whatever!” (roughly the equivalent of the older “Have it your way,” or “Suit yourself”).

It is worthwhile to discuss the possible motivations for those comments of Godement’s and Pedersen’s, not just for their “gossip” aspects, but for some deeper understanding of what Kap had contributed by his introduction of AW* algebras. To begin with Godement was a clever and strong young worker, in the earliest stage of the development of the theory of unitary representations of locally compact groups. Irving Segal was one of the great early pioneers and originators of that theory, especially as it concerned “operator algebras” as group algebras for such groups and the connection between the Hilbert space representations of each. Of course, there was the great Gelfand and his friend and collaborator Neumark (not to go into the details of the magnificent Soviet school—Krein, Raikov, Silov, and others), who were an inspiration to Segal, and largely through Segal, to Kap and to me. Godement was a rising young star in that representation theory, attracting a good deal of attention and, of course, plenty of French support. That was enough to put Segal squarely “on his case”. A bitter mathematical controversy erupted and played out in the pages of the *Mathematical Reviews* of those days. Now, the point: I would guess that Godement was taking a “swipe” at Kap with his AW* comment, whether consciously or not, whom he regarded as an ally and friend of Segal, certainly a colleague and member of the great Chicago school. That comment was very likely regarded by Godement as a small skirmish in his larger battle with Segal. Godement was much too honest to make that comment without including that (vitiating!) addendum on “simplified proofs”. There was a double irony, indeed, a web of ironies, here. For one thing, Segal and Kap were not on good terms at the time (but, more about that at a later point). Above all, most of the main players seemed to have missed the point to Kap’s introduction of AW* algebras: It was important (I would elevate that to *crucial*) to separate what was algebraic in the theory of von Neumann algebras from what required analytic (that is, primarily, measure-theoretic) considerations. Kap felt this instinctively, although the crushing weight of evidence for that importance had not yet mounted when he poured his time, thought, and energy into that project. In that same “afterthought” [IKa1,p.86], Kap refers to [RKa1] as “worthy of note”. I hope so; it provided the representation-independent characterization that people had sought of the von Neumann algebras (“rings of operators”, “W*-algebras”). The search for such a characterization was one of the two problems in this area that fascinated von Neumann most. (It is relevant for the application of such operator algebras as models of many quantum-mechanical systems—allowing us to select the family of states, the “normal states”, that is appropriate to the particular expectations to be measured, by passing to the correct, Hilbert-space representation.) That characterization would not have been found if Kap had not made clear the need to separate and study the algebraic properties of such algebras. The other information vital to producing the characterization [RKa1] of von Neumann algebras, which was almost, but not quite, available to von Neumann, is the 1943 characterization [G-N] of C*-algebras by Gelfand and Neumark. (Von Neumann had ceased active work in the area by that time, but always retained a strong interest in the subject.) Also needed was Segal’s recognition [Se1] that [G-N] embodied the representation techniques of the GNS construction. It seems appropriate to mention, as well, the very pretty and popular characterization of von Neumann algebras [Sa1] by Sakai as those C*-algebras that are isometrically isomorphic to the (norm-)dual of some Banach space.

As Irv notes [IKa1, p.86], still with reference to [RKa1], “By assuming suitable least upper bounds not just for projections but for all self-adjoint elements, one intrinsically characterizes W*-algebras.” However, the “suitable” (least upper bounds) masks the all-important assumption that there is a family of "states" of the algebra ("normal states"—order-preserving, linear functionals taking the value 1 at the identity operator) that respects the upper bounds and that "separates" the algebra (two elements with the same values at all those states are identical). It is that assumption that distinguishes the essentially algebraic from the measure-theoretic. Dixmier [JDi] had recognized that in the abelian case (the "classical" measure-theoretic situation), by providing an example of an abelian AW*-algebra that is not isomorphic to any abelian von Neumann algebra (such a von Neumann algebra is isomorphic to the algebra of bounded measurable functions on some measure space). It was, then, certain that the assumption of measures (or their corresponding integrals, the normal states) for the algebra was necessary for it to be a von Neumann algebra. Conjoining that assumption with some (infinite) "algebraic" assumption was then completely natural and what a few of us "dreamed" (rather than "conjectured") might be true. My order assumption on monotone nets (sequences, in the separable case) was the obvious way for me to go as I had recognized, during my thesis work, that the best way to study operator algebras, in the presence of noncommutativity, was through their order structure (as partially-ordered vector spaces). In his *Rings of Operators* [IKa2], Kap changes his mind about the proper way to axiomatize AW*-algebras [IKa1, p.86]. "As noted in the preface to [4], I later changed my mind about the proper way to axiomatize AW*-algebras. Why did I do it clumsily in the first place? Lame reply: The process of taking the least upper bound of a set of orthogonal projections was so fundamental and so heavily used that I slid into making it an axiom. However, more was needed since there might not be any projections other than 0 and 1. Making an assumption about maximal commutative subalgebras was unfortunate: Zorn's lemma had to be invoked every time the axiom was used." For me and most of my coworkers, I daresay, the use of Zorn's lemma is no hindrance. I am not in sympathy with Kap's reasons for renouncing the condition on maximal abelian algebras (very likely, because I view it as an analyst). The maximal abelian algebra is the "protective container" in which the analyst can carry all the vitally needed classical analysis on the journey into the noncommutative. It is unthinkable to research workers in the theory of von Neumann algebras to be without their maximal abelian subalgebras (whenever and wherever they are needed).

Gert Pedersen uses this condition to prove a lovely result [GKP1]: A C*-algebra acting on a Hilbert space with all its maximal abelian C*-subalgebras weak-operator closed is itself weak-operator closed. This result tied together a lot of loose ends and answered some puzzling questions. In particular, it was the key to showing that Kap's maximal-abelian-subalgebras axiom together with the "normal states" (of [RKa1], or what corresponds to them in the presence of Kap's assumption), again, characterizes von Neumann algebras (in a space-independent way). Kap's initial intuition was correct (and useful)—hardly calling for renunciation. Gert's contribution, certainly one of the cleverest in that area, underscores the irony in his "refuses to die" remark during his lecture. Why did he make it? As Kap notes in the "afterthought" to his density theorem, Gert was witty. I knew Gert well; he was obsessed with being witty, sometimes to the point where the aptness or accuracy of the "wit" was not a matter of great importance. As was often the case with Gert's "witty" remarks, they contained deep ambiguities (were they being made "positively"—admiringly, or "negatively"—scornfully) and an ample helping of self-deprecation (after all, Pedersen had been just about the cleverest contributor to the AW*-project; diminishing it diminishes him). What to make of Pedersen's remark? We shall never know—Kap certainly didn't. I incline to the view that Gert didn't have more in mind than the "wit": It was just a blend of the visceral motivations mentioned. There is still much work to be done in this area. Some of it looks difficult to me, and intimately tied to approximation theory.

As remarked before, Segal and Kap were not on good terms at the time of Godement's review of [IKa4]. There is double and triple irony here. Kap began with fondness and great respect for Segal, probably growing from contact with Segal at the Institute for Advanced Study just post World War II. Segal was very likely the "linch pin" for a small group at the Institute (among them, Warren Ambrose, Richard Arens, and Kap), succeeding in interesting them all in functional analysis and operator group algebras for locally compact groups. It is also very likely that Kap's urgings initiated the process that ended with Segal joining the faculty at the University of Chicago in 1947–48. I watched a small, sad drama unfold, silently (almost below the surface) during one day (in 1947–48) in the offices and corridors of Eckhart Hall. That day, as I passed and stopped at Segal's office, I saw Segal finishing a discussion with Kap in which he was describing a long, complicated measure-and-function-theoretic argument for some result he had just proved about "unitary invariants" for operators that (together with their adjoints) generate a "type I von Neumann algebra". For finite matrices, the "type I" is no restriction. That restriction takes us as close as we can be to the finite-dimensional case and still include infinite-dimensional Hilbert space. One large component of those invariants is a "multiplicity" decomposition of the action of the von Neumann algebra on the Hilbert space. Segal had been dealing with that in a heavy-handed, analytic manner. It was a "piece of cake" for Kap's algebraic, von-Neumann-algebra techniques—exactly what Kap was trying to teach us with his introduction of AW*-algebras. When Segal had finished, Kap blurted out, "But that's trivial, it can be done in a few lines." Segal went sallow, sullen, and silent. (I turned ashen.) After a moment, Segal said something to the effect that Kap hadn't understood him and Kap should try to write those few lines. Kap would, then, see that Segal was right (on the need for a complicated analytic proof). Kap agreed to try. By some coincidence, I happened to be in Kap's office talking to him that afternoon when Segal passed the door. Segal stopped and asked Kap if he had tried to write his proof. Maybe it was not a coincidence; maybe Segal, realizing that I had "witnessed his humiliation" that morning, thought that this would be a good time to confront Kap. He could claim his "vindication" and "redemption" (in my eyes) at the same time. That vindication was not forthcoming, and the redemption was never needed. Kap took a step over to his desk, which was covered by a twenty-centimeter-high mound of papers, letters, reprints, preprints, books, and whatnot, plunged his hand into the edge of the mound and plucked from it a partially folded slip of paper (about 7 by 12 centimeters in size) on which he had pencilled a few sentences. He went to his door, where Segal was standing, and handed Segal that slip of paper (with no flourishes, gestures, or facial expressions). Segal glanced at, though did not scrutinize, the slip with an expression that seemed to me to be a combination of annoyance and distaste, and walked on. I concluded that, at that exact moment, Kap had acquired a secure position on Segal's sizeable, pejorative, innuendo-and-defamation register. What a shame; Segal was one of Kap's heros, and with good reason. It was Segal who settled the early open question of whether or not the norm-closed, two-sided ideals in a C*-algebra are stable under the adjoint operation. He proved [Se2] that they were by showing that each norm-closed, one-sided ideal in a C*-algebra is generated (as a norm-closed, one-sided ideal) by its positive elements. For the proof, Segal created an ingenious (and very pretty) piece of "noncommutative analysis" (perhaps, the first—at least, the first I know of in the subject). This, together with Segal's seminal work on operator, group algebras and unitary representations of locally compact groups had won Kap's undying admiration. Why, then, the "blurting" by Kap? It comes down to a simple fact: Kap was "pure of heart". There was no malice present or intended when Kap said such things. It was never: "*You* are stupid," or "I am smarter than you." It was simply: "*That* is stupid," or "You are *being* silly." Kap was very definitely an equal opportunity "blurter"—he blurted mathematical corrections and comments at the powerful and well-established as quickly as at the powerless and not-yet established. André Weil was lecturing at a Chicago colloquium one afternoon. At one point, Weil stumbled in his presentation. He said, in effect, that some space was "complete" because, as Weil had noted, it was homeomorphic to a complete space. It was a slipped-mental-cog occurring during the passion of a lecture; it had nothing to do with the thrust of the argument. Those who were following that thrust were too concentrated to even notice, I imagine. I didn't notice. Kap did notice, and "blurted out," "That's silly, completeness is not a topological invariant." That to Weil, who had invented uniform structures (one of the lesser of his great contributions, but very useful, and interwoven with the notion of completeness)! The audience was stunned, I could hear no sound, not even breathing. About thirty milliseconds after the rest of the audience stopped breathing, Kap joined them, with an expression spreading over his face that said, clearly, "What on Earth have I done?!—I've just told the Great Man that he was being silly." And Weil's reaction? He glanced briefly at Kap, a small, restrained smile formed (not apologetic, but amused). Of course, Weil had caught and understood everything, instantly, with that glance. Not a word was said, and Weil lectured on. Hearts began to beat again as the audience realized that no lightning bolt was headed for Eckhart Hall.

Weil was always friendly and kind to me. I spoke to him closely enough to know what he was thinking in that situation. He saw that Kap had just realized the level of Kap's audacity—a pipsqueak Assistant Professor telling the "capo di tutti capi" that he is being silly. More than that, Weil knew that Kap was not going to "suffer" for this "incident"—no broken career, arms, legs, anything, because Weil prized intellectual honesty and integrity. It did not trouble Weil that he was "revealed" as (slightly) less than perfect, capable of an occasional slip. Weil did not, as Segal did, feel "humiliated" by Kap's "blurting". Weil took Kap's intentions for what they were: to have the best, most accurate, and most elegant mathematics out there; nothing personal involved.

I'll make some final comments about Kap's algebraic program that are directed, primarily, to the research workers in operator-algebra theory and the areas that make serious use of it. Without the fruits of Kap's program, we would be condemned to dealing with the general von Neumann algebra by using von Neumann's direct integral reduction theory [JvN3], its fussy, long, measure-theoretic arguments and (often irrelevant) countability restrictions, and its large, messy, clanking machinery. Where representations are concerned (of groups and group algebras) and decomposition into more basic components is needed, that decomposition is effected by either the von Neumann or Kaplansky techniques.

Except in very restricted circumstances ("type I von Neumann algebras"), decomposition into irreducibles is not usefully available. Such decomposition can be effected [M1, 2] (much to von Neumann's surprise), but not *uniquely* (*pathologically* non-uniquely, as Mautner showed us in [M1, 2]); it is not the way to go. In the infinite-dimensional (measure-theoretic) environment, decomposition into basic central components ("factors" in our language) is the appropriate goal. That can be effected by either the von Neumann or Kaplansky techniques—and Kaplansky's techniques are far superior for those purposes. (It was that "divide" that was ultimately the basis of the Kap-Segal rift I described.) There *is* the argument that the factors contain most of the substance of the subject, so we needn't bother with the "global" von Neumann algebra. I agree, but largely because Kap's techniques make the passage between global and local relatively easy. If we were doing this with the clanking machinery of direct integral reduction theory, that passage would be a "subject", with its own special articles and plenty of mistakes (remember Tomita's non-separable reduction theory [T], which even found its way into an edition of Neumark's otherwise fine *Normed Rings*, or Mautner's otherwise interesting [M1] demonstration that direct integral reduction into irreducibles is, at least, possible).

Perhaps a more alarming illustration of the problems in and pitfalls of working with direct-integral, reduction techniques is seen in the following. My "big (mathematical) brother", good friend, and occasional mentor, George Mackey, convinced himself (sometime in the mid-1960s, I think) that he had proved that each masa in a factor is "simple" (to use technician's current terminology — though it was introduced 55 years ago by Ambrose and Singer). It took several transatlantic letters (I was in Europe at the time) to convince George that that wasn't so. I had produced an example (using "free group factors") in the early 1950s and reconstructed it for my last letter in that exchange. (That example is, now, recorded in [RKa2, pp.359-60].) Let me add that George was, among other things, a master at navigating the currents of treacherous, measure-theoretic seas, but even great captains have lost ships in such seas. George was rarely foolhardy but always intrepid. On this one, unluckily, he chose the roiling waters of direct-integral, reduction theory to carry his argument.

The algebraic structure approach to operator algebras, in general, and von Neumann algebras, in particular, embodied in Kap's AW*-algebras [IKa4] was another of Kap's "great gifts to mankind" (to borrow from Gert Pedersen). It is about as sensible to scorn it as it was to scorn Lebesgue's measure and integration theory.

A paper [IKa5] that does not appear in Selecta [IKa1] had a great influence in the development of operator algebras. In that paper, Kap proves that automorphisms of a type I AW*-algebra that leave the center element-wise fixed are inner. In [IKa6], he had proved the result for * automorphisms of type I AW*-algebras. For the purposes of that proof, Kap introduces and develops the basics of the concept of "Hilbert C*-modules" (over commutative C*-algebras). That concept was broadened and expanded significantly by W. Paschke [Pas] and M. Rieffel [R1]. It has come to play an important role in the theory of operator algebras (e.g., it is a key component in Rieffel's "Morita-equivalence" results [R2] for C*-algebras). An excellent account, with important additions to the Hilbert C*-module theory, is to be found in the beautiful tract [L] of E. C. Lance.

A companion to Kap's automorphism result in [IKa5] is his proof that each derivation of a type I AW*-algebra (into itself) is inner. To recall, a derivation δ of an algebra $\mathfrak{A}$ (into itself) is a linear mapping (of $\mathfrak{A}$ into $\mathfrak{A}$) that satisfies the Leibniz rule:

$$\delta(AB) = \delta(A)B + A\delta(B).$$

If $T \in \mathfrak{A}$, then $\delta_T(A) = AT - TA$ defines a derivation δ_T. Such derivations are said to be *inner*. In more modern form, the derivations are "1-cocycles" of $\mathfrak{A}$ into $\mathfrak{A}$, in Hochschild's cohomology of associative algebras, and the inner derivations are the coycles that "cobound". It is classic that the derivations of the algebra of all linear transformations of a finite-dimensional, unitary space are inner. (That is, the first Hochschild cohomology group vanishes.) Kap's derivation result in [IKa5] includes the extension of that fact to the algebra of all bounded operators on a Hilbert space. Kap also noticed that he had proved the continuity of the derivation without assuming it—an "automatic" continuity result; he dares to ask (conjecture?), as the closing words in [IKa5]: "is every derivation of a C*-algebra automatically continuous?" A year or two later, Sakai [Sa2] proved this "conjecture" with an ingenious argument. Ten years later, the fact that all derivations of von Neumann algebras are inner was proved ([Sa3] and [RKa4]), after which a torrent of work on derivations (and even the extension to higher Hochschild cohomology groups) flowed through the literature of operator-algebra theory and mathematical physics.

The connection with mathematical physics is quickly explained (though, perhaps, as a surprise to some). The self-adjoint operator algebras provide the most convenient and natural framework for the mathematical model of quantum mechanics toward which Dirac [PDi] and von Neumann [JvN2] were striving. (It found its sharpest early expression in Segal's "Postulates…" [Se3].) The self-adjoint elements in the C*-algebra correspond to the (bounded) observables of the quantum mechanical system to be studied. The automorphisms, or rather, a one-parameter group of * automorphisms of the C*-algebra describe the (quantum) dynamics of that system. The generator of that one-parameter group of * automorphisms is a * derivation. The physical identification views that derivation as "Lie bracketing" observables with the energy (observable) of the system (which in the Heisenberg picture of dynamics as observables evolving in time corresponds to differentiating the "moving observable" with respect to time). So, while the mathematical development of this theory of derivations and automorphisms is of significant mathematical interest and beauty in its own right, its foundational relation to basic quantum physics is so close and important for an understanding of the mathematics of that physics, that its development cannot be left undone.

Another region of Kap's art is strewn with his glorious "giveaways". I'm not alluding to those (sometimes wonderful) ideas and projects we pass on to our (equally wonderful) students; but rather, those thoughts, suggestions, conjectures, questions, and other "tidbits" that some of us occasionally contribute to the "body mathematical". Some of those "giveaways" can be crucially important for the development of mathematics. The view I have heard expressed on occasion, that if there is "nothing in print" those giveaways were "never there", is a gross distortion of the way mathematics evolves. I'll illustrate that by describing two of Kap's contributions. The first refers to [G-N], mentioned earlier. That paper was one of several "characterization" papers appearing in the early 1940s (among them, [K-M1, 2]). That flurry of activity was stimulated by the success of M. H. Stone's papers [MSt1, 2] containing a characterization of the Boolean algebra of subsets of a set along with applications of that characterization. The Gelfand-Neumark characterization of norm-closed algebras of bounded operators acting on a Hilbert space, that are stable ("closed") under the adjoint operation was not among the earliest "characterizations" nor did it seem to have more intrinsic interest than any of the other structures being "characterized". I'm reasonably sure that Gelfand and Neumark were not especially proud of their contribution to the "characterization derby". Such characterizations should, at the very least, be elegant. Gelfand and Neumark had found it necessary to append two conditions to their characterization that they admit (in a footnote) to feeling may be superfluous. Nonetheless, their ingenuity (individual, and certainly, combined) shines through each paragraph of their article.

As it turned out, [G-N] is one of Gelfand's most important (arguably, *the* most important) contributions—which brings us back to Kap's earlier quote, "the applicability of a piece of mathematics is hard to predict." They were characterizing just the right construct, one with a multitude of critical connections. But surely they were disappointed by the "inelegance" of their characterization and its two "dangling" conjectures. Those conjectures quickly became the focus of much effort for the small band of us working in what had become the forefront of that sort of noncommutative harmonic analysis and representation theory. In particular, Kap and I were fascinated by those conjectures. We had many conversations about them. The first of those conjectures asserted that $A^*A + I$ is invertible for each A in the Banach algebra $\mathfrak{A}$ (with unit I), the algebra that Gelfand and Neumark were trying to prove is isometrically * isomorphic to a norm-closed, unital algebra of bounded operators acting on a Hilbert space and stable under the adjoint operation on bounded operators. Kap concentrated mostly on this first conjecture; it easily becomes the assertion that the spectrum of A^*A contains no real numbers less than 0. He had found a very clever argument to prove the conjecture, provided one knew that the sum of positive elements (self-adjoint elements with nonnegative real spectrum) is positive. But Kap couldn't prove this positivity at that time. In 1952, M. Fukamiya [F] proved that positivity, unaware of Kap's argument (unpublished, though Irv was willing to show it, and had shown it, to any of us who asked). When Kap saw that article, he discovered who was reviewing it (J. Schatz) and sent him his argument to include in the review [Sch] (to complete "Fukamiya's proof" of that Gelfand-Neumark conjecture). Kaplansky's argument was the cleverer part of the proof as far as I can see; he could, with full justice, have written a small note citing the Fukamiya article appropriately, but chose to handle it in the almost totally self-effacing manner I've described. It had taken ten years to settle that conjecture. This one of Kap's "giveaways" is just barely published—in someone else's review!

The second conjecture asserted that A and A^* have the same norm, for each A in $\mathfrak{A}$. Irv and I had plenty of fun discussing it. He was fairly convinced that it wasn't true. I felt that it was true, but with less conviction than Irv had about the contrary position. When Irv wrote to me about finding the Fukamiya article, I looked, again, at the second conjecture (the evening of the day in which Irv's letter arrived). I managed to prove that $\|A\| = \|A^*\|$ when A is an invertible element in $\mathfrak{A}$ (and that, in consequence, $A \to A^*$ is norm continuous). I wrote to Kap relaying that information and asked him if he felt that * need not be isometric as strongly as he had. He allowed that his conviction was shaken. Seven years later, Jim Glimm and I proved [G-K] that $\|A\| = \|A^*\|$ for all A in $\mathfrak{A}$. So, Gelfand and Neumark were quite right in their feelings, as proven ten and seventeen years later. (See [RKa5] for a full account, with arguments, of the Gelfand-Neumark theorem.)

Another, and final, sample of Kap's "giveaway" activities (though, by no means, the last one available) is a strong illustration of the fact that so much that is important in the development of mathematical ideas occurs (well) below the publication horizon. This sample begins, again, in Kap's office in 1949. Kap had received a reprint from the Soviet Union describing work in the then-nascent, complex-variable-Banach algebra development in functional analysis. It involved constructing an idempotent, different from 0 and the unit, in a commutative Banach algebra. Again, Kap fished it out of the mound of sundries covering his desk with a simple, nonstop motion of his arm. He asked me what I thought about the possibility of the same fact holding in a simple, unital C*-algebra. That is, must there be a nontrivial idempotent in such an algebra? I thought about it for a minute or two and, responded a little too forcefully, "No! Why should there be?" Kap thought that it actually might hold. That was the algebraist in Kap. He loved idempotents (and infected me with that love). On the other hand, my functional analysis experience had taught me (even in those tender years) that there were many escape routes for idempotents on the cold and forbidding terrain of infinite-dimensional, functional analysis. I was sure that there were simple C*-algebras with unit and no proper idempotents, and said so to Irv. "Of course there are," I told Kap—and proceeded to miss the big point! I added, "It may not be easy to find a counterexample, and so what, when you do? You then have an isolated counterexample, and what can you do with it?" I commented that I would wait for someone else to find it (Bruce Blackadar did [B] 32 years later), but faithfully passed Irv's question on to others—always making it clear that I felt there was an example (without non-trivial projections) and Irv thought that such idempotents might always be present.

What do I mean when I say, "I missed the big point" with my "so what" comment? Simply that the question Kap had posed was more important than I was allowing (much more!) or than Kap was insisting. More than that, both Kap and I were well aware of all the connections and basic techniques needed to conclude that the question was very important. We just didn't take the time to put it together and draw that conclusion. To begin with, at that point (1949), it was clear to us that the study of C*-algebras was not just an investigation of an interesting class of infinite-dimensional, semi-simple algebras; it was the study of the natural framework for all of (real) classical analysis, the commutative case, and thence all of noncommutative (quantum) real analysis through the noncommutative C*-algebras. We had all learned from Marshall Stone the intimate relation between an (infinite) algebraic structure and a topological space—both of us from Stone's ground-breaking Boolean algebra papers [MSt1, 2] published in the mid-1930s, and I, from a splendid, year-long course, as well, given by Stone the preceding year. Stone's methods for "pulling" points of an associated (topological) space from a given algebraic structure and topologizing that space with the then-developing techniques of functional analysis in the commutative case, was well understood by us. We were also explicitly aware of the paradigm of a general C*-algebra as the "function algebra" of a *non-commutative* topological space—and spoke of such algebras in those terms when that was useful. We knew, too, that that topological space was uniquely determined (up to homeomorphism, in the commutative case) by the algebraic structure, and that it was best to let the noncommutative space remain "virtual", dealing with it through the algebraic structure, just as it is most often best to let the "eigenvector" corresponding to a general point in the spectrum of a self-adjoint operator remain "virtual" rather than make it explicit with δ functions, approximating vectors, and such. Had Kap and I applied all that knowledge and technique to his idempotent question, we would have concluded, quickly, that we were asking about the existence of compact (because of the *unit*), totally noncommutative (because of the *simplicity*), connected spaces (because of the absence of *proper idempotents*). So, in these terms, I was asserting the existence of compact, (totally) noncommutative, connected topological spaces and Kap, with a lot less conviction (possibly, just for the "sporting" aspect of defending the other position) was asserting that there are no such spaces. On top of that, I was adding the question, "Who cares?" The clear answer to that should be, "Everyone!"—at least, every "hard" theoretician (chemist, physicist, and mathematician—and as we are discovering daily, each biologist as well), certainly everyone for whom quantum mechanical considerations play a role. Had Kap and I spent the extra ten minutes it would have taken thinking about the meaning of the question he had asked, we would both have been alert to its importance and probably "sure" of and agreed on its (affirmative) answer.

As far as I could see, and Kap and I were close enough so that I tended to know what occupied him when he was doing functional analysis, Kap did not think further about the idempotent (projection) question, nor did I, in the years immediately following our conversation. However, all that is just the beginning of the story. Somewhere in the mid-1950s, I thought of ("stumbled on" might be more accurate) an example of a "primitive" C*-algebra (one with a faithful, irreducible, representation on some Hilbert space) with no nontrivial projection. It was not particularly elegant or interesting, so I left it as unpublished notes (probably unfindable at this point). No great loss; in the very early 1960s, Jim Glimm found a nice example of such a primitive C*-algebra (independently—compare [Gr] as well). But those are far from the "simple" target we aimed for. During the academic year 1965–66, I visited Aarhus University in Denmark. At home one evening, doing what seemed to be quite unrelated work, I looked up from the page on which I was writing and realized, with what must be described as a certainty little short of absolute, that the perfect example of what Kap and I were seeking, were the C*-algebras, $\mathfrak{A}_{\mathcal{F}_n}$, arising from the free (non-abelian) groups $\mathcal{F}_n$ on n-generators ($n \geq 2$). Let L_g be the unitary operator on $l_2(\mathcal{F}_n)$ induced by left translation by g of functions in $l_2(\mathcal{F}_n)$, $\mathcal{A}_{\mathcal{F}_n}$ be the algebra of finite, complex, linear combinations of these L_g, $\mathfrak{A}_{\mathcal{F}_n}$ be the norm closure of $\mathcal{A}_{\mathcal{F}_n}$, and $\mathcal{L}_{\mathcal{F}_n}$ be the closure of $\mathcal{A}_{\mathcal{F}_n}$ relative to the topology of convergence on vectors in $l_2(\mathcal{F}_n)$, the strong-operator topology. Then $\mathcal{A}_{\mathcal{F}_n}$ is the (left) complex group algebra of $\mathcal{F}_n$, $\mathfrak{A}_{\mathcal{F}_n}$ is the (reduced, left) C*-group algebra of $\mathcal{F}_n$, and $\mathcal{L}_{\mathcal{F}_n}$ is the left von Neumann group algebra of $\mathcal{F}_n$. My "epiphany" revealed to me that each $\mathfrak{A}_{\mathcal{F}_n}$ is simple with no proper projections. All I needed was a proof! As noted, that thought occurred to me while I was involved in other research—deeply involved. So, I didn't try to work on that idea. Several years went by before I mentioned it to anyone. (I suppose I thought that I would get a chance to think, seriously, about it; but I never did.)

At the end of the 1960s (I'm not absolutely sure of the timing), while returning from lunch with the large, active, group of functional analysts and visitors at the University of Pennsylvania at that time, Robert Powers and I were walking side-by-side. He started to tell me of some work he was doing with what is now known as an "irrational rotation C*-algebra" (a "noncommutative torus"). I knew what was coming because a very good friend of, and frequent vistor to, our department, Daniel Kastler, had told me that Bob was searching for a projectionless, simple C*-algebra with these "torii". As Daniel so charmingly (as always) put it, "He is looking for a medal for the other side of his jacket" (an allusion to the spectacular breakthrough Powers had made, with factors of type III [RPo1], a few years before, and what has become known as "the Powers factors"). During that walk, Bob noted that, while he was expecting to show that there were no nontrivial projections in such algebras, he was quite surprised to construct many such projections. Marc Rieffel went on from the Powers computation to construct what seemed to be the full "K_0-theoretic" structure of the "torii" [R3], though he could not establish that he had it all.

When Powers finished telling me about his surprising families of projections, I decided to tell him about my free-group examples. I asked, "Do you want to know a family of simple C*-algebras with no proper projections?" and announced that I had such a family. That evinced a good deal of sputtering and confusion. Bob took that announcement in the natural way, but with considerable shock. He concluded that I had answered the Kaplansky question but that he didn't know of it or hadn't heard of it, for whatever reason that he didn't understand. Well, I'd had my fun and now, dispelled the confusion at once. "Oh, I have the examples," I said, "I am just missing the proofs. That is where you come in, if I show you the examples," I added. Neither Bob nor I would worry about such an arrangement being dealt with fairly. Over the next several months, Powers established that the examples were simple [RPo2] and made extensive calculations of the spectral properties of operators in $\mathfrak{A}_{\mathcal{F}_n}$ (not easy work). If the spectrum of such an operator is disconnected, integrating around a connected component of that spectrum, using the Banach-algebra-valued, holomorphic-function calculus produces a nontrivial idempotent in the algebra (and now, we are back to the starting point: Kaplansky, the reprint he had received, and the basis for the question he asked). At any rate, after those few months, Bob had worked so hard and been lost in so many calculation jungles that the mere mention of the problem turned him white as a sheet. I had "assured" him that those examples were what we wanted; he needn't waste time thinking otherwise. My "arrogant" assurance was partly humor, but mostly genuine conviction. Those examples and that project became widely known. Kaplansky's question had given birth to my conjecture about the free-group C*-algebras. Stalwarts other than Bob Powers tried the spectral calculation approach (among them Uffe Haagerup), but without success. Nonetheless, spectral properties of operators in the free-group C*-algebras has become a topic in its own right (not an easy one), with much information emerging that is vital for other purposes.

As noted, Bruce Blackadar settled the Kaplansky question [B] in a paper appearing in 1981. In 1981, M. Pimsner and D. Voiculescu [P-V1] proved my conjecture by constructing a six-term, cyclic, exact sequence from which they could compute the K-groups of $\mathfrak{A}_{\mathcal{F}_n}$ (and even more general C*-algebras). In 1979, Joel Cohen had shown that the "full" C*-algebra of $\mathcal{F}_n$ [JCo] (see also [Ch]) has no proper projections. Years earlier, Joel Cohen, a very bright young topologist, had been a postdoc in our department at the University of Pennsylvania. The question of idempotents in the complex, group algebra of $\mathcal{F}_n$ had come up in his work on topology. He asked me about that and I was able to prove (in fairly short order) that they had no proper projections. (Of course—when we now know that there are no such projections in the larger $\mathfrak{A}_{F_n}$. But that was still many years from being proved.) Joel was delighted with that. He trained himself to the point where he became a very serious worker on my conjecture, as [JCo] indicates. It is worth noting how much easier what I proved for Joel was than the eventual proof of my conjecture in [P-V1] as an illustration of how seemingly small changes alter the analytical difficulties (passing to the norm closure in this case). A further (stunning) illustration of that, for those who haven't struggled with such questions, is provided by examining $\mathcal{L}_{\mathcal{F}_n}$, the *strong-operator* closure of $\mathcal{A}_{\mathcal{F}_n}$, a von Neumann algebra. It is filled with proper projections (so many, that finite, linear combinations of them lie norm dense in that algebra). Why that should happen is quickly explained in terms of the paradigm of $\mathfrak{A}_{\mathcal{F}_n}$ as a noncommutative (continuous), function algebra associated with a compact, noncommutative topological space ("connected", as it turns out), while $\mathcal{L}_{\mathcal{F}_n}$ is the noncommutative (measurable) function algebra associated with a noncommutative measure space, and of course, measure algebras are stuffed with characteristic functions of sets (noncommutative, measurable sets, in this case). These characteristic functions correspond to idempotents in the von Neumann algebra.

Pimsner and Voiculescu [P-V2, 3] also completed Rieffel's program [R3] of determining the K-theory of the noncommutative "torii", proving that Rieffel had found all the projections. Their proof of my conjecture was considered the first real success of noncommutative K-theory. At the time of that proof, J. Cuntz [JCu1, 2] carried Joel Cohen's work on the full C*-group algebra of $\mathcal{F}_n$ further, determining its $\mathcal{K}_1$-group as well. Later, Cuntz found an easier (though highly nontrivial) proof of my conjecture. (It is the way of this area of mathematics that a very long and difficult argument, sooner or later, gets "compacted" into a few-page proof so incredibly clever that no mortal would ever produce it on the first go-around!) A. Connes was able to use his beautiful results to "manufacture" connected, noncommutative spaces "geometrically" [Con]—a very satisfying conclusion to that part of the project.

Well, there is much more to say about this development. It is, finally, the first serious noncommutative algebraic topology. I have only begun to list the great contributions made to that subject and to mention the superb mathematicians who made those contributions. At the base is Irving Kaplansky, whose algebraic curiosity forced him to wonder if there had to be idempotents in a simple, unital C*-algebra.

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About the Cover

JPEG Image Compression

This month's cover was produced entirely by David Austin, who also wrote the article on JPEG in this issue. He tells us:

The cover illustrates some aspects of the JPEG compression algorithms. In the background is a detail of the photograph blown up so that individual pixels become visible. The JPEG algorithm groups these pixels into 8 by 8 blocks, one of which is highlighted to the left of the photograph. Moving to the lower right, we see the luminance values for the pixels in another 8 by 8 block, the quantized Discrete Cosine Transform (DCT) coefficients representing the luminance values, and the zigzag order in which these coefficients are recorded. Finally, in the bottom center is a sequence of numbers—the ordered DCT coefficients for the luminance and blue and red chrominance values—describing the block just to the left and the reconstruction of the block from that sequence.

In the lower left is a representation of the wavelet coefficients that result when the JPEG 2000 algorithm, in which the Discrete Cosine Transform is replaced by a Discrete Wavelet Transform, is applied to this 16 by 16 block. The coefficients in the upper left corner of this block give a lower resolution version of the larger block. The blocks in the other three corners contain the information needed to reconstruct the full 16 by 16 block from the lower resolution.

—*Bill Casselman, Graphics Editor*
(notices-covers@ams.org)

WHAT IS...
JPEG?

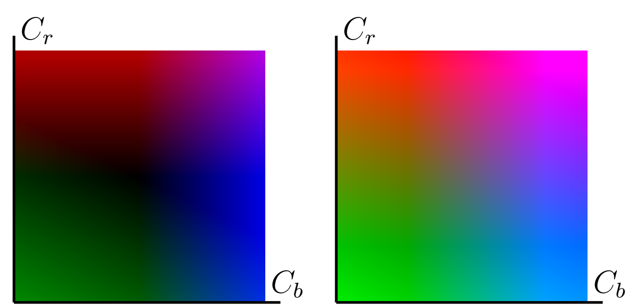
David Austin

The image below consists of a rectangular array of 3,871,488 pixels. The color of each pixel is determined by red, green, and blue components, each requiring one byte of computer memory. Naively, we expect the image to require 11,614,464 bytes. However, the size of the JPEG file containing this image is only 734,268 bytes, roughly 16 times smaller. We will describe the compression algorithm, developed by the Joint Photographic Experts Group (JPEG), that allows the image to be stored so compactly.

Rather than specifying the red, green, and blue components of a color, it is convenient to use three different quantities: luminance Y, which is closely related to the brightness of the color, and blue and red chrominances C_b and C_r, which roughly determine the hue. An invertible affine transform translates between the two representations; for instance, to recover the red R, green G, and blue B components, we use

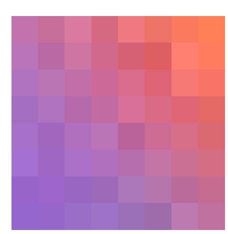
$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.0 & 0.0 & 1.40210 \\ 1.0 & -0.34414 & -0.71414 \\ 1.0 & 1.77180 & 0.0 \end{bmatrix} \times \begin{bmatrix} Y \\ C_b - 128 \\ C_r - 128 \end{bmatrix}.$$

Notice that the luminance contributes equally to the three color components. To help visualize this transformation, we show the colors that result from fixing the luminance and mixing various chrominance values.



$Y = 0$ $\qquad$ $Y = 100$

The algorithm proceeds by dividing the image into 8 by 8 blocks of pixels that are independently processed. Here is a sample block.



The (Y, C_b, C_r) components in our sample 8 by 8 block are shown below; lighter regions correspond to larger values.

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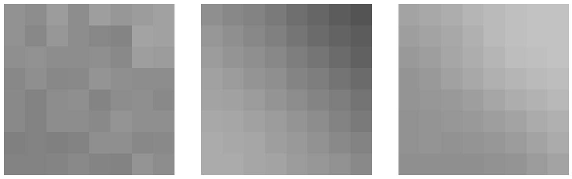


Y $\quad C_b$ $\quad C_r$

Notice that the luminance values produce a grayscale version of the image. As pyscho-visual experiments show that the human eye is most sensitive to the luminance values, the color transform concentrates the most important information into a single component. Color television uses a similar color model, enabling black and white televisions to display efficiently color images that are broadcast.

For reasons that will be explained later, we now express the component values as a linear combination of cosine functions of increasing frequency. For instance, if $Y_{x,y}$ is the luminance in column x and row y of our block, we write

$$Y_{x,y} = \sum_{u=0}^{7}\sum_{v=0}^{7} C_{u,v}F_{u,v}\cos\left[\frac{(2x+1)u\pi}{16}\right] \times \cos\left[\frac{(2y+1)v\pi}{16}\right].$$

(The normalizing constants $C_{u,v}$ need not concern us.) The coefficients $F_{u,v}$ are found by the two-dimensional Discrete Cosine Transform (DCT)

$$F_{u,v} = C_{u,v}\sum_{x=0}^{7}\sum_{y=0}^{7} Y_{x,y}\cos\left[\frac{(2x+1)u\pi}{16}\right] \times \cos\left[\frac{(2y+1)v\pi}{16}\right]$$

and efficiently computed using a version of the Fast Fourier Transform.

The values of the components in most blocks do not change rapidly, and the human eye is not particularly sensitive to these changes. Therefore, the DCT coefficients corresponding to higher frequencies will likely be small and may be ignored without affecting our perception of the image. This observation motivates our method for quantizing the DCT coefficients so they may be stored as integers.

Two ingredients are used in the quantization process. The first is a parameter α, chosen by the user to control the amount of compression and the quality of the image. Larger values of α lead to smaller files and lower quality images.

The second ingredient is an 8 by 8 matrix $Q = [Q_{u,v}]$ with the coefficients quantized by rounding $F_{u,v}/\alpha Q_{u,v}$. The $Q_{u,v}$ are chosen empirically and typically have larger values for higher frequencies so as to deemphasize those frequencies. For instance, a typical matrix used for quantizing the luminance DCT coefficients is

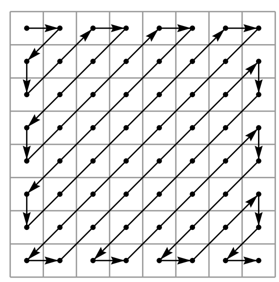
$$Q = \begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

Recognizing that the luminance carries more important visual information, we use different matrices for quantizing the coefficients describing luminance and chrominance. Processing our sample block with an intermediate value of α, the quantized luminance coefficients for our sample block are shown below.

u →, v ↓

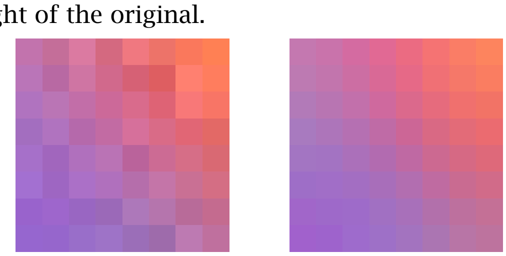
7	-2	1	0	0	0	0	0
4	0	1	0	0	0	0	0
1	-1	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

The quantized coefficients are ordered by following the arrows so that lower frequencies appear first.

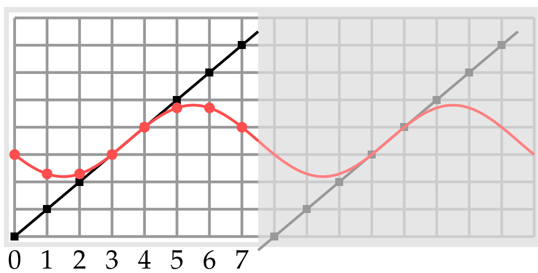


The quantized coefficients for the luminance component in our sample then produce the sequence 7, -2, 4, 1, 0, 1, 0, 1, -1 followed by 55 zeroes. Rather than storing each zero, we simply record the number of zeroes, which reduces the storage requirement significantly. Further compression is obtained by using a Huffman code to store the sequence of coefficients compactly.

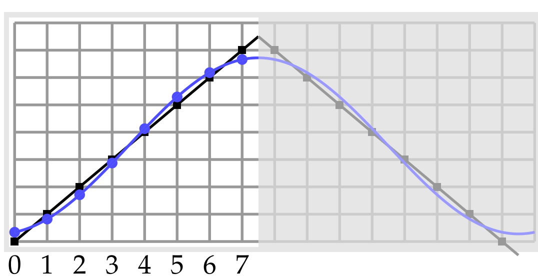
The image is reconstructed by reversing this process. The quantized coefficients give approximate values of $F_{u,v}$. These, in turn, give the (Y, C_b, C_r) components and the (R, G, B) components. The reconstructed block is shown to the right of the original.



The Discrete Fourier transform (DFT) may appear preferable to the DCT since it is more easily computed; however, our choice of the DCT is explained by our desire to concentrate the information in the low-frequency coefficients. For instance, consider the values, y_x, of one component in one row of an 8 by 8 block. The DFT expresses y_x as a linear combination of functions whose period is 8 resulting in a periodic extension of y_x. The transform therefore unnecessarily tracks the change between y_7 and $y_8 = y_0$, which can lead to significant high-frequency contributions. In the figure below, the y_x values are shown in black while the approximations given by the three lowest-frequency terms of the Fourier transform are in red.



By comparison, the DCT expresses y_x as a linear combination of functions whose period is 16 and that are symmetric about $x = 7.5$. This smoothes out the appropriate extension of y_x so that the DCT requires a relatively small contribution from high-frequency terms. Below we see the analogous approximation given by the DCT and note the improvement in the approximation. (These figures appear in [2].)

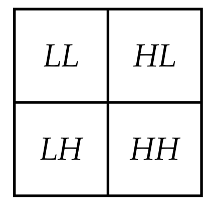


Since the 8 by 8 blocks are processed independently, discontinuities at the edges of the blocks become apparent at high compression ratios. In addition, it is often desirable to have the ability to reconstruct efficiently the image at intermediate resolutions. These reasons and others led to the creation of the JPEG 2000 compression algorithm. Among other differences, JPEG 2000 replaces the DCT with a discrete wavelet transform.

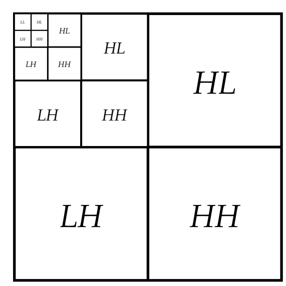
The JPEG 2000 algorithm divides the image into larger blocks, perhaps of size 256 by 256. To illustrate the wavelet transform, fix one row of pixels in a block and let y_x represent the values of one of the components. Now form wavelet coefficients

$$\begin{aligned} l_x &= (y_{2x} + y_{2x+1})/2 \\ h_x &= (y_{2x} - y_{2x+1})/2. \end{aligned}$$

The h_x are called "high-pass" coefficients, since they detect high-frequency changes, while the l_x are "low-pass" coefficients. Order them by listing all the low-pass coefficients followed by the high-pass coefficients and perform the same operation on the columns of wavelet coefficients to obtain blocks of coefficients:



The coefficients in the LL sub-block are obtained by averaging over 2 by 2 blocks of pixels and hence represent a lower resolution version of the image. The other three sub-blocks describe the changes necessary to construct the image at the higher resolution. We iterate this process on the LL sub-block thus storing the image at increasingly lower resolutions.



A quantization procedure detects regions where the values do not change significantly so that high-pass coefficients may be safely ignored.

Rather than the wavelet transform described above, which averages two adjacent values, the JPEG 2000 algorithm uses the Cohen-Daubechies-Feauveau (9, 7) wavelet transform, which finds a weighted average over nine adjacent values and thus produces smoother images.

The complexity of the JPEG 2000 algorithm, compared to that of the original JPEG algorithm, is an order of magnitude greater, and at low and medium compression ratios, the quality of the images produced by JPEG 2000 is not substantially better. At very high compression ratios, however, where JPEG's use of 8 by 8 blocks can cause the image quality to deteriorate severely, JPEG 2000 offers significantly better results.

Since JPEG 2000 asks us to work harder to produce images of generally comparable quality, it is not a clearly superior choice over JPEG. Indeed, only a few web browsers are currently capable of displaying JPEG 2000 images. Its principal advantage lies in providing a much more flexible format for working with images in environments where the increased complexity is not problematic.

For instance, the ability to reconstruct efficiently the image at different resolutions, which results from the use of the wavelet transform, allows users to search visually through many images at a low resolution quickly. JPEG 2000 also permits regions, designated by a user perhaps, to be displayed at a higher resolution, a reason that it is commonly used in medical imagery. Finally, it is possible for digital photographs, stored on a camera's memory card in the JPEG 2000 format, to be converted efficiently to a lower resolution to reduce memory usage after they are taken. JPEG 2000, being designed roughly ten years after JPEG, also includes other features, such as the ability to encrypt images, whose need was not anticipated earlier.

> David Austin also wrote about JPEG in "Image Compression: Seeing What's Not There", the September 2007 installment of the *Feature Column* on the AMS website (see `http://www.ams.org/featurecolumn/archive/image-compression.html`). The *Feature Column*, which appears monthly, presents accessible essays about mathematics that are designed for those who have already discovered the joys of mathematics as well as for those who are just getting to know its charms. The *Feature Column* is freely available at `http://www.ams.org/featurecolumn`.

Further Reading

[1] T. Archarya and P.-S. Tsai, *JPEG2000 Standard for Image Compression: Concepts, Algorithms and VLSI Architectures*, Wiley, Hoboken, 2005.

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Book Review

The Probability of God *and* Superior Beings

Reviewed by Hemant Mehta

The Probability of God: A Simple Calculation That Proves the Ultimate Truth
Stephen Unwin
Three Rivers Press, 2004, paperback
US$12.95, 272 pages, ISBN 978-1400054787

Superior Beings: If They Exist, How Would We Know?
Steven Brams
Springer, 2nd edition, 2007
US$41.95, 202 pages, ISBN 978-0387908779

Both Stephen Unwin and Steven Brams have their work cut out for them in trying to mathematize God. Theologians, scientists, and atheists all have their opinions on God's existence (or lack thereof), but these authors want to throw numbers into the mix. Both books offer creative approaches to the problem in their own unique ways. Still, one book is much easier to comprehend and a joy to read; the other, while fascinating in its own right, will most likely be found only on professors' bookshelves.

Stephen Unwin, a physicist and risk-analyst, is the author of *The Probability of God: A Simple Calculation That Proves the Ultimate Truth*. Unwin admits that an exact answer to God's existence won't be found but feels that he can contribute where great minds before him have failed: "[They] did not think of addressing the issue of God's existence in a formal, probabilistic setting. They looked at the question in a strictly binary, deterministic way. They asked, 'Is there a God, yes or no?'"

Here is the mother of all spoilers: The probability that the monotheistic, prayer-answering God exists is… 67%.

That may be the conclusion to the book, but it's hardly the climax. Rather, the focus is on the process of getting to that number. The questions I asked myself as I read the book included: What equation(s) did Unwin use? How did he find numbers to plug into it? Is there any merit to his method?

Unwin has asked himself all of these questions, and although one may not agree with his responses, he does explain them throughout each chapter. One of the more pleasant surprises in this book is how transparent his method is every step of the way. When a number is subjective (and there are many that are), Unwin says so, and he urges readers to plug in substitute values as they see fit. That's the enjoyment in his approach. In the appendix, he even offers a step-by-step tutorial for readers so they can set up spreadsheets on their computers and calculate the probability of God using their own values.

Before getting to the math, Unwin reaches out to those who may be skeptical of this entire process in the first place. He explains precisely the type of God he will be referring to and dismisses many of the "proofs" of God that are popular among Christians, including Intelligent Design and the Fine-Tuned Universe argument. He says that the

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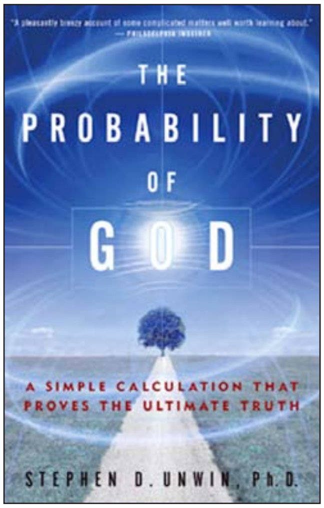


probability of God—whatever it will be—does not imply the literal truth of the Bible. He also boldly suggests that science-based arguments for or against the existence of God are "troublesome" and that they do not provide us with meaningful evidence to help us answer the God-existence question. This is a radical departure from the thinking of scientist and atheist Richard Dawkins, whose book *The God Delusion* states that the existence of God *is* a scientific hypothesis and must be treated as such.

Eventually, we get to the numbers by invoking Bayesian theory. Reverend Thomas Bayes was a Presbyterian minister and mathematician in the eighteenth century. Bayes' theory, expanded after his death, provides a systematic way to adjust a probability based on the evidence. However, to use it, a starting point is needed.

Unwin decides that "maximum ignorance" on the question of God would lead to a 50-50 chance that God exists. He adds that "this is the perfect, unbiased expression of agnosticism." I'm not convinced this is the proper starting place. However, to try to find a starting point upon which all people would agree would be futile. Without *some* initial number, though, there is no way to move forward. So we are forced to accept Unwin's 50% number so that further calculations can be made. Of all the numbers Unwin throws at the reader, I would argue that this is the most egregious one.

The other numbers are used to judge various areas of evidence that could be used in support of (or against) God. On the "Divine Indicator Scale", a "D-value" of 10 is used in an area if the evidence is much more likely to be produced *if God exists*, a D-value of 0.1 means the evidence is much more likely to be produced if God *does not exist*, and a D-value of 1 means the evidence is "God-neutral". There are numbers in between as well. These values are assigned to a variety of areas that cover everything from the "recognition of goodness" to the "existence of natural evil". All of this culminates in the final 67% probability of God's existence using Unwin's calculations.

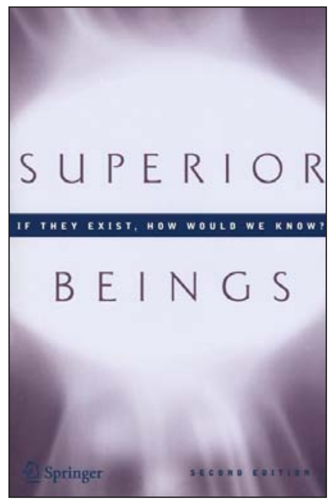
Unwin admits that this number is unique for him and others may achieve different results:

> Your assessment of the evidence may differ. So now that you have the hang of the process, you may wish to adjust the numbers as you see fit and see what results you derive. You may even have new evidentiary areas to add. (p. 129)

This book makes for a wonderful thought experiment and provides fodder for some great discussions. Trying to come up with rationales for different D-values and adding other evidentiary areas to the mix will produce a wide variety of probabilities of God's existence.

Once you realize the book is more philosophical than it is mathematical, it's much easier to digest. You focus less on the numbers and more on the technique.

Readers will appreciate the orderly way Unwin goes about finding his answer. I suspect, though, that if his final result of God's probability of existence had been 10% instead of 67%, religious readers would not be so keen to accept his method, just as non-religious readers may be skeptical of Unwin's 67% conclusion. Atheist readers will further object to many of Unwin's D-values (and his 50% starting point) as well as his statement that he finds "none of the atheistic explanations of compassion and morality highly convincing" (p. 108). However, they might appreciate, as I did, his attempt to put God's existence to the test.



The beauty of this book is that both ends of the religious spectrum can simply plug their own numbers (however produced) into Unwin's equation to get satisfying results. That also means people on neither side are likely to change their minds as a result of reading this book. However, the discussion shifts from debating God's existence to discussing whether goodness, evil, and miracles are more likely to result in a world with God rather than without—and this is a much more satisfying conversation than the ones that usually occur between theists and atheists.

Unwin does a particularly good job of warning lay readers when a more difficult math concept is approaching and reassuring them that it will be comprehensible. Also, along the way, we are treated to scripted vignettes that take place in a mall, a bevy of pop culture references, and plenty of sarcastic and humorous asides. They make the book easy to read and distinguish Unwin as a scholar who can certainly relate to nonmathematical people. At the same time, while the humor was appreciated early in the book, it became irritating later on when I wanted to get to the actual math.

The writing does get especially murky when Unwin discusses "faith", which he says lies outside the equations he had been using up to that point. He assessed his own belief probability to be 95%, meaning he was fairly certain that God existed. This, along with the 67% "reasoned truth probability" he had figured out earlier in the book, resulted in a 28% "faith factor", which Unwin says is necessary to bridge the discrepancy between the equation's result and his personal belief.

Incidentally, Michael Shermer, the publisher of *Skeptic* magazine, calls the book "innovative" and "an entertaining exercise in thinking." When Shermer plugged in his own numbers (again ranging from 0.1 to 10) into Unwin's equation, he found that the probability of God was only 2%.[2] All of Shermer's values were the same or lower than Unwin's, but it goes to show how the method described in this book can produce wildly varied results.

While Unwin's book makes for easy reading, the same cannot be said about Steven Brams's *Superior Beings: If They Exist, How Would We Know?*

In the introduction to the book, Brams writes,

> I know of no reasons, in principle, why some of the great religious-theological-philosophical questions of our age cannot be made more perspicuous, their analysis more coherent, and their implications better understood by the use of formal deductive methods appropriate to the problem at hand. The problems will vary, and so will the methods, but the marriage, if consummated, could have auspicious prospects. It will, I trust, not be dull. (p. 11)

Unfortunately, much of the book is dry and difficult to slog through. A bit of Unwin's humor would have benefited Brams's writing.

Brams does not attempt to prove or disprove God. He uses elementary ideas from game theory to create situations between a Person (P) and God (Supreme Being, SB) and discusses how each reacts to the other in these model scenarios. A variety of 2×2 matrices are presented in each chapter to show how the games would operate given God's supposed qualities of omniscience, omnipotence, immortality, and incomprehensibility. Some of these matrices lead to paradoxical outcomes; others are fairly straightforward.

While understanding the math is not out of reach for a layperson, the book is aimed at academics interested in seeing math used in a different way. In fact, once you learn how the hypothetical games are set up, they can become something of a parlor game for even the amateur mathematician.

From the outset, Brams gives the reader a crash course in how these matrices are set up. In the "Revelation Game", for example, the Person (P) has two options:

1) P can believe in SB's existence
2) P can not believe in SB's existence

The Supreme Being also has two options:

1) SB can reveal Himself
2) SB can not reveal Himself

Each player also has a primary and secondary goal. For the Person, the primary goal is to have his belief (or non-belief) confirmed by evidence (or lack thereof). The secondary goal is to "prefer to believe in SB's existence". For the Supreme Being, the primary goal is to have P believe in His existence, while the secondary goal is to not reveal Himself.

These goals allow us to rank all the outcomes for each player from best (4) to worst (1). We end up with a matrix as follows (the first number in the parentheses represents the SB's ranking for that box; the second number represents P's ranking):

	P believes in SB's existence	**P does not believe in SB's existence**
SB reveals Himself	P faithful; belief confirmed with evidence (3,4)	P unfaithful despite evidence; nonbelief is unconfirmed (1,1)
SB does not reveal Himself	P faithful; belief unconfirmed with no evidence (4,2)	P unfaithful without evidence; nonbelief is confirmed (2,3)

The question we must answer is: what is the Nash equilibrium in this case? When P believes in SB's existence, SB is better off not revealing Himself (since (4) > (3)). When P does not believe in SB's existence, the same result follows (since (2) > (1)). Thus, SB will not reveal Himself. Since P knows that to be the case, he must choose between believing (2) or not believing (3). Since (3) is ranked higher, the Nash equilibrium lies in the lower right hand corner of our matrix, showing us that the dominant strategy for both is when SB does not reveal himself and P does not believe in His existence. (Kudos are due to atheists everywhere.)

It takes a while for that game to make sense for those who have not been exposed to game theory before. Now, imagine 78 matrices just like that, many of which are explained in even greater depth. This is not light reading for the average Joe.

In another game that Brams discusses—the famous "Chicken" game—we achieve *two* Nash equilibria. How does this game relate to religion? Brams lets us know that "it is not implausible to think of man and God as being occasionally on a collision course, with possibly doleful results for both players" (p. 71). He also mentions biblical stories where these situations play out, including Cain's murder of Abel and Saul's disobeying of the prophet Samuel, both in defiance of God's will. Since this is discussed in the chapter on omniscience, the paradox lies in the fact that if the

[2]Scientific American, *July 2004. Shermer's article is available online at* `http://www.sciam.com`.

Person knows that God can predict his move, the Person is better off not compromising. God will do what is necessary to avoid disaster, which in this case means compromising. As Brams writes,

> Thus, if P is aware of SB's omniscience, he would prevail over him yielding the Nash equilibrium (2,4) in Chicken… I call [this] the *paradox of omniscience*. This is a paradox, I believe, because one would not expect this superior ability of SB to impede his position—the outcome he can ensure—in a game. Yet, it is precisely his omniscience, and P's awareness of it, which ensures that P obtains his best outcome and SB does not. (p. 71)

When you think about it that way, it's a fascinating concept to play around with. You want to know what other matrix manipulations take place in the book, and you want to create similar situations on your own.

Does Brams ever get the religion aspect wrong? Yes, though only in minor ways. He defines an agnostic as one who "chooses not to believe in [a Supreme Being's] existence" (p.19). In fact, he has defined an atheist. An agnostic would not take a side in the argument since knowledge of the existence (or nonexistence) of God can never be fully obtained. Brams makes a similar mistake later in the book when he writes that an atheist "would say that the question [of God's concern for us] is meaningless because God does not exist" (p. 38). Again, atheists do not assert that God does not exist; rather, that there is no evidence of God so they do not *believe* He exists. These quibbles are minor, though, and bear no impact on the ideas he presents in the book.

There are other compelling examples Brams uses in the book, including a thorough description of Newcomb's Problem and a fascinating matrix on the Punishment Game (where P chooses whether or not to sin, and SB decides whether or not to punish him).

Neither book will change your mind about God, but both offer novel ways of bringing math into the world of theology. This is a potentially ill-fated effort since the authors attempt to bring together a field that relies on certainty and proofs with one where both are elusive. However, both books usher in a novel way to debate the nature of God and the supernatural within a mathematical framework. It's rare to see a book about religion that can speak to multiple faith positions. Here we have two of them. Both can be cited by either side of the argument convincingly, and both will allow for a much more fulfilling conversation with people on opposite sides of the religious divide.

Book Review

A Certain Ambiguity

Reviewed by Danny Calegari

A Certain Ambiguity (A Mathematical Novel)
Gaurav Suri and Hartosh Singh Bal
Hardcover, Princeton University Press
US$27.95, 281 pages
ISBN-13: 9780691127095

In "A negative review of negative reviews" ([6]), Doron Zeilberger contends that "(a)nyone who wastes his time writing a review of a book that he or she dislikes, is a frustrated mathematician, who has an axe to grind, and just enjoys being mean."

Writing a novel, especially a novel with serious philosophical aims, is not easy, and Suri and Bal have made a serious attempt. They have chosen an ambitious and significant theme—the story of the gradual discovery and development of nonstandard axioms for geometry (hyperbolic geometry) and for set theory (undecidability of the Continuum Hypothesis), and the implications for epistemology. This theme reveals itself through the story of a young man called Ravi, who by chance takes a liberal arts mathematics undergraduate course at Stanford. The topic of the course is infinity, and Ravi's intuitions and naive notions are sharpened by an exposure to ideas such as cardinality, power sets, and so forth. At the same time, Ravi stumbles on evidence of a surprising episode in the life of his deceased grandfather Vijay and, by hunting through newspaper clippings and court transcripts, comes to learn about a parallel formative experience his grandfather underwent at a young age. Ravi's gradual discovery of the subtle and indirect nature of mathematical and historical reality is interspersed with (fabricated) "diary entries" by such historical figures as Pythagoras, Bolyai, and Cantor.

I find the premise of this book fascinating and am excited by the idea of a simultaneous examination of these issues from historical, scientific, and psychological viewpoints. I therefore regret (at the risk of arousing Zeilberger's spleen) that, despite finding some things to like here, I cannot recommend this book on literary, philosophical, or mathematical grounds (however, read on). The result is more of a novelty than a novel, and the authors' ambitions seem more grandiose than grand. Structurally, the book is sound, and even innovative. Numerous historical and fictional strands are played out, and the literary device of switching back and forth between narrative, newspaper excerpt, transcripted dialogue, diary entry, and so forth does a good job of organizing and integrating these strands.

The main disappointment is the disparity between the potential sophistication and depth of the subject matter, and the unremarkable depths to which Suri and Bal plumb it. Easiest to criticize (and least serious, in my opinion) is the cursory investigation of the mathematics. We are led through the usual pedestrian examples of sets that are in bijection to proper subsets (the real line and an open interval, the positive integers and the squares), Cantor's diagonal argument that for any set S the power set $\mathcal{P}(S)$ has greater cardinality than S, and so on. Irritatingly, there are some minor goofs even in the exposition of such basic material. In order to disprove the existence of a bijection of a particular set $A = \{c, *, a, ?, \#, q, t, \dots\}$ with $\mathcal{P}(A)$, the authors instead start to give a partial

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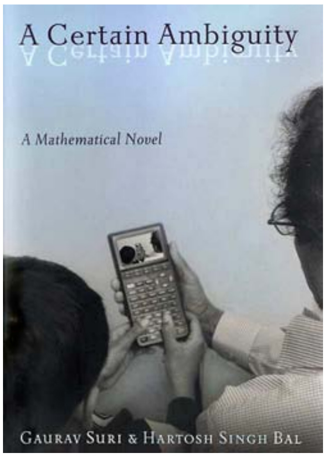
bijection of A with $\mathcal{P}(\mathcal{P}(A))$

$$\begin{aligned} c &\longleftrightarrow \{?, a\}, \{q\} \\ * &\longleftrightarrow \{c, a\}, \{\#, ?, *\}, \ldots \\ a &\longleftrightarrow \{\} \end{aligned}$$

and so on. Actually, I assume this is what they are doing; the notation makes it unclear exactly what set the range is supposed to be. However, in the next paragraph, the confusion is compounded by the assertion that "the element c is mapped to the subsets $\{?, a\}, \{q\}$, and so c does not occur in the set it is mapped into" (p. 171). Set or sets? If the authors cannot get basic things right, at least they can eulogize them: "(f)rom my current perch in retrospective adulthood I consider Cantor's proof about power sets to be one of the flagship creations of the human race. We have thought nothing more elegant or powerful, only different" (p. 170). If "perch" doesn't make you wince, the contrast between this encomium and the subsequent muddle will. There is inconsistent notation (the power set of A is $P[A]$ at one point, and $[A]$ later on, and then finally $P(A)$) and confusing exposition of elementary theorems in plane geometry. And for the reader who already has some familiarity with mathematics, there is boredom. Mathematically speaking, there is nothing here that is not already in every other popular or informal account of non-Euclidean geometry or the Continuum Hypothesis. All the high points are hit, like a tour bus doing Europe in seven days. Tangible examples of negative curvature in nature (lettuce leaves, seaweed) or sewing (pleats) are missing here; instead we read a newspaper account of an expedition to measure the effect of gravity on light rays. At one point, Nico the course instructor declares "I've read some things about this but I don't understand it fully, so I'm not going to talk about it" (p. 222). One gets the impression that the authors have taken a different position. There is a lot of waffle about the implications of the work of Gödel and Cohen, but no discussion of what they actually did. Mathematics in this book is a strut on which a range of philosophical opinions are propped up. Perhaps in reaction to this, I was provoked into reading something more substantial about the mathematics of the Continuum Problem. To the nonspecialist like myself, I can recommend *Set Theory and the Continuum Problem* by Smullyan and Fitting ([3]), or Woodin's pair of articles which appeared in the *Notices* ([5]).



The philosophical ambitions of the novel are more off-putting. In a broad sense, the novel preaches a kind of relativism in which truth is provisional and relative to a set of axioms that are accepted on some unknown basis. Further, there is an important distinction between the consistency of a theory and the question of whether that theory accurately models some phenomenon under discussion. Fine. A page and a half is devoted to a token comparison of several schools of thought on the interpretation of mathematical knowledge, e.g., Platonism, formalism, constructivism, quasi-empiricism, but the real target is elsewhere. The subplot revolving around Vijay is a sustained effort to "equate … faith in God with a mathematician's belief in absolute mathematics" (p. 258). In this subplot, opposite (but apparently symmetric) points of view are taken up by Vijay and by Judge John Taylor. The independence of the parallel postulate is taken to undermine Vijay's initial position that the Christian belief in the authority of the Bible is illogical and has no place in America, the "land of 'rationality and objectivity'" (p. 51). Leaving aside the question of whether a published professional number theorist working in 1919 could be unaware of the existence of a consistent theory of non-Euclidean geometry, there is no man in this argument who is not a straw man. I was irritated on behalf of mathematicians and theists alike by their banal and predictable interchanges. Ultimately, Vijay's position is undermined when he discovers that the "self-evident" parallel postulate may not correctly describe nature after all. Judge Taylor undergoes a similar examination of his faith. "That night I let myself see the world as an atheist must: a desolate planet occupied by people who had abandoned themselves to amoral meaninglessness" he writes (pp. 248-249). As for the axiomatic method, we get the following platitude: "(a)s long as (a man) is true to some core beliefs, he can't go too far wrong. Which starting point is true is not something we humans can make much progress on" (p. 255). Bleagh. The best one can say about this bit of homespun wisdom is that it has the virtue of being hopelessly naive about something important. From the Habermas-Lyotard debate (see [1] for an introduction) to the Sokal hoax ([4]), to recent atheist manifestos on the bestseller lists (e.g., [2]) the question of foundations for intellectual thought and especially for intellectual debate has never been more critical or urgent. Never mind.

Turning to the literary dimensions of the work, I am compelled to say that the prose is usually workmanlike, and the main characters' attitudes are generally sophomoric. But at least in this domain there are parts of the novel worth enjoying. The description of Ravi's emotional state as he lights his grandfather's funeral pyre is delicate and moving. And the story of his ambivalent quest to join the firm of Goldman-Sachs is compellingly factual (and, given the background of one of the authors, one suspects factually correct) and concrete. The character of Nico is sympathetic and admirable, and mainly by a process of tactful omission ("from the lower pitch of his voice I got that he didn't really want to debate his beliefs with me" (p. 157)) is made to seem wise and generous. The narrative is well-plotted, dynamic, and compelling, and rarely drags. There is even a latent love interest. I found it easy to start reading this book, and to keep on reading. While some of the fictitious "diary entries" are somewhat unconventional (e.g., Cantor's journal entry in which he records his wife saying "You are a huggable bear, Georg" (p. 105)), one can read these in the playful spirit in which they are offered without taking offense. The book plausibly succeeds somewhere at the interface of entertainment and journalism. Readers with no prior interest in mathematics or philosophy may find these aspects of the book at their level and be drawn in by the entertainment the book provides to a fascinating subject whose rewards and subtleties the book points to even if it does not illustrate them.

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[4] A. Sokal and P. Bricmont, *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science*, Picador, 1999.

[5] H. Woodin, The continuum hypothesis, Parts I and II, *Notices AMS* **48**, no. 6, pp. 567–576 and no. 7, pp. 681–690.

[6] D. Zeilberger, A negative review of negative reviews, `http://www.math.rutgers.edu/~zeilberg/Opinion63.html`.

Interview with Srinivasa Varadhan

Martin Raussen and Christian Skau

S. R. S. Varadhan is the recipient of the 2007 Abel Prize of the Norwegian Academy of Science and Letters. On May 21, 2007, prior to the Abel Prize celebration in Oslo, Varadhan was interviewed by Martin Raussen of Aalborg University and Christian Skau of the Norwegian University of Science and Technology. This interview originally appeared in the September 2007 issue of the *European Mathematical Society Newsletter.*

—Andy Magid

R & S: *Professor Varadhan, first of all we would like to congratulate you for having been awarded the Abel Prize this year.*

By extension, our congratulations go to the field of probability and statistics since you are the first recipient from this area. Incidentally, last year at the International Congress of Mathematicians in Madrid, Fields Medals were given to mathematicians with expertise in this area for the first time, as well.

How come it took so long time before probability and statistics were recognized so prestigiously, at the International Congress of Mathematicians last year and with the Abel Prize this year? Is it pure coincidence that this happens two years in a row? Could you add some comments on the development of the relations between probability and statistics on the one hand and the rest of mathematics on the other hand?

Varadhan: Probability became a branch of mathematics very recently in the 1930s after Kolmogorov wrote his book. Until then it was not really considered as a proper branch of mathematics. In that sense it has taken some time for the mathematical community to feel comfortable with probability the way they are comfortable with number theory and geometry. Perhaps that is one of the reasons why it took a lot of time.

In recent years probability has been used in many areas. Mathematical finance for example uses a lot of probability. These days, probability has a lot of exposure, and connections with other branches of mathematics have come up. The most recent example has to do with conformal invariance for which the Fields Medal was given last year. These connections have brought probability to the attention of the mathematics community, and the awards are perhaps a reflection of that.

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Career

R & S: *The next question is about your career. You were born in Chennai, the capital of Tamil Nadu, on the Southeast coast of India, in 1940. You went to school there and then to the Presidency College at Madras University. We would like to ask you about these formative years: What was the first reason for your interest in mathematical problems? Did that happen under the influence of your father, who was a teacher of mathematics? Were there other people, or were there specific problems that made you first interested in mathematics?*

Varadhan: My father was in fact a teacher of science, not so much mathematics. In my early school days I was good in mathematics, which just meant that I could add, subtract, and multiply without making mistakes. Anyway I had no difficulty with mathematics. At high school I had an excellent mathematics teacher who asked some of his better students to come to his house during weekends, Saturday or Sunday, and gave them extra problems to work on. We thought of these problems just as intellectual games that we played, it was not like an exam; it was more for enjoyment. That gave me the idea that mathematics is something that you can enjoy doing like playing chess or solving puzzles. That attitude made mathematics a much more friendly subject, not something to be afraid of, and that played a role in why I got interested in mathematics. After that I went to college for five years. I had excellent teachers throughout. By the time I graduated with a master's degree in statistics, I had three years of solid grounding in pure mathematics. My background was strong when I graduated from college.

R & S: *Was there a specific reason that you graduated in statistics rather than in other branches of mathematics?*

Varadhan: The option at that time was either to go into mathematics or into statistics. There was not that much difference between these two. If you went into mathematics, you studied pure and applied mathematics; if you went into statistics, you studied pure mathematics and statistics. You replaced applied mathematics with statistics; that was the only difference between the two programs. Looking back, part of the reason for going into statistics rather than mathematics was the perception that if you went into statistics your job opportunities were better; you could be employed in industry and so on. If you went into mathematics, you would end up as a school teacher. There was that perception; I do not know how real it was.

R & S: *With your degree in statistics it seemed quite natural that you continued at the Indian Statistical Institute at Kolkata. There you found yourself quite soon in a group of bright students that, seemingly without too much influence from their teachers, started to study new areas of fundamental mathematics and then applied those to problems coming from probability theory—with a lot of success. You were able to extend certain limit theorems for stochastic processes to higher dimensional spaces; problems that other mathematicians from outside India had been working on for several years without so much success. Could you tell us a bit about this development and whom you collaborated with?*

Varadhan: The Indian system at that time was very like much the British system: If you decided to study for a doctoral degree, there were no courses; you were supposed to do research and to produce a thesis. You could ask your advisor questions and he would answer you, but there was no formal guidance as is the case in the United States for example. When I went there I had the idea that I would be looking for a job within some industry. I was told that I should work on statistical quality control, so I spent close to 6 or 8 months studying statistical quality control; in the end, that left me totally unsatisfied.

Then I met Varadarajan, Parthasarathy, and Ranga Rao, who worked in probability from a totally mathematical point of view. They convinced me that I was not spending my time usefully, and that I better learn some mathematics if I wanted to do anything at all. I got interested, and I think in the second year I was there, we said to ourselves: Let us work on a problem. We picked a problem concerning probability distributions on groups. That got us started; we eventually solved the problem and in the process also learned the tools that were needed for it.

It was a lot of fun: the three of us constantly exchanged ideas starting at seven o'clock in the morning. We were all bachelors, living in the same dormitory. The work day lasted from 7 a.m. to 9 p.m.; it was a terrific time to learn. In fact, the second paper we wrote had Abel in its title, because it has something to do with locally compact abelian groups.

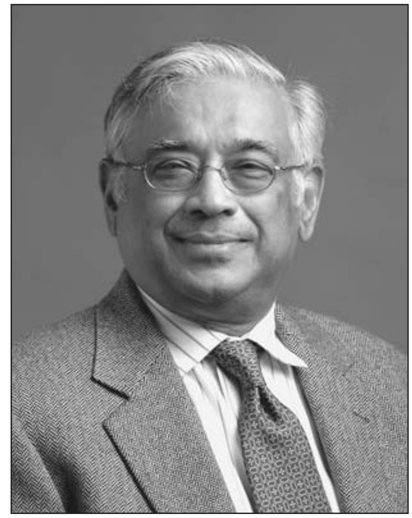


Photo: Anne Lise Flavik. Courtesy of the Norwegian Academy of Science and Letters.

Srinivasa S. R. Varadhan, winner of the 2007 Abel Prize.

R & S: *From what you tell us, it seems that your work can serve as an example for the fact that the combination of motivations and insights from real world problems on the one hand and of fundamental abstract mathematical tools on the other hand has shown to be extremely fruitful. This brings us to a question about the distinction between pure and applied mathematics that some people focus on. Is it meaningful at all—in your own case and maybe in general?*

Varadhan: I think that distinction, in my case at least, is not really present. I usually look at mathematics in the following way: There is a specific problem that needs to be solved. The problem is a mathematical problem, but the origin of the problem could be physics, statistics, or could be another application, an economic application perhaps. But the model is there, and it is clear what mathematical problem you have to solve. But of course, if the problem came from physics or some application, there is an intuition that helps you to reason what the possible answer could be. The challenge is how to translate this intuition into rigorous mathematics. That requires tools, and sometimes the tools may not be around and you may have to invent these tools, and that is where the challenge and the excitement of doing mathematics is, as far as I am concerned. That is the reason why I have been doing it.

India and the Third World

R & S: *May we come back to your Indian background? You are the first Abel Prize recipient with an education from a Third World country. In 1963 you left Kolkata and went to the Courant Institute of Mathematical Sciences in New York, where you still are working. We wonder whether you still strongly feel your Indian background—in mathematics, in training, your life style, your religion, and philosophy?*

Varadhan: For twenty-three years, I grew up in India, and I think that part of your life always stays with you. I am still very much an Indian in the way I live. I prefer Indian food to anything else, and I have some religious feelings about Hinduism and I am a practising Hindu. So my religious beliefs are based on my real life, and my lifestyle is very much Indian. But when you are living in the United States you learn to adjust a little bit, you perhaps have a combination of the two that you are comfortable with.

My training in India has been mainly in classical analysis. No matter what you do, even if you do the most abstract mathematics, you use it as a tool. At crucial points, I think you need to go back to your classical roots and do some tough estimates here and there; I think the classical training definitely helps there. The abstract mathematical tools then help you to put some results in perspective. You can see what the larger impact of what you have done is. To assess that, modern training gives you some help.

***R & S:** The best known Indian mathematician of the past, at least here in the West, is certainly Srinivasa Ramanujan. He is known both for his very untraditional methods and results, and his notebooks are still studied by a lot of mathematicians around the world. He is certainly also known for his tragic fate and his untimely death. Has he played a specific role in your life as a role model? Is that still true for many Indian mathematicians?*

Varadhan: I think the name of Ramanujan has been familiar to most Indians today. Maybe, when I was growing up, it was more familiar to people from the South than from the North, because he came from the southern part of India, but we definitely knew of him as a great mathematician. At that age, I did not really know the details of his work. Even now, I have only a vague idea of what it is about. People still do not seem to know how exactly he arrived at those results. He seemed to have a mental process that led him to these things, which he has not fully explained in his work. In spite of the years Ramanujan spent with Hardy, the West was not able to penetrate the barrier and understand how his mind worked. I do not think we can do anything about it now.

Mathematical Institutions

***R & S:** You spent the last years of your life in India at the Indian Statistical Institute (ISI) at Kolkata. There is another well-known research institute in India, the Tata Institute. We know that there has been some competition between these two institutions although they specialize in different fields. Can you comment on this competition, the ongoing relations between the two institutes and their respective strengths?*

Varadhan: I do not know when the competition started. The Indian Statistical Institute was founded by Mahalanobis in 1931; the Tata Institute was founded by Bhabha in 1945. They were both great friends of Jawaharlal Nehru, the prime minister at the time, and he encouraged them both. Maybe there are some rivalries at that level, the institutional level. The mathematics division of the Indian Statistical Institute had Dr. C. R. Rao, who was my advisor, as its scientific director, and the mathematics division of the Tata Institute was headed by Dr. Chandrasekharan; he was the moving force behind the mathematics school of Tata Institute. Maybe there is some competition there.

I know many of the faculty of the Tata Institute; in fact many of them were from the same region in the South and they went to the same university, the same college, perhaps even to the same high school. So the relationships between the two faculties have always been friendly.

It is true, the emphasis is very different. At Tata, they have concentrated on number theory and algebraic geometry and certain parts of abstract mathematics. The Indian Statistical Institute on the other hand has concentrated more on probability and statistics. Although there has been some overlap, it is really not that much.

***R & S:** We have heard that you still entertain close relations to India and to Chennai and its mathematical institute, in particular. And in general, you are interested in the academic development of Third World countries, in particular through the Third World Academy of Sciences. Please tell us about your connections and your activities there?*

Varadhan: I go to Chennai maybe once a year now. Earlier it used to be twice a year, when my parents were alive. I used to go and spend a month or two in Chennai, and I visited the two mathematical institutions in Chennai: there is the Chennai Mathematics Institute, and there is also the Institute of Mathematical Sciences in Chennai. I have visited both of them at different times. I have close contacts with their leadership and their faculty.

In earlier times, I visited the Bangalore Centre of the Tata Institute: The Tata Institute in Mumbai has a Centre for Applicable Mathematics in Bangalore. I spent some time visiting them, and we have had students from there coming to the Courant Institute to take their degrees and so on. To the extent possible, I try to go back and keep in touch. Nowadays, with email, they can ask me for advice, and I try to help out as much I can. The next couple of years, I have some plans to spend part of my sabbatical in Chennai lecturing at Chennai Mathematics Institute.

***R & S:** You are already the second Abel Prize winner working at the Courant Institute of Mathematical Sciences in New York, after Peter Lax. At least in the world of applied mathematics, the Courant Institute seems to play a very special role. Could you explain how this worked out? What makes the Courant Institute such a special place?*

Varadhan: We are back to the 1930s, when the Courant Institute was started. There was no applied mathematics in the United States. Richard

Courant came to the U.S. and he started this mathematics institute with the emphasis on applied mathematics. His view of applied mathematics was broad enough so that it included pure mathematics. I mean, he did not see the distinction between pure and applied mathematics. He needed to apply mathematics, so he developed the tools; he needed to do it. And from that point of view, I think analysis played an important role.

The Courant Institute has always been very strong in applied mathematics and analysis. And in the 1960s, there was a grant from the Sloan Foundation to develop probability and statistics at the Courant Institute. They started it, and probability was successful, I think. Statistics did not quite work out, so we still do not have really much statistics at the Courant Institute. We have a lot of probability, analysis, and applied mathematics, and in recent years some differential geometry as well. In these areas we are very strong.

The Courant Institute has always been successful in hiring the best faculty. The emphasis has mostly been on analysis and applied mathematics. Perhaps that reflects why we have had two Abel Prize winners out of the first five.

Mathematical Research: Process and Results

R & S: *You have given deep and seminal contributions to the area of mathematics which is called probability theory. What attracted you to probability theory in the first place?*

Varadhan: When I joined my undergraduate program in statistics, probability was part of statistics; so you had to learn some probability. I realised that I had some intuition for probability in the sense that I could sense what one was trying to do, more than just calculating some number. I cannot explain it, I just had some feeling for it. That helped a lot; that motivated me to go deeper into it.

R & S: *Modern probability theory, as you mentioned earlier, started with Kolmogorov in the 1930s. You had an interesting encounter with Kolmogorov: He wrote from Moscow about your doctoral thesis at the Indian Statistical Institute, which you finished when you were twenty-two years old: "This is not the work of a student, but of a mature master." Did you ever meet Kolmogorov? Did you have any interaction with him mathematically later?*

Varadhan: Yes, I have met him; he came to India in 1962. I had just submitted my thesis, and he was one of the examiners of the thesis, but he was going to take the thesis back to Moscow and then to write a report; so the report was not coming at that time. He spent a month in India, and some of us graduate students spent most of our time travelling with him all over India. There was a period where we would meet him every day. There were some reports about it mentioned in the Indian press recently, which were not quite accurate.

But there is one incident that I remember very well. I was giving a lecture on my thesis work with Kolmogorov in the audience. The lecture was supposed to last for an hour, but in my enthusiasm it lasted an hour and a half. He was not protesting, but some members in the audience were getting restless. When the lecture ended, he got up to make some comments and people started leaving the lecture hall before he could say something, and he got very angry. He threw the chalk down with great force and stormed out of the room. My immediate reaction was: There goes my Ph.D.! A group of students ran after him to where he was staying, and I apologized for taking too much time. He said: No no; in Russia, our seminars last three hours. I am not angry at you, but those people in the audience, when Kolmogorov stands up to speak, they should wait and listen.

R & S: *That is a nice story!*

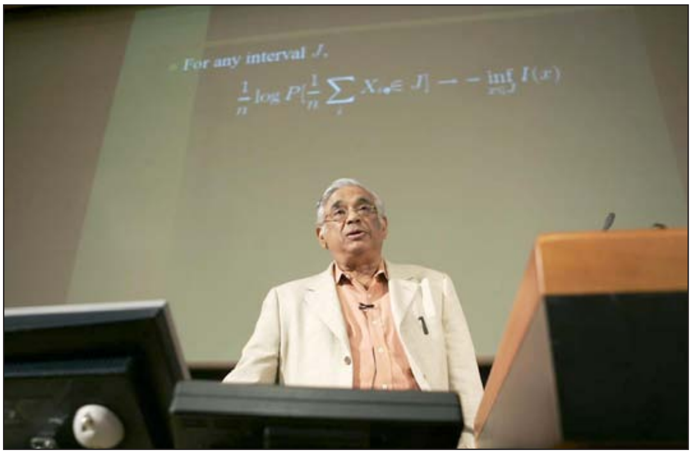
Among your many research contributions, the one which is associated with so-called large deviations must rank as one of the most important. Can you tell us first what large deviations are and why the study of these is so important; and what are the applications?

Varadhan: The subject of large deviations goes back to the early 1930s. It in fact started in Scandinavia, with actuaries working for the insurance industry. The pioneer who started that subject was named Esscher[1]. He was interested in a situation where too many claims could be made against the insurance company, he was worried about the total claim amount exceeding the reserve fund set aside for paying these claims, and he wanted to calculate the probability of this. Those days the standard model was that each individual claim is a random variable, you assume some distribution for it, and the total claim is then the sum of a large number of independent random variables. And what you are really interested in is the probability that the sum of a large number of independent random variables exceeds a certain amount. You are interested in estimating the tail probabilities of sums of independent random variables.

People knew the central limit theorem at the time, which tells you that the distribution of sums of independent random variables has a Gaussian approximation. If you do the Gaussian approximation, the answer you get is not correct. It is not correct in the sense that the Gaussian approximation is still valid, but the error is measured in terms of difference. Both these numbers are very small, therefore the difference between them is small, so the central limit theorem is valid. But you are interested in how small it is; you are interested in

[1] *F. Esscher, On the probability function in the collective theory of risk,* Skandinavisk Actuarietidskrift **15** *(1932), 175–195.*

Photo: Terje Bendiksby/Scanpix. Courtesy of the Norwegian Academy of Science and Letters.



Varadhan at the University of Oslo where he gave his Abel lecture.

the ratio of these two things, not just the difference of these small numbers.

The idea is: how do you shift your focus so that you can look at the ratio rather than just at the difference? Esscher came up with this idea that is called Esscher's tilt; it is a little technical. It is a way of changing the measure that you use in a very special manner. And from this point of view, what was originally a tail event, now becomes a central event. So you can estimate it much more accurately and then go from this estimate to what you want, usually by a factor which is much more manageable. This way of estimation is very successful in calculating the exact asymptotics of these tail probabilities. That is the origin of large deviations. What you are really interested in is estimating the probabilities of certain events. It does not matter how they occur; they arise in some way. These are events with very small probability, but you would like to have some idea of how small it is. You would like to measure it in logarithmic scale, "*e* to the minus how big". That is the sense in which it is used and formulated these days.

R & S: *Large deviations have lots of applications, not the least in finance; is that correct?*

Varadhan: I think in finance or other areas, what the theory actually tells you is not just what the probability is, but it also tells you if an event with such a small probability occurred, how it occurred. You can trace back the history of it and explain how it occurred and what else would have occurred. So you are concerned with analysing entire circumstances. In Esscher's method, there is the tilt that produced it; then that tilt could have produced other things, too; they would all happen if this event happened. It gives you more information than just how small the probability is. This has become useful in mathematical finance because you write an option which means: if something happens at a certain time, then you promise to pay somebody something. But what you pay may depend on not just what happened at that time, it may depend on the history. So you would like to know if something happened at this time, what was the history that produced it? Large deviation theory is able to predict this.

R & S: *Together with Donsker you reduced the general large deviation principle to a powerful variational principle. Specifically, you introduced the so-called Donsker-Varadhan rate function and studied its behaviour. Could you elaborate a little how you proceeded, and what type of rate functions you could handle and analyse?*

Varadhan: If you go back to the Esscher theory of large deviations for sums of random variables, that requires the calculation of the moment-generating function. Since they are independent random variables, the moment-generating functions are products of the individual ones; if they are all the same, you get just the *n*-th power of one moment-generating function. What really controls the large deviation is the logarithm of the moment-generating function. The logarithm of the *n*-th power is just a multiple of the logarithm of the original moment-generating function, which now controls your large deviation. On the other hand, if your random variables are not independent, but dependent like in a Markov chain or something like that, then there is no longer just one moment-generating function. It is important to know how the moment-generating function of the sum grows; it does not grow like a product but it grows in some way. This is related by the Feynman-Kac formula to the principal eigenvalue of the generator of the Markov process involved. There is a connection between the rate function and the so-called principal eigenvalue. This is what our theory used considerably. The rate function is constructed as the Legendre transform or the convex conjugate of the logarithm of the principal eigenvalue.

R & S: *Before we leave the subject of the large deviation principle, could you please comment on the so-called Varadhan integral lemma which is used in many areas. Why is that?*

Varadhan: I do not think Varadhan's lemma is used that much, probably large deviation theory is used more. The reason why I called it a lemma is that I did not want to call it a theorem. It is really a very simple thing that tells you that if probabilities behave in a certain way, then certain integrals behave in a certain way. The proof just requires approximating the integral by a sum and doing the most elementary estimate. What is important there is just a point of view and not so much the actual estimates in the work involved; this is quite minimal.

R & S: *But it pops up apparently in many different areas. Is that correct?*

Varadhan: The basic idea in this is very simple: if you take two positive numbers *a* and *b* and raise them to a very high power and you look at the sum, the sum is just like the power of the larger one;

the smaller one is insignificant, you can replace the logarithm of the sum by just a maximum. The logarithm of the sum of the exponential behaves just like the maximum. That is the idea when you have just a finite number of exponentials, then in some sense integrating is not different from summation if you have the right estimates. That was how I looked at it, and I think this arises in many different contexts. One can use the idea in many different places, but the idea itself is not very complicated.

R & S: *That is often the case with important results in mathematics. They go back to a simple idea, but to come up with that idea, that is essential!*

You realized that Mark Kac's old formula for the first eigenvalue of the Schrödinger operator can be interpreted in terms of large deviations of a certain Brownian motion. Could you tell us how you came to this realization?

Varadhan: It was in 1973, I just came back from India after a sabbatical, and I was in Donsker's office. We always spent a lot of time talking about various problems. He wanted to look at the largest eigenvalue which controls the asymptotic behaviour of a Kac integral: I think people knew at that time that if you take the logarithm of the expectation of a Kac type exponential function, its asymptotic growth rate is the first eigenvalue. The first eigenvalue is given by a variational formula; that is classical. We knew that if we do large deviations and calculate asymptotically the integrals, you get a variational formula, too. So, he wanted to know if the two variational formulas have anything to do with each other: Is there a large deviation interpretation for this variational formula?

I was visiting Duke University, I remember, some time later that fall, and I was waiting in the library at Duke University for my talk which was to start in half an hour or so. Then it suddenly occurred to me what the solution to this problem was. It is very simple. In the Rayleigh-Ritz variational formula, there are two objects that compete. One is the integral of the potential multiplied by the square of a function; the other one is the Dirichlet form of the function. If you replace the square of the function and call it a new function, then the Dirichlet form becomes the Dirichlet form of the square root of that function. It is as simple as that. And then the large deviation rate function is nothing but the Dirichlet form of the square root of the density. Once you interpret it that way, it is clear what the formula is; and once you know what the formula is, it is not that difficult to prove it.

R & S: *This brings us naturally to the next question: If you occasionally had a sudden flash of insight, where you in an instant saw the solution to a problem that you had struggled with, as the one you described right now: Do these flashes depend on hard and sustained preparatory thinking about the problem in question?*

Varadhan: Yes, they do: What happens is, once you have a problem you want to solve, you have some idea of how to approach it. You try to work it out, and if you can solve it the way you thought you could, it is done, and it is not interesting. You have done it, but it does not give you a thrill at all. On the other hand, if it is a problem in which everything falls into place, except for one thing you cannot do; if only you could do that one thing, then you would have the whole building, but this foundation is missing. So you struggle and struggle with it, sometimes for months, sometimes for years and sometimes for a lifetime! And eventually, suddenly one day you see how to fix that small piece. And then the whole structure is complete. That was the missing piece. Then that is a real revelation, and you enjoy a satisfaction which you cannot describe.

R & S: *How long does the euphoria last when you have this experience?*

Varadhan: It lasts until you write it up and submit it for publication. Then you go on to the next problem!

R & S: *Your cooperation with Daniel Stroock on the theory of diffusions led to several landmark papers. The semigroup approach by Kolmogorov and Feller had serious restrictions, we understand, and Paul Levy suggested that a diffusion process should be represented as a stochastic differential equation. Itô also had some very important contributions. Could you explain how you and Stroock managed to turn this into a martingale problem?*

Varadhan: I have to step back a little bit: Mark Kac used to be at Rockefeller University. Between New York University and Rockefeller University, we used to have a joint seminar; we would meet one week here and one week there and we would drive back and forth. I remember once going to Rockefeller University for a seminar and then coming back in a taxi to NYU. Somebody mentioned a result of Ciesielski, a Polish probabilist who was visiting Marc Kac at that time: You can look at the fundamental solution of a heat equation, for the whole space, and look at the fundamental solution with Dirichlet boundary data in a region. The fundamental solution for the Dirichlet boundary data is smaller, by the maximum principle, than the other one. If you look at the ratio of the two fundamental solutions, then it is always less than or equal to one. The question is: As t, the time variable in the fundamental solution, goes to zero, when does this ratio go to 1 for all points x and y in the region? The answer turns out to be: if and only if the region is convex! Of course, there are some technical aspects, about sets of capacity zero and so on. Intuitively, the reason it is happening is that the Brownian path, if it goes from x to y, in time t, as time t goes to zero, it would have to go in a straight line. Because its mean value remains the same as that of the Brownian bridge, which is always linear, and thus a line connecting the two points. The variance goes to zero, if you do not give it much time. That means it follows a straight line. That suggests that, if your space were not flat but curved, then it should probably go along the geodesics. One would expect therefore that the fundamental solution of the heat equation with variable coefficients should look like *e* to the minus the square of the geodesic distance divided by $2t$; just like the heat equation does with the Euclidean distance.

This occurred to me on the taxi ride back. That became the paper on the behaviour of the fundamental solution for small time. In fact, I think that was the paper that the PDE people at Courant liked, and that gave me a job. At that time, I was still a postdoc.

Anyway, at that point, the actual proof of it used only certain martingale properties of this process. It did not really use so much PDE, it just used certain martingales. Stroock was a graduate student at Rockefeller University at that time; we used to talk a lot. I remember, that spring, before he finished, we would discuss it. We thought: If it is true that we could prove this by just the martingale properties, then those martingale properties perhaps are enough to define it. Then we looked at it and asked ourselves: Can you define all diffusion processes by just martingale properties?

It looked like it unified different points of view: Kolmogorov and Feller through the PDE have one point of view, stochastic differential people have another point of view, semigroup theory has still another point of view. But the martingale point of view unifies them. It is clear that it is much more useful; and it turned out, after investigation, that the martingale formulation is sort of the weakest formulation one can have; that is why everything implies it. Being the weakest formulation, it became clear that the hardest thing would be to prove uniqueness.

Then we were able to show that whenever any of the other methods work, you could prove uniqueness for this. We wanted to extend it and prove uniqueness for a class which had not been done before, and that eluded us for nearly one and a half years until one day the idea came, and we saw how to do it and everything fell into place.

R & S: *That was another flash of inspiration?*

Varadhan: That was another flash; that meant that we could do a lot of things for the next four to five years that kept us busy.

R & S: *Before we leave your mathematical research, we would like to ask you about your contribution to the theory of hydrodynamic limits, that is, describing the macroscopic behaviour of very large systems of interacting particles. Your work in this area has been described as viewing the environment from the travelling particle. Could you describe what this means?*

Varadhan: I will try to explain it. The subject of hydrodynamic scaling as it is called, or hydrodynamic limits, is a subject that did not really start in probability. It started from classical mechanics, Hamiltonian equations, and it is the problem of deriving Euler equations of fluid flow directly as a consequence of Hamiltonian motion. After all, we can think of a fluid as a lot of individual particles and the particles interact, ignoring quantum effects, according to Newtonian rules. We should be able to describe how every particle should move. But this requires solving a 10^{68}-dimensional ODE, and only then you are in good shape. Instead we replace this huge system of ODEs by PDEs, a small system of nonlinear PDEs, and these nonlinear PDEs describe the motion of conserved quantities.

If there are no conserved quantities, then things reach equilibrium very fast, and nothing really moves. But if there are conserved quantities, then they change very slowly locally, and so you have to speed up time to a different scale. Then you can observe change of these things. Mass is conserved, that means density is one of the variables; momenta are conserved, so fluid velocity is one of the variables; the energy is conserved, so temperature becomes one of the variables. For these conserved quantities, you obtain PDEs. When you solve your partial differential equations, you get a solution that is supposed to describe the macroscopic properties of particles in that location. And given these parameters, there is a unique equilibrium for these fixed values of the parameters which are the average values.

In a Hamiltonian scheme, that would be a fixed surface with prescribed energy and momentum, etc. On that surface the motion is supposed to be ergodic, so that there is a single invariant measure. This invariant measure describes how locally the particles are behaving over time. That is only described in statistical terms; you cannot really pin down which particle is where; and even if you could, you do not really care.

This program, although it seems reasonable in a physical sense, has not been carried out in a mathematical sense. The closest thing that one has come to is the result by Oscar Lanford who has shown that, for a very small time scale, you can start from the Hamiltonian system and derive the Boltzmann equations. Then to go from Boltzmann to Euler requires certain scales to be large; it is not clear if the earlier results work in this regime. The mathematical level of these things is not where it should be.

On the other hand, if you put a little noise in your system, so that you look at not a deterministic Hamiltonian set of equations, but stochastic differential equations, with particles that move and jump randomly, then life becomes much easier. The problem is the ergodic theory. The ergodic theory of dynamical systems is very hard. But the ergodic theory of Markov processes is a lot easier. With a little bit of noise, it is much easier to keep these things in equilibrium. And then you can go through this program and actually prove mathematical results.

Now coming to the history: We were at a conference in Marseille at Luminy, which is the Oberwolfach of the French Mathematical Society. My colleague George Papanicolaou (who I think should be here in Oslo later today) and I were taking a walk down to the calanques. And on the way back, he was describing this problem. He was interested in interacting particles, Brownian motion interacting under some potential. He wanted to prove the hydrodynamic scaling limit. I thought the solution should be easy; it seemed natural somehow. When I came back and looked at it, I got stuck regardless how much I tried. There were two critical steps, I figured out, that needed to be done; one step I could do, the second step I could not do. For the time being, I just left it at that. Then, a year later, we had a visitor at the Courant Institute, Josef Fritz from Hungary. He gave a talk on hydrodynamic limits; he had a slightly different model. By using different techniques, he could prove the theorem for that model. Then I realized that the second step on which I got stuck in the original model, I could do it easily in this model. So we wrote a paper with George Papanicolaou and one of his students Guo; that was my first paper on hydrodynamic limits. This work was more for a field than for an actual particle system which was what got me interested in the subject.

When you look at particles, you can ask two different questions. You can ask what is happening to the whole system of particles, you do not identify them; you just think of it as a cloud of particles. Then you can develop how the density of particles changes over time. But it does not tell you which particle moves where. Imagine particles have two different colours. Now you have two different densities, one for each colour. You have the equation of motion for the sum of the two densities, but you do not have an equation of motion for each one separately. Because to do each one separately, you would have to tag the particles and to keep track of them! It becomes important to keep track of the motion of a single particle in the sea of particles.

A way to analyse it that I found useful was to make the particle that you want to tag the centre of the universe. You change your coordinate scheme along with that particle. Then this particle does not move at all; it stays where it is, and the entire universe revolves around it. So you have a Markov process in the space of universes. This is of course an infinite dimensional Markov process, but if you can analyse it and prove ergodic theorems for it, then you can translate back and see how the tagged particle would move; because in some sense how much the universe moves around it or it moves around the universe is sort of the same thing. I found this method to be very useful, and this is the system looked at from the point of view of the moving particle.

Photo: Heiko Junge/Scanpix. Courtesy of the Norwegian Academy of Science and Letters.

Three Abel laureates at the Abel monument: (l. to r.) Lennart Carleson, Srinivasa Varadhan, and Peter Lax.

Work Style

R & S: *Very interesting! A different question: Can you describe your work style? Do you think in geometric pictures or rather in formulas? Or is there an analytic way of thinking?*

Varadhan: I like to think physically in some sense. I like to build my intuition as a physicist would do: What is really happening, understanding the mechanism which produces it, and then I try to translate it into analysis. I do not like to think formally, starting with an equation and manipulating and then see what happens. That is the way I like to work: I let my intuition guide me to the type of analysis that needs to be done.

R & S: *Your work in mathematics has been described by a fellow mathematician of yours as "Like a Bach fugue, precise yet beautiful." Can you describe the feeling of beauty and aesthetics that you experience when you do mathematics?*

Varadhan: I think the quotation you are referring to can be traced back to the review of my book with Stroock by David Williams. I think mathematics is a beautiful subject because it explains complicated behaviour by simple means. I think of mathematics as simplifying, giving a simple explanation for much complex behaviour. It helps you to understand why things behave in a certain manner. The underlying reasons why things happen are usually quite simple. Finding this simple explanation of complex behaviour, that appeals most to me in mathematics. I find beauty in the simplicity through mathematics.

Photograph courtesy of the authors.

May 2007 interview in Oslo. Left to right, Christian Skau, Martin Raussen, Srinivasa Varadhan.

Public Awareness

R & S: *May we now touch upon the public awareness of mathematics? There appears to be a paradox. Mathematics is everywhere in our life, as you have already witnessed from your perspective: in technical gadgets, in descriptions and calculations of what happens on the financial markets, and so on. But this is not very visible for the public. It seems to be quite difficult for the mathematical community to convince the man on the street and the politicians of its importance.*

Another aspect is that it is not easy nowadays to enroll new bright students in mathematics. As to graduate students, in the United States more than half of the Ph.D. students come from overseas. Do you have any suggestions what the mathematical community could do to enhance its image in the public, and how we might succeed to enroll more students into this interesting and beautiful subject?

Varadhan: Tough questions! People are still trying to find the answer. I do not think it can be done by one group alone. For a lot of reasons, probably because of the nature of their work, most mathematicians are very introverted by nature. In order to convince the public, you need a kind of personality that goes out and preaches. Most research mathematicians take it as an intrusion on their time to do research. It is very difficult to be successful, although there are a few examples. The question then becomes: How do you educate politicians and other powerful circles that can do something about it about the importance of education? I think that happened once before when the Russians sent the Sputnik in 1957. I do not know how long it will take to convince people today. But I think it is possible to make an effort and to convince people that mathematics is important to society. And I think that signs are there, because one of the powerful forces of the society today are the financial interests, and the financial interests are beginning to realize that mathematics is important for them. There will perhaps be pressure from their side to improve mathematics education and the general level of mathematics in the country; and that might in the long run prove beneficial; at least we hope so.

R & S: *In connection with the Abel Prize, there are also other competitions and prizes, like the Niels Henrik Abel competition and the Kapp Abel for pupils, the Holmboe Prize to a mathematics teacher, and furthermore the Ramanujan Prize for an outstanding Third World mathematician. How do you judge these activities?*

Varadhan: I think these are very useful. They raise the awareness of the public. Hopefully, all of this together will have very beneficial effect in the not too distant future. I think it is wonderful what Norway is doing.

Private Interests

R & S: *In our very last question, we would like to leave mathematics behind and ask you about your interests and other aspects of life that you are particularly fond of. What would that be?*

Varadhan: I like to travel. I like the pleasure and experience of visiting new places, seeing new things and having new experiences. In our profession, you get the opportunity to travel, and I always take advantage of it.

I like music, both classical Indian and a little bit of classical Western music. I like to go to concerts if I have time; I like the theatre, and New York is a wonderful place for theatre. I like to go to movies.

I like reading Tamil literature, which I enjoy. Not many people in the world are familiar with Tamil as a language. It is a language which is 2,000 years old, almost as old as Sanskrit. It is perhaps the only language which today is not very different from the way it was 2,000 years ago. So, I can take a book of poetry written 2,000 years ago, and I will still be able to read it. To the extent I can, I do that.

R & S: *At the end, we would like to thank you very much for this interesting interview. These thanks come also on behalf of the Norwegian, the Danish and the European Mathematical Societies. Thank you very much.*

Varadhan: Thank you very much. I have enjoyed this interview, too.

Building a Research Career: Mathematics Research Communities

Allyn Jackson

With the expectation of funding from the National Science Foundation, the AMS is launching a new program designed to nurture budding researchers and help them build collaborative communities centered on research. Called Mathematics Research Communities (MRC), the program is geared toward mathematicians at the "peridoctoral" stage, meaning those who are close to finishing the doctorate or have recently finished. The program will bring together peridoctoral mathematicians with a passion for research and provide them with structured activities aimed at building social and collaborative networks through which they can inspire and sustain each other in their work. "The aim of MRC is to encourage young mathematicians when they are establishing their research careers by building communities in which the camaraderie comes from sharing research activities," said Ellen Maycock, the Society staff member overseeing the MRC. "It's a way of laying foundations, and individuals could end up being influenced for the rest of their lives."

MRC is inspired by several existing programs but is not quite like any of them. One inspiration is Project NExT, which has been highly successful in preparing the next generation of mathematics professors through a rich program of professional development. MRC differs from Project NExT by putting less emphasis on teaching and also by focusing on specific research topics. Another inspiration is the GAEL conferences, which have been held in Luminy, France. GAEL stands for "Géométrie Algébrique En Liberté", which suggests a bit of naughtiness but also refers to the need for young mathematicians to have time and space to develop free of the constraints of the older generation. At the GAEL conferences, peridoctoral mathematicians give talks and discuss their research with others in the same area. A small number of senior researchers are invited by the younger researchers in order to give a few lectures and provide guidance, but the conference is mainly conducted by and for the young mathematicians.

In 2003 and 2004, while he was AMS president, David Eisenbud of the University of California, Berkeley, initiated two experimental AMS summer conferences along the lines of GAEL. The 2003 conference was on commutative algebra and consisted mainly of lectures by recent Ph.D.'s and graduate students who were just finishing up their theses. In 2004 the topic was algebraic geometry, and the conference had a different structure: In the mornings young researchers gave Bourbaki-style expository talks, and in the afternoons the participants broke up into small working groups, each led by a senior mathematician who would give a brief lecture and then get participants working on problems that had come up during the conference. (A webpage for the 2004 conference is available at `http://math.stanford.edu/~vakil/snowbird/`.) The response to the conferences was enthusiastic. The young participants found it rewarding and encouraging to exchange ideas with and give support to others at the same career stage. Many came away with new contacts and felt motivated and revitalized to continue in research.

The response to these two conferences persuaded the AMS that there is a real need for a program focused on nurturing the research careers of young mathematicians and sowing the seeds for building future groups of research collaborators. In the summer of 2007 the Society submitted a proposal for the MRC to the National Science Foundation and by December of that year received word that the proposal would be funded for three years. The first MRC activities will begin in the summer of 2008 under the guidance of an advisory board chaired by Eisenbud.

MRC has five main components. The first is a set of one-week summer conferences: three will be held in 2008, and four will be held each summer thereafter. They will alternate between a large conference in a broad research area with approximately forty young mathematicians and four to five senior research mathematicians and two

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MRC Conferences for Summer 2008

Teichmüller Theory and Low-Dimensional Topology
June 14–20, 2008
40 participants
Organized by: Francis Bonahon, University of Southern California; Howard Masur, University of Illinois at Chicago; Abigail Thompson, University of California at Davis; and Genevieve Walsh, Tufts University

Scientific Computing and Advanced Computation
June 21–27, 2008
20 participants
Organized by: John Bell, Lawrence Berkeley National Laboratory; Randall LeVeque, University of Washington; Juan Meza, Lawrence Berkeley National Laboratory

Computational Algebra and Convexity
June 21–27, 2008
20 participants
Organized by: Henry Schenck, University of Illinois at Urbana-Champaign; Michael Stillman, Cornell University; Jan Verschelde, University of Illinois at Chicago

All conferences will be held in Snowbird, Utah. For information on applying to MRC, visit the webpage `http://www.ams.org/amsmtgs/mrc.html`.

smaller conferences on more focused areas run simultaneously, that will include approximately twenty young mathematicians and two to three senior researchers. Careful choices of conference topics over the years will ensure that a wide range of mathematical areas is covered. The emphasis of all the conferences will be on the young mathematicians, but the exact structure is not set in stone so that organizers will have flexibility tailoring the conferences as they see fit. The conferences will also include activities focused on professional development topics, such as how to write a research paper, how to give an effective research talk, how to prepare a grant proposal, and the like.

One of the main professional development activities comes in the second component of MRC, which consists of Special Sessions at the Joint Mathematics Meetings in the winter following the conferences. All MRC participants will attend the JMM, allowing them to reestablish contacts made during the summer conferences and possibly providing venues to speak on their own work. Each MRC conference topic will have a full-day Special Session. For each topic the primary responsibilities for the Special Session will be placed in the hands of a group of several young MRC participants. Organizing the Special Sessions will provide the young researchers with valuable experience in an important activity of the professional lives of mathematicians.

The third component will be a private online discussion network to help MRC participants keep in touch outside the formal MRC events. The AMS is currently investigating what kind of software would be best to use. The fourth component focuses on mentoring of MRC participants by senior mathematicians. The goal is to develop a mentoring program that for each summer conference would be active for at least two years following the conference. Several options for carrying out this part of the program are under consideration. The savvy and experience that young people often have in using electronic communication will be tapped: Groups of MRC participants will be given resources to study and recommend the best means for the discussion and mentoring networks.

The final component of the MRC is evaluation, for which the AMS will launch an eight-year longitudinal study. Individuals accepted into MRC will agree to remain in touch with the AMS for the following five years, and the AMS will track for five years the career paths of all of the young mathematicians who attend the summer conferences in 2008, 2009, and 2010. Through the Annual Survey of the Mathematical Sciences, the AMS has built up a great deal of experience in gathering data of this sort. The Annual Survey does not track new doctorates after their first employment, so the study of the MRC participants will enrich the Annual Survey data by providing new information about the peridoctoral career stage.

The main criterion for participation in MRC is enthusiasm for research. Such enthusiasm is not dependent on where one got a Ph.D. or where one found a first job, so it is expected that the MRC will bring together a diverse group of young researchers from a variety of institutions and backgrounds. The MRC will have an emphasis on attracting young women mathematicians and helping them remain on the research track and will make similar efforts to reach out to minority groups underrepresented in mathematics. "The goal is to help create vibrant, active, and exciting research communities that will benefit everyone by forging closer connections and promoting collaborations," said Eisenbud. "We also want to provide examples and mentoring that will help make young mathematicians better and more productive citizens of the large research community in which we live."

MRC Advisory Board

Manjul Bhargava, Princeton University
Ruth Charney, Brandeis University
Panagiota Daskalopoulos, Columbia University
Robert J. Daverman, University of Tennessee, Knoxville
David Eisenbud (Chair), University of California, Berkeley
David Manderscheid, University of Nebraska, Lincoln
Charles Newman, Courant Institute, New York University
James Sethian, University of California, Berkeley
Alejandro Uribe, University of Michigan

My Summer at the Voice of America

Adriana Salerno

Each year the AMS sponsors a fellow to participate in the Mass Media Fellowship program of the American Association for the Advancement of Science. This program places science and mathematics graduate students in summer internships at media outlets. In the article below, the 2007 Fellow, Adriana Salerno of the University of Texas, Austin, describes her experiences during her fellowship at Voice of America. For information about applying for the fellowship, see the January 2008 issue of the Notices, *page 62, or visit the website* `http://www.ehrweb.aaas.org/massmedia.htm`. *The application deadline is* ***January 15, 2008***.

—Allyn Jackson

Every college freshman is faced with an important decision: what to major in. In my case, I believe it was a rather unusual set of alternatives. I didn't know if I wanted to study math or communications. I had the opportunity to study either, which made the decision even harder. It is probably clear to anyone reading this what choice I made, but the decision was based on practicality rather than preference. My rationale was that if I ever changed my mind or realized I had made the wrong decision, it would be much easier to switch from math to communications than the other way around. I figured that after many years of not doing math I wouldn't be able to pick it up very easily, but I would always be interested in reading and writing and therefore keep developing good communication skills.

It was evident to me, the more I got into math, that the connection between people who do math and everyone else was broken. To "outsiders", mathematics seemed to work much like a secret society that allowed in only certain privileged people (sometimes referred to as geniuses). I then started fantasizing about being able to bridge that gap, expose our society, but I didn't really know how. The idea that I could be a communicator and a mathematician at the same time never crossed my mind. When I saw the announcement for the AAAS/AMS Mass Media Fellowship it was like having an epiphany; it felt almost as though it was meant to be. I definitely wanted to give it a try. My advisor was very supportive so I went for it.

Fast forward five months, and there I am, walking through security of a government building in Washington, DC, on my way to my first meeting with all the writers and editors of the English Features department at the Voice of America (VOA). I wasn't familiar with the VOA, and soon after receiving the announcement that I had won the fellowship I figured out why: it is a government-run radio station that broadcasts internationally but not inside the United States.

I was assigned to write English language features, which are 4- to 5-minute long stories. The best thing about this format is that it allowed me to research topics more deeply and slowly than I could have were I writing short news updates. I quickly learned that there were three possible ways in which my stories could be used: they could air with a science news magazine called *Our World* (and by magazine I mean a radio program presenting short segments on a variety of topics); they could be aired together with the English news broadcast; or they could be picked up by one of the many language services, translated, and aired with their own news broadcasts.

The fellowship was billed as a science journalism fellowship, so I was supposed to report on all sorts of science topics. But I admit that my goal from the beginning was to try to get as many stories about math on the air as I could. My editor, Rob Sivak, was a little hesitant at first because he felt I was operating in my comfort zone, but after a while it was evident to both him and me that talking about math on the radio was possibly the hardest thing to do. I was lucky that most of the math ideas I pitched to Rob were accepted. I think he also wanted to see what I could do.

My first math story was about Raghu Varadhan, the 2007 Abel Prize winner. This one was received very positively by Rob because it was about a mathematician, not so much about math, and because Varadhan is from India and we have many listeners there. He was great to interview and I think the piece was one of my best. The main challenge I encountered was "voicing" the piece—that is, reading it for radio. It was only the second piece I had voiced, and I was still pretty terrible at it.

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It took about six tries of reading the whole thing through until Rob agreed to "publish it" (i.e., make it available to the different outlets I mentioned earlier). I was happy to be given the opportunity to read the pieces I wrote, I felt that they were more my own. I also loved that Rob wouldn't let me get away with mediocre readings and that he treated me as if I was a regular employee, not just the resident math nerd who's trying her hand at something different.

I learned that for the VOA one really needed to think about the international appeal of stories. Once I pitched a story about how drinking too much water might be harmful for athletes, and soon it was pointed out that many of our listeners might not be too concerned about runners who drink *too much* water…For our stories to be as relevant to someone in Washington, DC, as to someone in Africa, we had to write in a way that transcended cultural and language barriers. Doing so enabled me to see things from a different, less local perspective and gave me a sense of what is really important to communicate.

My math pieces were easily separated into two categories: the first focused on a more human angle of math, like the story on Varadhan, which was mostly a biography, and the story about the first U.S. team to go to the China Girls Math Olympiad, which focused on issues of girls and mathematics; the second was more geared towards applications of math, and in this category were the story about how optimal control theory (I had to fight to use those words in my story) can be used to model the growth of tumors, and the story about Keith Devlin and Gary Lorden's new book, *The Numbers Behind NUMB3RS*, about how math can be used in crime-solving in real life, and in fiction. I was able to show our listeners a glimpse of what the people who do math are like and what math can be good for.

I really appreciated the chance to learn about things I knew nothing about before the summer (nanotechnology, chimp cognition, acoustics, number symbolism, and bird flu vaccines) and talking to really interesting people (like Ian Stewart, one of my idols). But I must say that the best thing about the experience is that I succeeded in achieving my goal to some extent: I got mathematics on the air, and in fact to the whole world.

I have now realized that the choice I made a few years ago was not as life-changing as I thought: I picked math, and through a process that seems almost too serendipitous to be true, I found my way back to communications. I now also have a completely new perspective on what it is I might want to do. I still love math and hope to be doing research in the future, but I want to try to combine it with my love of explaining math to others. I feel my experience this summer was definitely the best way to get my foot in the door.

A Valuable Diversion

John Haws

As a software engineer at the SAS Institute in Cary, NC, I use my education and training in applied mathematics every day. I draw on lessons I have gained through experience in my industry jobs, including four years as an applied mathematician at the Boeing Company and three years in a data mining group in New Orleans. I have had many opportunities to explore the diversity of scientific computing applications used in industrial applications, including data fitting, high-performance computing, and numerical analysis. However, unlike many of my peers at SAS and at my other jobs, I also bring another valuable experience to my work, having served as a Teach For America high school math teacher in one of our nation's highest-need school districts. This article is a reflection of those two years, noting the impact on the students I taught and the impact on my career since then. I hope this account of my experiences will be useful to advisers of undergraduate mathematics majors who might be considering applying to Teach for America, and more generally to graduate students and young mathematicians contemplating various career paths.

Background

In 1992 I had recently graduated from Loyola University in New Orleans with a Bachelor of Science in mathematics and was considering my options. At the time, graduate school was a logical path for someone with my major, but I was not ready to immediately continue several more years of school. I wanted to expand my horizons and grow as an individual.

I learned about an organization called Teach For America. The organization offered recent college graduates the chance to impact educational inequity in America by teaching for two years in some of the nation's highest-need schools. Through the experience participants had the opportunity to develop leadership and problem-solving skills and a deeper understanding of some of the problems facing public education. Although many people cautioned me about postponing graduate school and losing touch with mathematics or falling behind, Teach For America offered the perfect opportunity for the growth I was looking for.

I became a corps member in the summer of 1992 and was placed in the Rio Grande Valley of Texas. I was assigned to teach algebra and pre-algebra at Pharr-San Juan-Alamo (PSJA) North High School, in Pharr, Texas, a small farming community on the Texas-Mexico border. The Rio Grande Valley is known for its prolific agriculture industry, especially the Ruby Red grapefruits that grow abundantly along nearly every highway; the Rio Grande Valley is also home to some of the nation's most impoverished counties and fastest-growing populations.

Teaching Algebra in the Rio Grande Valley

According to a 2006 SchoolMatters report (`http://www.schoolmatters.com`), approximately 41 percent of the students in the PSJA district are classified as Limited English Proficiency, and approximately 90 percent are classified as economically disadvantaged. In 1992, PSJA North High School was no different; I arrived to find that many of my students were English learners and that most of them were eligible for free or reduced lunch. Core classes such as math, English, and science typically had enrollments of thirty or more students, which was the case with the classes I taught. Many students had interrupted school experiences due to migrant lifestyles or tenuous living conditions.

Early in my first year I found that I was teaching many students whose mathematics proficiency far exceeded their placements, especially in the three pre-algebra classes I taught. As I evaluated the early homework and tests of the students in my classes, I quickly realized that many of them possessed math skills well beyond pre-algebra, but most likely poor language skills had prevented them from scoring higher on English-based placement exams and thus placing in a higher level class. I decided I would not let a language barrier impede their mathematical growth and began working with some of the students in my pre-algebra classes to accelerate their studies. We set out to cover the state-prescribed Algebra I objectives so that these students could bypass the normal intermediate algebra class that followed and move directly into geometry the following year.

I set up a system during class time so that some students would work alone or within small groups on an accelerated curriculum, while I focused on the rest of the class. For a final exam, I gave the accelerated group a year-end exam from an Algebra I class known to be one of the most advanced. The group scored high on the exam, and with the

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results I was able to convince the principal to allow them to advance.

I began my second year with a great deal of confidence, having survived a tumultuous first year and come away with a number of successes. I started the year by building on the successful system from the previous year in each of my classes. While I continued to provide brief lectures to each class as a whole, I also divided the students into small groups of three or four, in which they worked independently. I encouraged them to assist each other in learning, and after the brief lectures, I would move from group to group, spending time with the groups that most needed my attention. In essence, I had tailored my lessons so that the numerous barriers obstructing each individual's mathematics learning could be addressed. In the end, only one other class in the district outscored my classes on the state-instituted year-end algebra exams.

My relatively deep understanding of mathematics allowed me to create a somewhat nontraditional system for my students, and it challenged them in rigorous ways. Furthermore, because the students responded well to my nontraditional approach, it validated my feelings and ideas in the face of the challenges posed by teaching in the demanding environment of a high school classroom. This reciprocal relationship meant that the more the students responded to my teaching, the more confidence I gained and the more comfortable I became as a teacher. It is exactly that confidence and comfort that I took away from my two years of teaching and into graduate school and my professional life.

Pursuing Graduate Education in Applied Math

When I did begin graduate school at North Carolina State University after my two-year commitment to Teach for America, I was reminded of that initial warning about losing touch and falling behind. There were certainly students in my cohort who seemed to have a stronger grasp of technical details, or who more quickly latched onto the theory. However, I had several advantages over my peers that set me apart: there were few students who had been exposed to nonacademic environments; who were comfortable speaking in front of a large group; who were confident enough in themselves to embrace the adversity of graduate school; or who had practiced teaching skills. My maturity and real-world experience allowed me to quickly catch up on the technical knowledge. As a teacher, I encouraged my students not to rely on tricks and mnemonic devices, but to instead focus on the general principles of the theory and exercises; this allowed them to effectively tackle new problems and face exams with confidence. Likewise, one of the keys for me in graduate school success was moving beyond algorithmic details and embracing general theoretical principles, and I often reflected on the encouragement I offered students when I myself was trying to step back and understand theoretical concepts of specific exercises.

Professional Career

The skills and confidence I developed from the classroom have continued to follow me throughout my professional career. Following graduate school I joined the Boeing Company as an applied mathematician in September of 2001, four years after beginning my Ph.D. studies. At Boeing, my group's work was divided between researching new technologies and providing advanced mathematics in support of engineering processes. However, as a result of the unexpected and tragic events of September 11, the context for the work and the priorities of our group changed drastically and research funding at Boeing was greatly reduced. Again I relied on the confidence I had gained through my Teach For America experience. Although I was trained as a numerical linear algebraist, I adapted to the new environment by quickly learning new disciplines and finding opportunities to work in analytic geometry, operations research, and physics modeling projects. As a result, I had the opportunity to contribute to models of wind tunnel data, the efficient routing of airplanes through the national airspace system, and models of fracture propagation. I learned that in industry perseverance and agility in challenging situations, and the ability to quickly learn new technologies, are traits that are far more valuable than a focused expertise in a specific field of research.

Conclusion

More than a decade later, I now have the luxury of reflecting on my experience teaching, and I can state unequivocally that those two years were pivotal to who I am today. The two years I spent teaching at PSJA-North High School as a Teach For America corps member made a difference in the lives and education of the students I taught and made a difference in my own professional and personal life. I continue to benefit from the insight, skills, and confidence of that experience. In addition, as a parent and civic-minded community member, I have significant insight on educational inequality and specifically on the need for innovative teachers and curricula in math and science, both in my own community and the nation as a whole. Looking ahead, I am enthusiastic about being well-qualified to contribute to technological research in an industrial setting, and I am equally enthusiastic about advocating improvements in math education, particularly for underserved students who deserve an excellent education, perhaps by serving on my local school board or by volunteering with one of the many innovative science programs available to high school students.

2007 Annual Survey of the Mathematical Sciences

(First Report)

Preliminary Report on the 2006–2007 New Doctoral Recipients

Polly Phipps, James W. Maxwell, and Colleen Rose

The preliminary report of the 2007 Annual Survey gives a broad picture of 2006–07 new doctoral recipients from U.S. departments in the mathematical sciences, including their employment status in fall 2007. This report is based on information collected from a questionnaire distributed to departments in April 2007. A follow-up questionnaire was distributed to the individual new doctoral recipients in October 2007. This questionnaire will be used to update and revise results in this report, which are based on information from the departments that produced the new doctorates. Those results will be published in the Second Report of the 2007 Annual Survey in the August 2008 issue of the *Notices* of the AMS. Another questionnaire concerned with data on fall 2007 course enrollments, graduate students, and departmental faculty was distributed to departments in September 2007. Results from this questionnaire will appear in the Third Report of the 2007 Annual Survey in the November 2008 issue of the *Notices* of the AMS.

The Faculty Salary Survey report, traditionally published as part of this report, will appear in the March issue of Notices of the AMS. The 2007 Annual Survey represents the fifty-first in an annual series begun in 1957 by the American Mathematical Society. The 2007 Survey is under the direction of the Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Institute of Mathematical Statistics, the Mathematical Association of America and the Society of Industrial and Applied Mathematics. The current members of this committee are Richard Cleary, Amy Cohen-Corwin, Richard M. Dudley, John W. Hagood, Abbe H. Herzig, Donald R. King, David J. Lutzer, James W. Maxwell (ex officio), Bart Ng, Polly Phipps (chair), David E. Rohrlich, and Henry Schenck. The committee is assisted by AMS survey analyst Colleen A. Rose. Comments or suggestions regarding this Survey Report may be directed to the committee.

Polly Phipps is a senior research statistician with the Bureau of Labor Statistics. James W. Maxwell is AMS associate executive director for special projects. Colleen A. Rose is AMS survey analyst.

Preliminary Report on the 2006–2007 New Doctoral Recipients

This report presents a statistical profile of recipients of doctoral degrees awarded by departments in the mathematical sciences at universities in the United States during the period July 1, 2006, through June 30, 2007. It includes a preliminary analysis of the fall 2007 employment plans of 2006–07 doctoral recipients and a demographic profile summarizing characteristics of citizenship status, sex, and racial/ethnic group.

Table 1: Number of Departments Responding to Doctorates Granted Survey

Group I (Pu)	24 of 25 including 0 with no degrees
Group I (Pr)	17 of 23 including 0 with no degrees
Group II	45 of 56 including 3 with no degrees
Group III	56 of 75 including 19 with no degrees
Group IV	55 of 87 including 1 with no degrees
Group Va	18 of 21 including 2 with no degrees

See "Definitions of the Groups" on page 263.

All information came from the departments that awarded the degrees.

Table 1 provides the departmental response rates for the 2007 Survey of New Doctoral Recipients. See page 263 for a description of the groups. No adjustments were made in this report for nonresponding departments.

This preliminary report will be updated in the Second Report of the 2007 Annual Survey using information gathered from the new doctoral recipients. The Second Report will appear in the August 2008 issue of the *Notices* of the AMS.

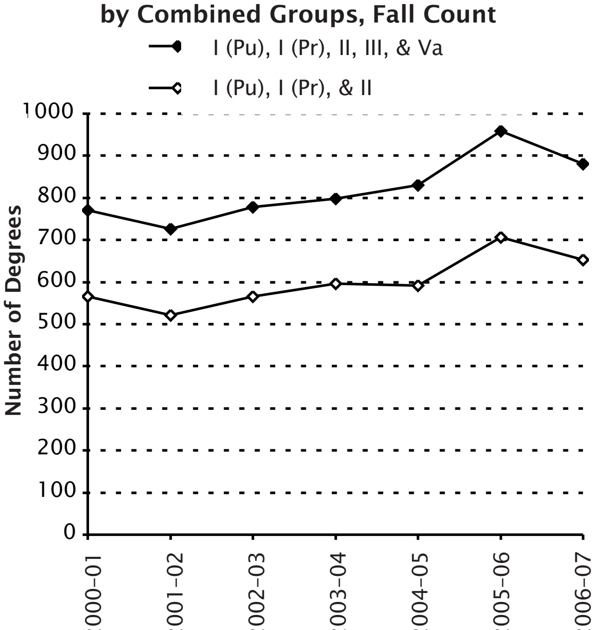
Changes in the Annual Survey occur over time, and these changes need to be considered when comparing results in this report to those in prior years. Information about changes that occurred in 1997 or later can be found in the First Report for the 2000 Annual Survey in the February 2001 issue of the *Notices* of the AMS.

In this First Report's tables referring to new doctoral recipients, "Fall" refers to results based on information about new doctoral recipients received from departments granting their degrees. This information is gathered in the first fall following the academic year in which the degrees were granted. "Final" refers to results based on supplemental information received from the new doctoral recipients themselves as well as additional new

Table 2: New Doctoral Degrees Awarded by Group, Fall Count

Group	I (Pu)	I (Pr)	II	III	IV	Va	TOTAL
1997–98	306	174	264	129	213	77	**1163**
1998–99	292	152	241	136	243	69	**1133**
1999–00	256	157	223	132	284	67	**1119**
2000–01	233	129	203	125	237	81	**1008**
2001–02	218	139	164	124	222	81	**948**
2002–03	258	138	170	121	239	91	**1017**
2003–04	195	187	215	111	243	90	**1041**
2004–05	243	146	203	153	285	86	**1116**
2005–06	307	184	216	140	287	111	**1245**
2006–07	300	119	234	138	279	87	**1157**

Figure 1: New Doctoral Degrees Awarded by Combined Groups, Fall Count



Highlights

There were 1,157 new doctoral recipients reported for 2006-07 by departments responding in time for the 2007 First Report. The drop from the 1,245 new doctoral recipients reported for fall 2006 is the result of the increase in the number of departments that did not respond in time for this year's report.

There were 500 U.S. citizens reported among this year's new doctoral reicpients, 43% of the total. Last year's figure was 42%.

Based on responses from departments alone, the fall 2007 unemployment rate for the 1,028 new doctoral recipients whose employment status is known is 4%, down from 4.4% for fall 2006.

Seventy-eight new doctoral recipients hold positions at the institution that granted their degree, although not necessarily in the same department. This is 8% of the new doctoral recipients who are currently known to have jobs and 12% of those who have academic positions in the U.S. Twenty-two new doctoral recipients have part-time positions.

The number of new doctoral recipients employed in the U.S. is 864, down 20 from last year. The number of new doctoral recipients employed in academic positions in the U.S. decreased to 651 from 671 last year.

Of the 864 new doctoral recipients taking positions in the U.S., 187 (22%) have jobs in business and industry; increasing for the fourth consecutive year. The fall 2007 number is up 12% from fall 2006, and is up 90 (93%) from the fall 2003. The number of new doctoral recipients taking jobs in government is down 19 (43%) over fall 2006.

Among the 864 new doctoral recipients having employment in the U.S., 405 (47%) are U.S. citizens (up from 404 (46%) last year). The number of non-U.S. citizens having employment in the U.S. is 459, down from 480 last year.

Among the 320 new doctoral recipients hired by U.S. doctoral-granting departments, 48% are U.S. citizens (up from 43% last year). Among the 330 having other academic positions in the U.S., 53% are U.S. citizens (down from 54% last year).

Of the 1,157 new doctoral recipients, 32% (365) are female, the same percentage reported in fall 2006. Of the 500 U.S. citizen new doctoral recipients, 29% (145) are females, up from 27% in fall 2006.

Among the 500 U.S. citizen new doctoral recipients, 2 are American Indian or Alaska Native, 28 are Asian, 10 are Black or African American, 12 are Hispanic or Latino, 3 are Native Hawaiian or Other Pacific Islander, 428 are White, and 17 are of unknown race/ethnicity.

Group IV produced 279 new doctorates, of which 127 (46%) are females, compared to all other groups combined, where 238 (27%) are females. In Group IV, 87 (31%) of the new doctoral recipients are U.S. citizens (while in the other groups 47% are U.S. citizens).

Thirty-three percent of the new doctorates had a dissertation in statistics/biostatistics (339). The next highest percentage was in algebra and number theory with 15% (171).

The Faculty Salary Survey report, traditionally published as part of this report, will appear in the March issue of Notices of the AMS.

Table 3: Full-Time Graduate Students in Groups I, II, III, & Va, Fall 1996 to Fall 2006

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total full-time graduate students	**9003**	**8791**	**8838**	**9637**	**9361**	**9972**	**10444**	**10707**	**10565**	**11686**
Female	2691	2770	2766	3016	2899	3136	3215	3245	3111	3478
% Female	29%	32%	31%	31%	31%	31%	31%	30%	29%	30%
% U.S. citizen	57%	55%	53%	53%	49%	51%	54%	55%	56%	56%
Total first-year graduate students	**2386**	**2458**	**2664**	**2839**	**2875**	**2996**	**2711**	**3004**	**2832**	**3161**
Female	836	859	866	879	1014	1038	902	983	851	1024
% Female	35%	35%	33%	31%	35%	35%	33%	33%	30%	32%
% U.S. citizen	55%	55%	53%	54%	53%	55%	56%	60%	59%	55%

(Data Reprinted from Table 6B in Third Report, 2006 Annual Survey)

doctoral recipients not reported by departments in time for publication in the First Report. These results are published each August in the Second Report.

Doctoral Degrees Granted in 2006–07

Table 2 shows the number of new doctoral degrees granted by the different doctoral groups surveyed in the Annual Survey for the past ten years. The 1,157 new doctorates granted by these departments in 2006–07 is a decrease of 88 from the fall count for 2005–06.

The response rates were above 70% for all groups except Group IV; response rates decreased in all groups. Overall, thirty less departments responded in time for the First Report this year than responded last year. A careful review of the non-responding departments confirms that this year's drop in the reported total new doctoral recipients is the result of the increase in non-responding departments. For departments responding in both fall 2006 and fall 2007, the fall 2007 total is 1,078 compared with 1,049 reported in fall 2006. The reader should keep this point in mind when fall 2007 figures are compared with fall 2006.

The number 1,157 of new doctoral recipients is a preliminary count. A final count will appear in the Second Report in the August 2008 issue of the *Notices* of the AMS. Efforts continue to obtain data from as many of the nonresponding departments as possible.

From Table 2 we see that all groups except Group II reported a decrease in the number of doctoral recipients from the previous year. Group I (Pr) reported the largest decrease (65), but the decrease is almost certainly the result of the five additional Group I (Pr) departments that did not respond in time for this report. Only the decrease reported for Group Va is independent of changes in the number of responding departments. Group II reported the only increase, and this increase would have been higher but for the nine departments that reported in fall 2006 but not in fall 2007.

The 2006–07 numbers in Table 2 will be broken down in various ways, such as by sex, in later sections of this report. The names of the 1,157 new doctoral recipients are found on pages 280–99 of this issue of the *Notices*.

Table 3 gives historical information about various types of full-time graduate students in Groups I, II, III, and Va combined. These data, gathered in the 2006 Departmental Profile survey, are reprinted from Table 6B of the Third Report of the 2006 Annual Survey (*Notices* of the AMS, November 2007). From these data we can see that total number of full-time graduate students in the doctoral mathematics groups has been generally increasing since 1999, with this year's enrollment the largest reported. Similarly, the number of full-time graduate students who are U.S. citizens has been increasing since 2002 and remains stable this year at

Figure 2: Percentage of New Doctoral Recipients Unemployed (as reported in the respective Annual Survey Reports 1995–2007)

Report	Fall	Final
1995–96	9.4%	8.1%
1996–97	6.8%	3.8%
1997–98	7.2%	4.9%
1998–99	6.2%	4.7%
1999–00	4.6%	3.3%
2000–01	5.6%	3.7%
2001–02	4.3%	2.9%
2002–03	5.1%	5.0%
2003–04	5.7%	4.4%
2004–05	7.3%	3.9%
2005–06	4.4%	3.3%
2006–07	4.0%	*

*To appear in the Second Report.
Note: Prior to 1998–99, the percentages include new doctoral recipients from Group Vb.

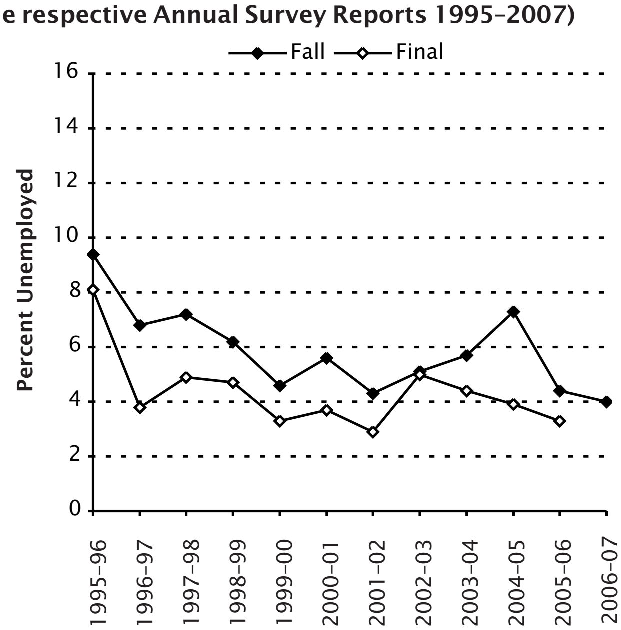


Table 4A: Employment Status of 2006–07 New Doctoral Recipients in the Mathematical Sciences by Field of Thesis

TYPE OF EMPLOYER	FIELD OF THESIS												TOTAL
	Algebra/ Number Theory	Real, Comp., Funct., & Harmonic Analysis	Geometry/ Topology	Discr. Math./ Combin./ Logic/ Comp. Sci.	Probability	Statistics/ Biostat.	Applied Math.	Numerical Analysis/ Approxi- mations	Linear Nonlinear Optim./ Control	Differential, Integral, & Difference Equations	Math. Educ.	Other/ Unknown	
Group I (Public)	18	12	17	7	3	3	7	5	0	10	0	1	**83**
Group I (Private)	20	4	17	4	0	2	2	6	0	5	0	0	**60**
Group II	17	7	10	5	1	4	8	5	0	14	0	0	**71**
Group III	7	4	3	3	1	15	8	1	2	2	3	1	**50**
Group IV	1	0	0	0	2	31	2	0	0	3	0	0	**39**
Group Va	0	2	0	4	0	0	6	3	0	2	0	0	**17**
Master's	5	7	6	5	2	19	5	4	1	5	5	0	**64**
Bachelor's	29	13	15	13	4	12	12	8	1	11	3	1	**122**
Two-Year College	3	0	1	0	0	1	0	1	0	1	0	0	**7**
Other Academic Dept.	5	4	5	3	2	54	15	8	3	4	3	1	**107**
Research Institute/ Other Nonprofit	2	1	3	0	1	12	7	2	0	2	0	0	**30**
Government	2	0	2	0	0	10	8	3	0	2	0	0	**27**
Business and Industry	8	0	6	15	15	101	14	12	6	8	0	2	**187**
Non-U.S. Academic	30	9	11	9	2	19	7	1	4	17	1	0	**110**
Non-U.S. Nonacademic	0	0	1	0	2	4	0	1	0	0	0	0	**8**
Not Seeking Employment	2	0	0	0	0	1	2	0	0	0	0	0	**5**
Still Seeking Employment	9	2	4	4	1	12	5	3	0	1	0	0	**41**
Unknown (U.S.)	9	4	11	5	2	20	10	4	2	3	3	1	**74**
Unknown (non-U.S.)*	4	3	5	6	3	19	4	5	2	3	1	0	**55**
TOTAL	**171**	**72**	**117**	**83**	**41**	**339**	**122**	**72**	**21**	**93**	**19**	**7**	**1157**
Column Subtotals Male	128	52	91	62	30	187	93	49	17	68	8	7	**792**
Column Subtotals Female	43	20	26	21	11	152	29	23	4	25	11	0	**365**

*Includes those whose status is reported as "unknown" or "still seeking employment".

Table 4B: Employment Status of 2006–07 New Doctoral Recipients in the Mathematical Sciences by Type of Degree-Granting Department

TYPE OF EMPLOYER	TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT						TOTAL	Row Subtotals	
	Group I (Public) Math.	Group I (Private) Math.	Group II Math.	Group III Math.	Group IV Statistics	Group Va Applied Math.		Male	Female
Group I (Public)	47	19	5	2	2	8	**83**	65	18
Group I (Private)	31	19	4	0	2	4	**60**	44	16
Group II	24	8	29	4	4	2	**71**	48	23
Group III	7	2	11	21	6	3	**50**	29	21
Group IV	3	1	4	2	29	0	**39**	24	15
Group Va	7	0	0	1	0	9	**17**	12	5
Master's	11	2	24	15	12	0	**64**	39	25
Bachelor's	32	9	45	31	4	1	**122**	77	45
Two-Year College	2	0	2	1	0	2	**7**	3	4
Other Academic Dept.	11	10	19	10	50	7	**107**	71	36
Research Institute/ Other Nonprofit	3	6	3	0	11	7	**30**	17	13
Government	6	0	3	4	8	6	**27**	21	6
Business and Industry	39	10	16	19	88	15	**187**	127	60
Non-U.S. Academic	40	16	25	4	17	8	**110**	87	23
Non-U.S. Nonacademic	1	2	0	0	4	1	**8**	7	1
Not Seeking Employment	1	1	2	0	1	0	**5**	2	3
Still Seeking Employment	8	3	7	10	7	6	**41**	32	9
Unknown (U.S.)	16	8	25	7	16	2	**74**	51	23
Unknown (non-U.S.)*	11	3	10	7	18	6	**55**	36	19
TOTAL	**300**	**119**	**234**	**138**	**279**	**87**	**1157**	**792**	**365**
Column Subtotals Male	224	88	165	93	152	70	**792**		
Column Subtotals Female	76	31	69	45	127	17	**365**		

*Includes those whose status is reported as "unknown" or "still seeking employment".

Table 4C: Field of Thesis of 2006–07 New Doctoral Recipients by Type of Degree-Granting Department

TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT	FIELD OF THESIS												TOTAL
	Algebra/ Number Theory	Real, Comp., Funct., & Harmonic Analysis	Geometry/ Topology	Discr. Math./ Combin./ Logic/ Comp. Sci.	Probability	Statistics/ Biostat.	Applied Math.	Numerical Analysis/ Approxi- mations	Linear Nonlinear Optim./ Control	Differential, Integral, & Difference Equations	Math. Educ.	Other/ Unknown	
Group I (Public)	84	29	43	37	12	8	29	13	6	35	0	4	**300**
Group I (Private)	32	3	34	8	8	3	14	4	0	13	0	0	**119**
Group II	42	27	36	10	11	7	40	25	5	22	8	1	**234**
Group III	11	12	3	15	5	34	18	10	5	13	11	1	**138**
Group IV	0	0	0	0	0	279	0	0	0	0	0	0	**279**
Group Va	2	1	1	13	5	8	21	20	5	10	0	1	**87**
Column Total	**171**	**72**	**117**	**83**	**41**	**339**	**122**	**72**	**21**	**93**	**19**	**7**	**1157**

Table 5A: 2006–07 New Doctoral Recipients Employed in the U.S by Type of Degree-Granting Department

	Group						
Type of Employer in U.S.	I (Pu)	I (Pr)	II	III	IV	Va	TOTAL
Groups I, II, III, IV, and Va	119	49	53	30	43	26	**320**
Master's, Bachelor's, and 2-Year Colleges	45	11	71	47	16	3	**193**
Other Academic and Research Institutes	14	16	22	10	61	14	**137**
Government	6	0	3	4	8	6	**27**
Business and Industry	39	10	16	19	88	15	**187**
TOTAL	**223**	**86**	**165**	**110**	**216**	**64**	**864**

Table 5B: Number of New Doctoral Recipients Taking Positions in Business and Industry in the U.S. by Type of Degree-Granting Department, Fall 2003 to Fall 2007

	Group						
Year	I (Pu)	I (Pr)	II	III	IV	Va	TOTAL
Fall 2003	19	13	5	8	45	7	**97**
Fall 2004	9	13	9	9	50	9	**99**
Fall 2005	5	9	14	15	64	8	**115**
Fall 2006	27	14	19	9	80	18	**167**
Fall 2007	39	10	16	19	88	15	**187**

56%. The number of first-year full-time graduate students who are U.S. citizens had been increasing until 2004 when it reached 60%, dropping slightly last year and then again this year to 55%. The percentage of females among full-time graduate students in the combined mathematics groups has remained relatively stable over the 10-year period shown.

Employment Plans of 2006–07 New Doctoral Recipients

Tables 4A, 4B, and 4C each provide a different cross-tabulation of the 1,157 new doctoral recipients in the mathematical sciences. These tables contain a wealth of information about these new doctoral recipients, some of which will be discussed in this report. Note that these tables give a breakdown by sex for type of employer, type of degree-granting department, and field of thesis. Keep in mind that the results in this report come from the departments giving the degrees and not from the degree recipients themselves. These tables will be updated using information from the doctoral recipients themselves and will appear in the 2007 Second Report in the August 2008 issue of the *Notices* of the AMS.

The last column (Total) in Table 4A can be used to find the overall unemployment rate. In this and other unemployment calculations in this report, the individuals whose employment status is not known (Unknown (U.S.) and Unknown (non-U.S.)) are first removed, and the unemployment fraction is the number still seeking employment divided by the total number of individuals left after the

Table 5C: Number of New Doctoral Recipients Taking U.S. Academic Positions by Type of Degree-Granting Department, Fall 2003 to Fall 2007

	Group						
Year	I (Pu)	I (Pr)	II	III	IV	Va	TOTAL
Fall 2003	123	76	117	60	118	40	**534**
Fall 2004	110	113	130	70	142	49	**614**
Fall 2005	131	88	130	83	131	39	**602**
Fall 2006	167	108	123	86	137	50	**671**
Fall 2007	178	76	146	87	120	43	**650**

Table 5D: Academic Positions in U.S. Filled by New Doctoral Recipients by Type of Hiring Department, Fall 2003 to Fall 2007

	Group					
Year	I–III	IV	Va	M&B	Other*	TOTAL
Fall 2003	203	39	9	156	127	**534**
Fall 2004	222	63	17	154	158	**614**
Fall 2005	231	45	12	188	126	**602**
Fall 2006	262	69	12	185	143	**671**
Fall 2007	264	39	17	186	144	**650**

*Includes other academic and research institutes/nonprofit.

"Unknowns" are removed. The overall unemployment rate for these data is 4.0%. This figure will be updated later with information gathered from the individual new doctoral recipients. The figure for fall 2006 was 4.4%. Figure 2 shows how this unemployment rate compares with other years over the past decade. The unemployment rates, calculated using Table 4B, vary from group to group, with a high of 8.1% for Group III and lows of 2.8% for Group 1 (Pr) and 2.9% for both Groups I (Pu) and IV.

There are 864 new doctoral recipients employed in the U.S. Table 5A gives a breakdown of type of employer by type of degree-granting department for these 864 new doctoral recipients. Of these, 650 (75%) hold academic positions, 27 (3%) are employed by government, and 187 (22%) hold positions in business and industry.

In the First Report for 2005–06, there were 884 new doctoral recipients employed in the U.S., of which 671 (76%) held academic positions, 46 (5%) were in government, and 167 (19%) were in business and industry. The number of new doctoral recipients employed in the U.S. decreased in all categories except "Business and Industry" and "Other Academic and Research Institutes" which increased 12% and 4%, respectively. "Government" showed the largest decrease at 41% , and "Master's, Bachelor's and Two-Year Colleges" showed the smallest increase at 1.5% .

Table 5B shows the number of new doctoral recipients who took positions in business and industry by the type of department granting their degree for fall 2003 to fall 2007. The number of new doctoral recipients taking jobs in business and industry has been steadily increasing since 2003. The fall 2007 number is up 12% from fall 2006, and the fall 2007 number is up 90 from fall 2003 number (97).

Among the 864 new doctoral recipients known to have employment in the U.S. in fall 2007, Group II has the smallest percentage taking jobs in business and industry at 10% and Group IV the highest at 41%.

Table 5C shows the number of new doctoral recipients who took academic positions in the U.S. by type of department granting their degree for fall 2003 to fall 2007. The number of new doctoral recipients taking academic employment in fall 2007 has decreased 3%. Among the 864 new doctoral recipients employed in the U.S. in fall 2007, 75% have academic positions. This percentage is highest

Table 5E: Females as a Percentage of 2006–07 New Doctoral Recipients Produced by and Hired by Doctoral-Granting Groups

	Group						
Percent	I (Pu)	I (Pr)	II	III	IV	Va	TOTAL
Produced	25%	26%	29%	33%	46%	20%	**32%**
Hired	22%	27%	32%	42%	38%	29%	**31%**

Table 5G: 2006–07 New Doctoral Recipients Having Employment in the U.S. by Type of Employer and Citizenship

	CITIZENSHIP		
U.S. EMPLOYER	**U.S.**	**Non-U.S.**	**TOTAL**
Academic	330	320	650
Groups I–Va	154	166	320
M, B, & 2-Year	117	76	193
Other Acad. & Research Inst.	59	78	137
Government, Business & Industry	75	139	214
TOTAL	**405**	**459**	**864**

Table 5F: Employment Status of 2006–07 New Doctoral Recipients by Citizenship Status

	CITIZENSHIP				
		NON-U.S. CITIZENS			
TYPE OF EMPLOYER	U.S. CITIZENS	Permanent Visa	Temporary Visa	Unknown Visa	**TOTAL**
U.S. Employer	405	72	368	19	**864**
U.S. Academic	330	56	247	17	**650**
Groups I, II, III, and Va	136	19	119	7	**281**
Group IV	18	4	15	2	**39**
Non-Ph.D. Department	166	30	96	8	**300**
Research Institute/Other Nonprofit	10	3	17	0	**30**
U.S. Nonacademic	75	16	121	2	**214**
Non-U.S. Employer	22	1	92	3	**118**
Non-U.S. Academic	22	1	85	2	**110**
Non-U.S. Nonacademic	0	0	7	1	**8**
Not Seeking Employment	5	0	0	0	**5**
Still Seeking Employment	23	3	15	0	**41**
SUBTOTAL	455	76	475	22	**1028**
Unknown (U.S.)	45	7	21	1	**74**
Unknown (non-U.S.)*	0	0	51	4	**55**
TOTAL	**500**	**83**	**547**	**27**	**1157**

*Includes those whose status is reported as "unknown" or "still seeking employment".

Table 6: Sex, Race/Ethnicity, and Citizenship of 2006–07 New Doctoral Recipients

	MALE					FEMALE					
		NON-U.S. CITIZENS					NON-U.S. CITIZENS				
RACIAL/ETHNIC GROUP	U.S. CITIZENS	Permanent Visa	Temporary Visa	Unknown Visa	Total Male	U.S. CITIZENS	Permanent Visa	Temporary Visa	Unknown Visa	Total Female	**TOTAL**
American Indian or Alaska Native	0	0	0	0	0	2	1	1	0	4	**4**
Asian	19	16	229	5	269	9	23	113	5	150	**419**
Black or African American	9	3	15	0	27	1	1	2	0	4	**31**
Hispanic or Latino	9	3	17	0	29	3	1	4	0	8	**37**
Native Hawaiian or Other Pacific Islander	2	0	1	0	3	1	0	0	0	1	**4**
White	301	15	103	5	424	127	11	46	1	185	**609**
Unknown	15	7	11	7	40	2	2	5	4	13	**53**
TOTAL	**355**	**44**	**376**	**17**	**792**	**145**	**39**	**171**	**10**	**365**	**1157**

for Group I (Pr) and Group II at 88% and lowest for Groups IV at 56%.

Table 5D shows the number of positions filled with new doctoral recipients for each type of academic employer. Increases in positions filled by new doctoral recipients were realized by all groups except Group IV. The biggest increase in hires of new doctorates into academic positions was in Group Va (42%). Hires of new doctorates into positions at research institutes decreased 14%, from 35 in 2006 to 30 in 2007.

In fall 2007, 78 new doctoral recipients held positions in the institution that granted their degree, although not necessarily in the same department. This represents 8% of new doctoral recipients who are currently employed in the U.S. and 12% of the U.S. academic positions held by new doctoral recipients. In fall 2006 there were 60 such individuals making up 6.8% of the new doctoral recipients who were employed at the time of the First Report. Twenty-two new doctoral recipients have taken part-time positions in fall 2007 compared with 14 in fall 2006.

Information about 2006–07 Female New Doctoral Recipients

Tables 4A and 4B give male and female breakdowns of the new doctoral recipients in 2006–07 by Field of Thesis, by Type of Degree-Granting Department, and by Type of Employer.

Overall, 365 (32%) of the 1,157 new doctoral recipients in 2006–07 are female. In 2005–06, 394 (32%) of the new doctoral recipients were female. This percentage varies over the different groups, and these percentages are given in the first row of Table 5E. This year the percentage of females produced is highest again for Group IV at 46%, compared with 47% last year. While Group Va produced the lowest percentage this year (20%), it is down from last year's percentage of 38%.

The second row of Table 5E gives the percentage of the new doctoral recipients hired who are female for each of the Groups I, II, III, IV, and Va. In addition, 39% of the new doctoral recipients hired in Group M, master's departments, are female; 37% of the new doctoral recipients hired in Group B, bachelor's departments, are female, up from 27% last year. This year, Group III hired the highest percentage of women with 42%.

The unemployment rate for female new doctoral recipients is 2.8%, compared to 4.5% for males and 4.0% overall.

The percentage of female new doctoral recipients within fields of thesis ranged from 19% in linear, non-linear optimization/control, to 45% in statistics, and 58% in mathematics education.

Later sections in this First Report give more information about the female new doctoral recipients by citizenship and the female new doctoral recipients in Group IV.

Employment Information about 2006–07 New Doctoral Recipients by Citizenship and Type of Employer

Table 5F shows the pattern of employment within employer categories broken down by citizenship status of the new doctoral recipients.

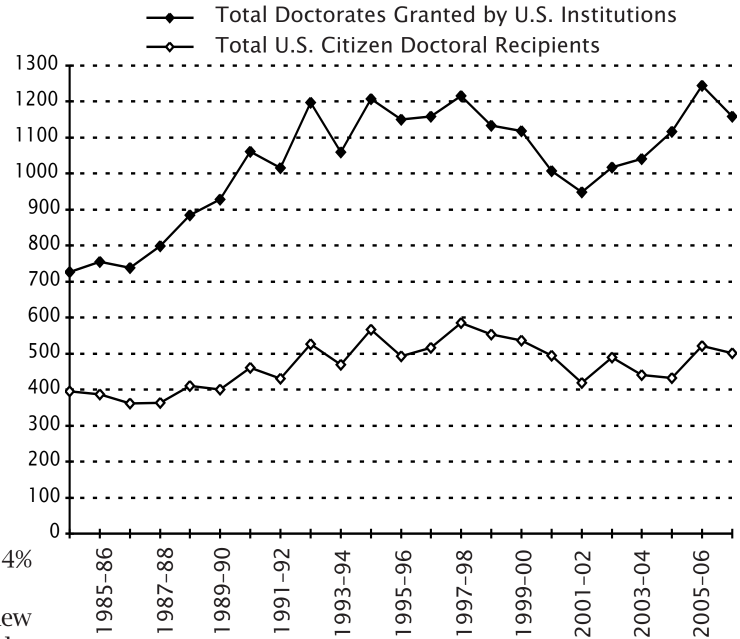
The unemployment rate for the 455 U.S. citizens is 5.1% compared to 6.4% in fall 2006. The unemployment rate for non-U.S. citizens is 3.1%. This varies by type of visa. The unemployment rate for non-U.S. citizens with a permanent visa is 4%, while that for non-U.S. citizens with a temporary visa is 3.2%. Among U.S. citizens whose employment status is known, 89% are employed in the U.S. Among non-U.S. citizens with a permanent visa whose employment status is known, 95% have jobs in the U.S. (last year this percentage was 89%), while the similar percentage for non-U.S. citizens with a temporary visa is 77% (last year the percentage was 79%). The number of non-U.S. citizens having

Table 7: U.S. Citizen Doctoral Recipients, Fall Counts

Year	Total Doctorates Granted by U.S. Institutions	Total U.S. Citizen Doctoral Total	%
1980–81	839	567	68%
1985–86	755	386	51%
1990–91	1061	461	43%
1995–96*	1150	493	43%
2000–01	1008	494	49%
2001–02	948	418	44%
2002–03	1017	489	48%
2003–04	1041	441	42%
2004–05	1116	433	39%
2005–06	1245	522	42%
2006–07	1157	500	43%

*Prior to 1998–99, the counts include new doctoral recipients from Group Vb. In addition, prior to 1982–83, the counts include recipients from computer science departments.

Figure 3: U.S. Citizen Doctoral Recipients, Fall Counts



employment in the U.S. is 459, down 4.4% from 480 last year.

Table 5G is a cross-tabulation of the 864 new doctoral recipients who have employment in the U.S. by citizenship and broad employment categories, using numbers from Table 5F. Of the 864 new doctoral recipients having jobs in the U.S., 47% are U.S. citizens (up from 46% last year). Of the 320 new doctoral recipients who took jobs in U.S. doctoral-granting departments, 48% are U.S. citizens (up from 43% last year). Of the 330 who took other academic positions, 53% are U.S. citizens (down from 54% last year). Of the 214 who took nonacademic positions, 35% are U.S. citizens. Of the 405 U.S. citizens employed in the U.S., 38% have jobs in a doctoral-granting department, 43% are in other academic positions, and 19% are in nonacademic positions. For the 459 non-U.S. citizens employed in the U.S., the analogous percentages are 36%, 34%, and 30% respectively.

Sex, Race/Ethnicity, and Citizenship Status of 2006–07 New Doctoral Recipients

Table 6 presents a breakdown of new doctoral recipients according to sex, racial/ethnic group, and citizenship status. The information reported in

Table 8: Sex of U.S. Citizen Doctoral Recipients, Fall Counts

Year	Total U.S. Citizen Doctoral Recipients	Male	Female	% Female
1980–81	567	465	102	18%
1985–86	386	304	82	21%
1990–91	461	349	112	24%
1995–96*	493	377	116	24%
2000–01	494	343	151	31%
2001–02	418	291	127	30%
2002–03	489	332	157	32%
2003–04	441	297	144	33%
2004–05	433	313	120	28%
2005–06	522	379	143	27%
2006–07	500	355	145	29%

*Prior to 1998–99, the counts include new doctoral recipients from Group Vb. In addition, prior to 1982–83, the counts include recipients from computer science departments.

Figure 4: Females as a Percentage of U.S. Citizen Doctoral Recipients and Graduate Students, Fall Counts

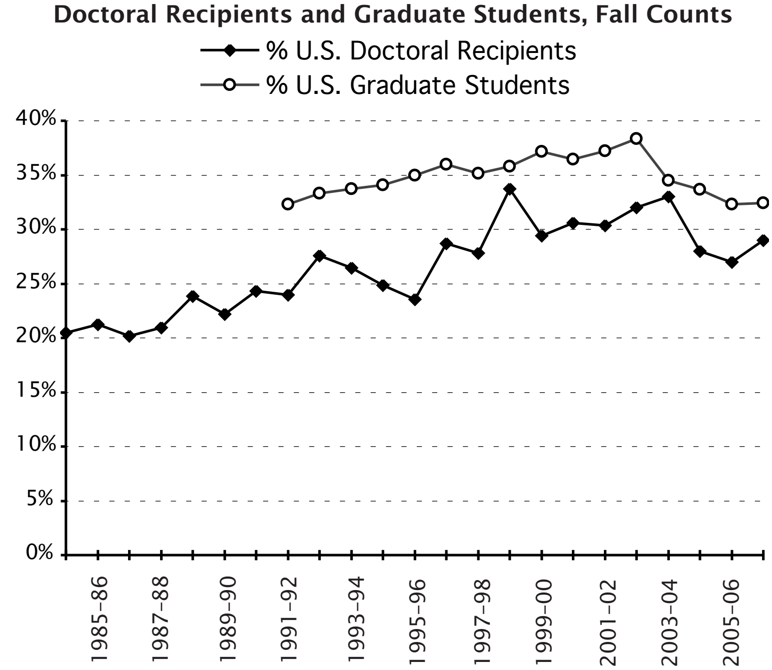


Table 9: Sex and Citizenship of 2006–07 New Doctoral Recipients by Type of Degree Granting Department

	GROUP												TOTAL	
	I (Pu)		I (Pr)		II		III		IV		Va			
CITIZENSHIP	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
U.S.	121	34	43	20	76	30	35	17	50	37	30	7	**355**	**145**
Non-U.S.	103	42	45	11	89	39	58	28	102	90	40	10	**437**	**220**
TOTAL	**224**	**76**	**88**	**31**	**165**	**69**	**93**	**45**	**152**	**127**	**70**	**17**	**792**	**365**

this table was obtained in summary form from the departments granting the degrees.

There were 500 (43%) U.S. citizens among the 1,157 new doctoral recipients in 2006–07. Among U.S. citizens, 2 are American Indian or Alaska Native (female), 28 are Asian (19 males and 9 females), 10 are Black or African American (9 males and 1 female), 12 are Hispanic or Latino (9 males and 3 females), 3 are Native Hawaiian or Other Pacific Islander (2 males and 1 female), 428 are White (301 males and 127 females), and 17 are of unknown race/ethnicity (15 males and 2 females). Among non-U.S. citizens, there are 2 American Indian or Alaska Native (female), 391 Asians, 21 Blacks or African Americans, 25 Hispanics or Latinos, 1 Native Hawaiian or Other Pacific Islander, 181 Whites, and 36 are of unknown race/ethnicity.

Table 7 (and Figure 3) gives the number of new U.S. doctoral recipients and the number of U.S. citizens back to 1980-81. The 500 U.S. citizen new doctoral recipients is down by 37 (7%) from 1999–00. The percentage of U.S. citizen new doctoral recipients has increased this year to 43% from 42% in fall 2006, although this year the total number of doctorates granted decreased.

Females make up 29% of the 500 U.S. citizens receiving doctoral degrees in the mathematical sciences in 2006–07. Last year this percentage was 27%. Among the 657 non-U.S. citizen new doctoral recipients, 33% (220) are female, down from last year's 35%.

Table 8 (and Figure 4) gives the historical record of U.S. citizen new doctoral recipients, broken down by male and female for past years, going back to 1980–81. The number of female U.S. citizen new doctoral recipients is down 13 (8%) from 158 in 1999–00 and down 22% from an all-time high of 187 in 1998–99. Figure 4 also displays the percentage of females among U.S. citizen (full-time) graduate students beginning in fall 1993.

Table 9 gives a sex and citizenship breakdown of the new doctorates within each of the six groups of doctoral-granting departments. Among all 1,157 new doctoral recipients, 45% of the males and 40% of the females are U.S. citizens. Within the groups the percentage of the new doctoral recipients who are U.S. citizens is lowest in Group IV at 31% and highest in Groups I (Pr) at 53%. The number of U.S. citizen new doctoral recipients is lower than the number of non-U.S. citizen new doctoral recipients in all doctoral granting groups for 2006-07, with the exception of males in Group I (Pu) and females in Group I (Pr).

2006–07 New Doctoral Recipients with Dissertations in Statistics/Biostatistics and Probability

Group IV contains U.S. departments (or programs) of statistics, biostatistics, and biometrics

Table 10: New Doctoral Recipients with Dissertations in Statistics/Biostatistics and Probability

Year	Group IV Depts Surveyed	Group VI Depts Responding (percent)	New Doctoral Recipients in Group IV only				New Doctoral Recipients in Statistics/Biostatistics and Probability, Group IV and Other* Groups				New Doctoral Recipients Hired by Group IV	
			Total	Female (percent)	Jobs in Bus & Ind	Percentage Unemployed	Total	Group IV	Other Groups	Percentage Unemployed	Male	Female
1997–98	82	59 (72%)	213	73 (34%)	70	3.2%	294	199	95	3.7%	25	10
1998–99	91	72 (79%)	243	87 (36%)	57	4.9%	320	240	80	5.8%	29	20
1999–00	89	75 (84%)	284	110 (39%)	79	2.4%	351	278	73	2.0%	24	22
2000–01	86	70 (81%)	237	98 (41%)	59	5.1%	289	221	68	5.3%	27	14
2001–02	86	72 (84%)	222	92 (41%)	56	6.0%	288	221	67	5.4%	31	15
2002–03	86	74 (86%)	239	98 (41%)	45	2.1%	302	234	68	3.3%	20	19
2003–04	87	65 (75%)	243	97 (40%)	50	3.0%	318	241	77	4.0%	48	15
2004–05	87	63 (72%)	285	126 (44%)	64	4.5%	374	283	91	5.4%	26	19
2005–06	88	60 (68%)	287	134 (47%)	80	1.6%	396	278	118	2.0%	41	28
2006–07	86	50 (58%)	279	127 (46%)	88	2.9%	380	279**	101***	3.9%	24	15
Statistics	55	34 (62%)	215	95 (44%)	71	3.2%					15	9
Biostatistics	31	16 (52%)	64	32 (50%)	18	2.3%					9	6

* Includes other academic departments and research institutes/other nonprofits.

** Of 279, there were 279 in statistics/biostatistics and none in probability. For complete details, see Table 4C.

*** Of 101, there were 60 in statistics/biostatistics and 41 in probability. For complete details, see Table 4C.

reporting a doctoral program. In the Annual Survey Reports, Group IV is referred to as the Statistics Group. In addition, other groups in the Annual Survey produce new doctoral recipients with dissertations in statistics/biostatistics or probability. The other groups produced 101 new doctoral recipients with dissertations in statistics/biostatistics or probability in 2006–07 and have averaged 83.8 per year over the ten-year period reported in Table 10. Information about these 101 new doctoral recipients and the 279 new doctoral recipients in Group IV is found in this section of the report.

Table 10 contains information about new doctoral recipients in Group IV as well as those with dissertations in statistics/biostatistics and probability in other groups for this year as well as for the past nine years. The last two rows of Table 10 give a split of the 2006–07 results between the 55 statistics departments and the 31 biostatistics and biometrics departments in Group IV. This year 380 new doctorates had a dissertation in statistics/biostatistics (339) or probability (41), a 4% decrease from last year's number. Those with dissertations in statistics/biostatistics and probability accounted for 33% of new doctorates in 2006–07. Quite a bit of the variation in numbers from year to year in Table 10 is due to the changes made in the departments in Group IV over the ten years and to the relatively low response rate for this group. At the time of the Second Report last year, 73 of 88 (83%) of Group IV departments had responded.

Group IV has 87 departments for 2006–07, 13 more than the next largest doctoral group. It contains 30% of all doctoral departments surveyed, and the 55 Group IV departments responding to the Annual Survey reported 279 new doctoral recipients, 24% of all new doctoral recipients in 2006–07. This is the lowest percentage of responding Group IV departments since 1995–96 when it was 68%. The number of new doctoral recipients in Group IV is down 8 from the number reported at this time last year, while the number of departments responding is down 10 from the number responding by this time last year.

Because of its size, the data from Group IV have a large effect on the results when all doctoral groups are combined. Furthermore, Group IV results are often quite different from those for Groups I (Pu), I (Pr), II, III, and Va. Group IV results can mask important changes in the other doctoral groups. In the following paragraphs some of these differences are presented. The trends noted below have also been observed in past reports.

Group IV is producing a larger percentage of female doctorates than the other doctoral groups. Table 9 shows that for the Group IV new doctoral recipients, 127 of 279 (46%) are female, while 238 of 878 (27%) are female in the other doctoral groups. Among U.S. citizens, females accounted for 37 of the 87 (43%) Group IV new doctoral recipients, while for the other groups 108 of 413 (26%) were female. Overall, 146 of 500 (29%) U.S. citizen new doctoral recipients were female.

Group IV is producing a smaller percentage of U.S. citizen new doctorates than the other doctoral groups. In Group IV, 87 of 279 (31%) new doctoral recipients are U.S. citizens, while in other groups 413 of 878 (47%) are U.S. citizens. In Group IV, 90 (71%) of the 127 females were not U.S. citizens.

Group IV doctorates are more likely to take jobs in business and industry than those in other doctoral groups. Of the 216 new doctoral recipients from Group IV who found employment in the U.S., 88 (41%) took jobs in business or industry. From the other groups, 648 new doctoral recipients found employment in the U.S., of which 99 (15%) took jobs in business or industry.

Group IV doctorates have a lower unemployment rate than the other doctoral groups.The employment status for 245 Group IV new doctoral recipients is known, and 7 (2.9%) are unemployed. For the other groups, the employment status of 783 is known, and 34 (4.3%) are unemployed. Group IV is hiring a bigger percentage of females than the other doctoral groups. Fifteen of 39 (38%) new doctoral recipients hired by Group IV departments were female, down from last year's 41%, the lowest percentage of female hires reported since 1998–1999. The other doctoral groups reported that 83 of 281 (30%) new doctoral recipients hired were female, up from last year's 24%.

Group IV had 279 new doctoral recipients with fields of thesis in statistics/biostatistics (279) and the other doctoral departments had 101 with fields of thesis in statistics/biostatistics (60) and probability (41) (last year the other doctoral departments had 59 new doctorates in statistics and 59 in probability). The distribution of these degrees among the various groups can be found in Table 4C. The number of new doctoral recipients with theses in statistics/biostatistics and probability (380) is substantially larger than any other field, with algebra and number theory next with 171.

Previous Annual Survey Reports

The 2006 First, Second, and Third Annual Survey Reports were published in the *Notices* of the AMS in the February, August, and November 2007 issues respectively. These reports and earlier reports, as well as a wealth of other information from these surveys, are available on the AMS website at `www.ams.org/employment/surveyreports.html`.

Acknowledgments

The Annual Survey attempts to provide an accurate appraisal and analysis of various aspects of the academic mathematical sciences scene for the use and benefit of the community and for filling the information needs of the professional organizations. Every year, college and university departments in the United States are invited to respond. The Annual Survey relies heavily on the conscientious efforts of the dedicated staff members of these departments for the quality of its information.

On behalf of the Annual Survey Data Committee and the Annual Survey Staff, we thank the many secretarial and administrative staff members in the mathematical sciences departments for their cooperation and assistance in responding to the survey questionnaires.

Other Data Sources

American Association of University Professors, *The Annual Report on the Economic Status of the Profession 2004–2005*, Academe: Bull. AAUP (April 2005), Washington, DC.

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Conference Board of the Mathematical Sciences, *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 2005 CBMS Survey*, American Mathematical Society, Providence, RI, 2007.

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National Opinion Research Center, *Doctorate Recipients from United States Universities: Summary Report 2005*, Survey of Earned Doctorates, Chicago, IL, 2006.

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National Science Board, *Science and Engineering Indicators—2006* (NSB 06-01), National Science Foundation, Arlington, VA, 2006.

National Science Foundation, *U.S. Doctorates in the 20th Century* (NSF 06-319), Arlington, VA, 2006

______ , *Characteristics of Doctoral Scientists and Engineers in the United States: 2003* (NSF 06-329), Detailed Statistical Tables, Arlington, VA, 2006.

______ , *Graduate Students and Postdoctorates in Science and Engineering: Fall 2004* (NSF 06-325), Arlington, VA, 2006.

______ , *Plans for Postdoctoral Research Appointments Among Recent U.S. Doctorate Recipients* (NSF 04-308), Arlington, VA, 2004.

______ , *Science and Engineering Degrees, by Race/Ethnicity of Recipient: 1992–2001* (NSF 04-318), Detailed Statistical Tables, Arlington, VA, 2004.

______ , *Science and Engineering Doctorate Awards: 2003* (NSF 05-300), Detailed Statistical Tables, Arlington, VA, 2004.

______ , *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2004* (NSF 004-317), Arlington, VA, 2004.

Definitions of the Groups

As has been the case for a number of years, much of the data in these reports is presented for departments divided into groups according to several characteristics, the principal one being the highest degree offered in the mathematical sciences. Doctoral-granting departments of mathematics are further subdivided according to their ranking of "scholarly quality of program faculty" as reported in the 1995 publication *Research-Doctorate Programs in the United States: Continuity and Change.*[1] These rankings update those reported in a previous study published in 1982.[2] Consequently, the departments which now compose Groups I, II, and III differ significantly from those used prior to the 1996 survey.

The subdivision of the Group I institutions into Group I Public and Group I Private was new for the 1996 survey. With the increase in number of the Group I departments from 39 to 48, the Annual Survey Data Committee judged that a further subdivision of public and private would provide more meaningful reporting of the data for these departments.

Brief descriptions of the groupings are as follows:

Group I is composed of 48 departments with scores in the 3.00–5.00 range. Group I Public and Group I Private are Group I departments at public institutions and private institutions respectively.

Group II is composed of 56 departments with scores in the 2.00–2.99 range.

Group III contains the remaining U.S. departments reporting a doctoral program, including a number of departments not included in the 1995 ranking of program faculty.

Group IV contains U.S. departments (or programs) of statistics, biostatistics, and biometrics reporting a doctoral program.

Group V contains U.S. departments (or programs) in applied mathematics/applied science, operations research, and management science which report a doctoral program.

Group Va is applied mathematics/applied science; Group Vb, which was no longer surveyed as of 1998–99, was operations research and management science.

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

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

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

[1]Research-Doctorate Programs in the United States: Continuity and Change, *edited by Marvin L. Goldberger, Brendan A. Maher, and Pamela Ebert Flattau, National Academy Press, Washington, DC, 1995.*

[2]*These findings were published in* An Assessment of Research-Doctorate Programs in the United States: Mathematical and Physical Sciences, *edited by Lyle V. Jones, Gardner Lindzey, and Porter E. Coggeshall, National Academy Press, Washington, DC, 1982. The information on mathematics, statistics, and computer science was presented in digest form in the April 1983 issue of the* Notices *of the AMS, pages 257–67, and an analysis of the classifications was given in the June 1983* Notices *of the AMS, pages 392–3.*

Mathematics People

Lovász Receives Bolyai Prize

On September 30, 2007, László Lovász was awarded the Bolyai Prize, one of the highest honors in Hungarian scientific life. The prize carries a cash award of €50,000 (approximately US$71,000). The purpose of the Bolyai Prize is to draw public attention to the importance of science.

László Lovász was born in Budapest in 1948. He received the Dr.Rher.Nat. degree from Eötvös Loránd University (1971) and the Candidate of Math. Sci. (1970) and Dr.Math.Sci. (1977) degrees from the Hungarian Academy of Sciences. After holding positions at Eötvös Loránd University and József Attila University in Hungary, he moved to Yale University in 1993. He was a senior researcher at Microsoft Research from 1999 until 2006, when he took up his present position as director of the Mathematical Institute at Eötvös Loránd University. His research centers on combinatorial optimization, algorithms, complexity, graph theory, and random walks. His honors include the Fulkerson Prize of the AMS and the Mathematical Programming Society (1982) and the Wolf Prize (1999).

During the Bolyai Prize presentation at the Hungarian Academy of Sciences, a brief laudatio for Lovász was delivered by Gábor Szabó, president of the board of trustees of the Bolyai Award Foundation. Szabó is professor of physics at the University of Szeged and a corresponding member of the academy. He kindly provided for the *Notices* an English version of the laudatio, together with explanatory footnotes. The laudatio follows.

"Ladies and Gentlemen!

"The task with which I stand before you makes me feel honored, but the task is impossible. It is obviously impossible to introduce in a very limited time frame one of the most eminent contemporary mathematicians of the world. To make the situation even more complicated, Dr. Lovász has a rather broad scientific interest—as we have seen in the previous video presentation—and his lifework is based on very abstract results, such as the LLL base reduction algorithm or the Lovász local lemma. As these can hardly be explained briefly, instead I will try to demonstrate to you the exceptional talent of the new Bolyai laureate.

"During his high school years László Lovász won three times the International Student Olympics. Later, as a university student—yes, it is no mistake—he earned the candidate of science title with his paper submitted to the National Scientific Competition for Students.[1] And at the age of thirty-one he became a member of the Hungarian Academy of Sciences.[2] The comet-like start was followed by an even brighter scientific career. The fact that Dr. Lovász has achieved really lasting results is also proven by his numerous scientific honors, out of which I want to cite only two: the Wolf Prize, which is considered by many as the Nobel of mathematics, and the presidency of the International Mathematical Union, a position he took up in 2007.

"A group of eminent Hungarian-born scientists—the legendary Martians[3]—has played a pivotal role in twentieth century U.S. science. László Lovász is commensurable with them. There is, however, a very important difference. After an exceptional scientific career abroad, in 2006 he returned to Hungary."

—Allyn Jackson

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[1] *At that time in Hungary the Candidate of Science (C.Sc.) title awarded by the Hungarian Academy of Sciences was higher than the doctor (Ph.D.) degree awarded by the universities. Due to formal university regulations one was not allowed to apply for the Ph.D. with results achieved during undergraduate years. No such rules existed in the academy, because apparently nobody ever considered it possible that a student could achieve results that would entitle him to apply for the C.Sc. title.*

[2] *László Lovász was by far the youngest member ever of the Hungarian Academy of Sciences.*

[3] *There are different versions of the "Martian" story. The best known, perhaps, is that of the Nobel-prize winning physicist Leon Lederman. In his 1993 book* The God Particle, *Lederman wrote, "The production of scientists and mathematicians in the early 20th century was so prolific that many otherwise calm observers believe Budapest was settled by Martians in a plan to infiltrate and take over the planet Earth." The group of "alien" scientists referred to contained such names as Leo Szilard, Eugene Wigner, Theodore von Kármán, John von Neumann, Dennis Gabor, Edward Teller, and others.*

Kedlaya Receives PECASE Award

Kiran Kedlaya of the Massachusetts Institute of Technology has been chosen to receive a 2006 Presidential Early Career Award for Scientists and Engineers (PECASE) for his work in the mathematical sciences. He was one of fifty-eight young researchers to receive the award, 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.

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

—From an NSF announcement

Khare Wins Fermat Prize

Chandrashekhar Khare of the University of Utah has been awarded the 2007 Fermat Prize for his proof, in collaboration with Jean-Pierre Wintenberger, of Serre's modularity conjecture in number theory.

The Fermat Prize, given every two years, recognizes outstanding research in the fields in which Pierre de Fermat made significant contributions: statements of variational principles, foundations of probability and analytical geometry, and number theory.

The prize carries a cash award of €20,000 (approximately US$29,300).

—From a Université Paul Sabatier announcement

Kutyniok Receives 2007 von Kaven Prize

Gitta Kutyniok of Princeton University has been selected to receive the 2007 von Kaven Prize in Mathematics for her outstanding work in the field of applied harmonic analysis. This prize is awarded by the von Kaven Foundation, which is administered by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation). Kutyniok, who was born in 1972 and is currently funded in the DFG's Heisenberg Program, received the prize at the Gauss Lecture, held by the Deutsche Mathematiker-Vereinigung (German Mathematical Society) in Marburg in November 2007. This is the third time the von Kaven Prize has been given. The prize includes a cash award of €10,000 (approximately US$14,000).

This year's winner of the von Kaven Prize is working on wavelets, curvelets, and something she herself developed called shearlets, which are systems of functions that can be useful in signal analysis. Her research has very tangible applications. For instance, the shearlets Kutyniok developed assist in the analysis of vast amounts of data. In particular, they can be used to detect the geometric properties of data volumes, for instance the direction of edges in images. This makes these functions useful for purposes such as analyzing data generated by tomography and other medical imaging techniques and for data compression of image formats such as JPEG. Working together with Canadian researchers, Kutyniok hopes to use shearlets to identify stable and efficient algorithms for the analysis of seismic signals generated by studies of the Earth's crust. She is also investigating the fundamental properties of function systems, as well as the mathematical modeling of sensor networks using the theory of fusion frames.

—From a DFG announcement

Lauret Awarded ICTP/IMU Ramanujan Prize

Jorge Lauret, professor of differential geometry at the Universidad Nacional de Córdoba, Argentina, has been awarded the 2007 Srinivasa Ramanujan Prize "in recognition of his outstanding contributions to differential geometry and group representation."

The prize is awarded annually by the Abdus Salam International Centre for Theoretical Physics (ICTP), and the prizewinner is selected by ICTP through a committee of five eminent mathematicians appointed in conjunction with the International Mathematical Union (IMU). The prize recognizes a researcher from a developing country who is less than forty-five years of age on December 31 of the year of the award and who has conducted outstanding research in a developing country. Funding for the US$10,000 cash award comes from the Niels Henrik Abel Memorial Fund through the participation of the International Mathematical Union.

—Allyn Jackson

Dani Receives TWAS Prize in Mathematics

TWAS, the Academy of Sciences for the Developing World, has announced the winners of the TWAS Prizes for 2007. Each winner will receive a US$10,000 check and be invited to lecture about his or her research at the academy's Silver Jubilee anniversary celebration, scheduled to take place in Mexico City November 10–13, 2008.

Shrikrishna Dani, senior professor, School of Mathematics, Tata Institute of Fundamental Research, Mumbai, has been named the winner of the 2007 TWAS Prize in mathematics for his fundamental contributions to the study of unipotent flows on homogenous spaces of Lie groups. He has also made significant contributions to probability measures on Lie groups. Dani is also well known for his work on the behavior of orbits on homogenous space concerning, for example, closure, distribution, recurrence, boundedness, and divergence, and for relating these factors to questions in Diophantine approximation. His results on uniform recurrence of trajectories of unipotent flows played an important role in Ratner's proof of the Raghunathan conjecture. With G. A. Margulis, Dani has made notable improvements to Ratner's uniform distribution theorem and deduced a quantitative version of the Oppenheim conjecture.

—From a TWAS announcement

Châu Awarded Oberwolfach Prize

Ngô Bao Châu of the Université de Paris-Sud, Orsay, has been awarded the 2007 Oberwolfach Prize for achievement in algebra and number theory. He was born in Hanoi, Vietnam, in 1972. As a high school student, he won two gold medals in the 29th and 30th International Mathematical Olympiads (IMO). He received his Ph.D. in 1997 from the Université de Paris-Sud, Orsay. In 2004, along with Gérard Laumon, he received the Clay Research Award, the first Vietnamese mathematician to be so honored.

The prize carries a cash award of €5,000 (approximately US$7,300). The prize is funded by the Oberwolfach Foundation and is awarded approximately every three years in cooperation with the Mathematisches Forschungsinstitut Oberwolfach to young European mathematicians.

—From an Oberwolfach Foundation announcement

Neuenkirch Receives 2007 Information-Based Complexity Young Researcher Award

Andreas Neuenkirch of the University of Frankfurt has been awarded the Information-Based Complexity Award for Young Researchers for 2007. The award is given every year for significant contributions to information-based complexity by a young researcher who has not reached his or her thirty-fifth birthday by September 30 of the year of the award. The prize consists of US$3,000 and a plaque.

The award committee this year consisted of Josef Dick, University of New South Wales; Jakob Creutzig, TU Darmstadt; Christiane Lemieux, University of Waterloo; Dirk Nuyens, Katholieke Universiteit; Friedrich Pillichshammer, University of Linz; Joseph F. Traub, Columbia University; and Henryk Wozniakowski, Columbia University and University of Warsaw.

—Joseph F. Traub, Columbia University

Solymosi and Taylor Awarded Aisenstadt Prize

The Centre de Recherches Mathématiques (CRM) in Montreal has announced that Jozsef Solymosi of the University of British Columbia and Jonathan Taylor of the Université de Montréal are the recipients of the 2008 André-Aisenstadt Mathematics Prize. The prize, consisting of C$3,000 (approximately US$3,100) and a medal, recognizes achievements in research by young Canadian mathematicians. The selection committee consisted of the members of the CRM Scientific Advisory Panel: Jim Berger, Jerry Bona, Jean-Pierre Bourguignon, Jean-Louis Colliot-Thélène, Mark Goresky, Alice Guionnet, François Lalonde (CRM director), Thomas Salisbury, Catherine Sulem, Mary F. Wheeler, and Jean-Christoph Yoccoz.

Concerning the works realized by Solymosi, each member of the selection committee was struck by the extraordinary efficiency and elegance of his results at the cutting edge of a new field, additive combinatorics (sometimes called arithmetic combinatorics), that combines combinatorics, harmonic analysis, number theory, and probability. They appreciated the simplicity and deep insight in each of his works.

In Taylor's work, the committee was impressed by the exceptional breadth of expertise in probability, geometry, and statistics and their impact in so many fields of research. Although the committee only took into consideration the mathematical aspects of his works, this was already enough to award the prize to Taylor with enthusiasm.

—From a CRM announcement

NSF CAREER Awards Made

The Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) has honored sixteen mathematicians in fiscal year 2007 with Faculty Early Career Development (CAREER) awards. The NSF established the awards to support promising scientists, mathematicians, and engineers who are committed to the integration of research and education. The grants run from four to five years and range from US$150,000 to US$400,000 each. The 2007 CAREER grant awardees and the titles of their grant projects follow.

Hao-Min Zhou, Georgia Tech Research Corporation, Georgia Institute of Technology: Computing Information in Image Processing and Stochastic Differential Equations; Huibin Zhou, Yale University: Asymptotic Statistical Decision Theory and Its Applications; Hao Zhang, North Carolina State University: Nonparametric Models Building, Estimation, and Selection with Applications to High-Dimensional Data Mining; Dongbin Xiu, Purdue University: High-Performance Computational Method for Stochastic Design Problems; Zhiqiang Tan, Rutgers University: Nonparametric Likelihood, Estimating Functions, and Causal Inference; Scott R. Sheffield, New York University:

Random Surfaces and Conformal Probability; Brian C. Rider, University of Colorado, Boulder: Random Matrices, Random Schrödinger, and Communication; Peter J. Mucha, University of North Carolina, Chapel Hill: Model Fluid-Solid Interactions, Networks REUs, and BioCalculus; Jiashun Jin, Purdue University: Inferences on Large-Scale Multiple Comparisons: The Temptation of the Fourier Kingdom; Anil N. Hirani, University of Illinois, Urbana-Champaign: Algebraic Topology and Exterior Calculus in Numerical Analysis; Serkan Gugercin, Virginia Polytechnic Institute and State University: Reduced-Order Modeling and Controller Design for Large-Scale Dynamical Systems via Rational Krylov Methods; Carlos Garcia-Cervera, University of California, Santa Barbara: Multilevel Physics in the Study of Solids: Modeling, Analysis, and Simulations; Alexander Gamburd, University of California, Santa Cruz: Expander Graphs: Interactions between Arithmetic, Group Theory, and Combinatorics; David M. Fisher, Indiana University: New Analytic Techniques in Group Theory; Patrick Cheridito, Princeton University: Quantification of Risk; Indira L. Chatterji, Ohio State University Research Foundation: Tripodal Geometry and Applications.

—Elaine Kehoe

AAAS Fellows Chosen

Five mathematicians have been elected as new fellows to the Section on Mathematics of the American Association for the Advancement of Science (AAAS). The new fellows are: Carlos Castillo-Chavez, Arizona State University; Tony F. Chan, National Science Foundation; Bruno Nachtergaele, University of California, Davis; Lawrence Sirovich, Mount Sinai School of Medicine; and Robert J. Zimmer, University of Chicago.

—From an AAAS announcement

Beth Samuels (1975–2007)

The mathematics community suffered the loss of a promising recent Ph.D. on January 5, 2007, when Beth Sharon Samuels passed away after a two-and-a-half year battle with breast cancer. Beth was a National Science Foundation Research Training Group Postdoctoral Fellow and visiting assistant professor at the University of California, Berkeley. She is survived by her husband, physicist Ari Tuchman, and their two daughters, Danelle Sophia, 4, and Natalia Meshi, 2.

Beth was born on March 24, 1975, in Los Angeles. After high school she spent a year focused on Jewish studies in Jerusalem, Israel, and earned her B.A. in mathematics from Columbia University in 1997. According to Patrick Gallagher, Beth energized the undergraduate program there by restoring the senior thesis, an initiative she took almost entirely on her own. The senior thesis survives as a major component of Columbia's undergraduate curriculum. After two years teaching Jewish studies, Beth returned to mathematics, earning her Ph.D. from Yale in 2005 under Ilya Piatetski-Shapiro.

Beth was highly regarded by all who knew her for her dedication to mathematics and her exceptional personality. This was unfortunately taken to another level after it was discovered in September 2004 that she had breast cancer (while six months pregnant). In the next six months she went through cancer treatment and delivered a healthy baby. During this time she also wrote her Ph.D. thesis, applied for jobs, and continued her research. Beth was recognized by the American Institute of Mathematics as one of five finalists for its five-year fellowship in 2005.

—Stephen Miller, Rutgers University

Correction

The November 2007 issue of the *Notices* carried a news item "U.S. High School Girls Compete at China Girls' Math Olympiad" (pages 1347–1348). The item should have supplied the complete list of the sponsors of the project to send the U.S. teams to the competition: IBM Almaden Research Center, Akamai Foundation, Mathematical Sciences Research Institute, Mathematical Association of America, Shiing-Shen Chern Foundation for Mathematical Research, and Sunlin and Priscilla Chou Foundation.

—Allyn Jackson

Mathematics Opportunities

National Academies Research Associateship Programs

The Policy and Global Affairs Division of the National Academies is sponsoring the 2008 Postdoctoral and Senior Research Associateship Programs. The programs are meant to provide opportunities for Ph.D., Sc.D., or M.D. scientists and engineers of unusual promise and ability to perform research at more than 100 research laboratories throughout the United States and overseas.

Full-time associateships will be awarded for research in the fields of mathematics, chemistry, earth and atmospheric sciences, engineering, applied sciences, life sciences, space sciences, and physics. Most of the laboratories are open to both U.S. and non-U.S. nationals and to both recent doctoral recipients and senior investigators.

Amounts of stipends depend on the sponsoring laboratory. Support is also provided for allowable relocation expenses and for limited professional travel during the period of the award.

Awards will be made four times during the year, in February, May, August, and November. The deadline for application materials to be postmarked or for electronic submissions for the February 2008 review is **February 1, 2008**; for the May review, **May 1, 2008**; for the August review, **August 1, 2008**; and for the November review, **November 1, 2008**.

For further information and application materials, see the National Academies website at `http://www7.nationalacademies.org/rap/index.html` or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: `rap@nas.edu`.

—From an NRC announcement

Summer Program for Women Undergraduates

The 2008 Summer Program for Women in Mathematics (SPWM2008) will take place at George Washington University in Washington, DC, from June 30 to August 1, 2008. This is a five-week intensive program for mathematically talented undergraduate women who are completing their junior years and may be contemplating graduate study in mathematical sciences. The goals of this program are to communicate an enthusiasm for mathematics, to develop research skills, to cultivate mathematical self-confidence and independence, and to promote success in graduate school.

Applicants must be U.S. citizens or permanent residents studying at a U.S. university or college who are completing their junior years or the equivalent and have mathematical experience beyond the typical first courses in calculus and linear algebra. Sixteen women will be selected. Each will receive a travel allowance, campus room and board, and a stipend of US$1,750. The deadline for applications is **February 29, 2008**. Early applications are encouraged. For further information, please contact the director, Murli M. Gupta, email: `mmg@gwu.edu`, telephone: 202-994-4857; or visit the program's website at `http://www.gwu.edu/~spwm/`. Application material is available on the website.

—Murli M. Gupta, George Washington University

Call for Nominations for 2008 IBC Prize

The Prize for Achievement in Information-Based Complexity is awarded every year for outstanding achievement in information-based complexity. It is awarded for work done in a single year, in a number of years, or over a lifetime. The work can be published in any journal, in a number of journals, or in monograph form. The award consists of US$3,000 and a plaque.

The deadline for nominations for the award is **March 31, 2008**. However, a person does not have to be nominated to win the award. For more information, contact Joseph Traub at `traub@cs.columbia.edu`.

—Joseph Traub, Columbia University

News from the Clay Institute

The Clay Mathematics Institute (CMI) will hold its 2008 Research Conference May 11–12 at the Massachusetts Institute of Technology. The program features eight lectures on recent research developments and the presentation of the Clay Research Awards. Confirmed speakers are Helmut Hofer, Assaf Naor, Rahul Pandharipande, and Scott Sheffield. The full program will be announced at a later date on the CMI website, `http://www.claymath.org`. In addition, please see CMI's website for details of last year's program.

—CMI announcement

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

Dhahran, Saudi Arabia

College of Applied & Supporting Studies

GENERAL STUDIES DEPARTMENT

Associate / Assistant Professor Positions

The Department of General Studies at King Fahd University of Petroleum & Minerals (KFUPM) in Dhahran, Saudi Arabia invites applications for full-time faculty positions at the rank of Associate/ Assistant Professors in the following fields :

1. Sociology
2. Political Science
3. Psychology
4. History
5. Library & Research Methods
6. Cultural & regional Studies
7. Speech & Communication Studies
8. Future Studies

Applicants are expected to hold a Ph.D. degree with a strong commitment to research and teaching as well as serving the university. Applicants are also expected to have superior ability to teach in English(as the language of instruction at KFUPM is English). Candidates with Middle Eastern expertise are strongly encouraged to apply.

SALARY AND BENEFITS:

These positions are full-time two-year renewable contracts with competitive tax free salary based on qualifications and experience, free furnished air-conditioned on-campus housing unit with free essential utilities and maintenance. Subject to University policy, the appointment includes the following additional benefits: Air ticket/s to Dammam on appointment; annual repatriation air tickets to Dammam for the faculty and up to three of his dependents; tuition fees for school-age dependent children enrolled in local schools; local transportation allowance; Two months' paid summer vacation, end-of service benefits, and free access to recreation facilities. KFUPM campus has a range of facilities including medical & dental clinic, teaching and research support facilities such as an extensive library acquisitions and library databases, computing facilities, smart classrooms, and research and teaching laboratories. The campus is within a very short distance from the cities of Dammam and Al-Khobar.

Review of applications will continue until the positions are filled.
To Apply : Send (preferably by e-mail) cover letter, detailed resume, completed KFUPM application form with copies of credentials (academic degrees & transcript/s) and three referees to the following address :

Dean of Faculty & Personnel Affairs
DEPT. REF.No. GSD-07
KFUPM Box 5005, Dhahran 31261, Saudi Arabia
E-mail: faculty@kfupm.edu.sa **or** c-gsd@kfupm.edu.sa Fax: +966-3-860-2429 or 860-2442

To download the KFUPM Application Form, Click on the link
http://www.kfupm.edu.sa/fpa/serv/InfApplicFacPosi.mht

Please quote DEPT. reference no.GSD-07 in your initial application

For more information, please visit the following links:

KFUPM Web Site: http://www.kfupm.edu.sa Deanship of Faculty & Personnel Affairs: http://www.kfupm.edu.sa/fpa

For Your Information

News from PIMS

The Pacific Institute for the Mathematical Sciences (PIMS) is pleased to announce that Alejandro Adem has been appointed the new director of PIMS. He will commence his five-year term on July 1, 2008.

Presently the PIMS deputy director, Adem is a professor of mathematics at the University of British Columbia in Vancouver, Canada, and holds the Canada Research Chair in Algebraic Topology. He received his B.Sc. in 1982 from the National University of Mexico and his Ph.D. from Princeton University in 1986. After holding a Szegö Assistant Professorship at Stanford University and spending a year at the Institute for Advanced Study in Princeton, he joined the faculty of the University of Wisconsin-Madison in 1990, where he remained until 2004. Adem has held visiting positions at the Eidgenössisches Technische Hochscule (ETH)-Zurich, the Max Planck Institute in Bonn, the University of Paris VII and XIII, and Princeton University.

Adem's mathematical interests span a variety of topics in algebraic topology, group cohomology, and related areas. He has authored and coauthored numerous research articles as well as two highly regarded monographs, *Cohomology of Finite Groups* and *Orbifolds and Stringy Topology*. He has given over two hundred invited talks on his research throughout the world and has supervised several Ph.D. students and postdoctoral fellows. He was awarded the U.S. National Science Foundation Young Investigator Award in 1992, a Romnes Faculty Fellowship in 1995, and a Vilas Associate Award in 2003. He has extensive editorial experience and is currently an editor for the *Memoirs of the AMS* and *Transactions of the AMS*.

Adem brings extensive administrative experience to PIMS. He served as chair of the Department of Mathematics at the University of Wisconsin-Madison during the period 1999–2002, and since 2005 he has been the deputy director at PIMS. Adem's credentials as a scientific organizer include serving for four years as cochair of the Scientific Advisory Committee at the Mathematical Sciences Research Institute at Berkeley (MSRI) and as a member of MSRI's Board of Trustees. Since 2005 he has been a member of the Scientific Advisory Board for the Banff International Research Station (BIRS).

Adem brings a wealth of experience in organizing international collaborations connecting Canadian mathematical scientists with colleagues abroad. This includes his leadership in organizing the first joint meeting between the Canadian and Mexican mathematical societies in 2006, as well as his crucial role in the development of the Pacific Rim Mathematical Association (PRIMA). He will continue to build on PIMS's outstanding record of mathematical collaboration between academic, industrial, and international partners.

Further information about PIMS is available on the Web at `http://www.pims.math.ca`.

—From a PIMS announcement

STIX Fonts Project Completes Design Phase

The AMS is one of a group of six scientific publishers that have collaborated to produce the Scientific and Technical Information Exchange (STIX) fonts. In October 2007 the group announced the release of the fonts in a beta test version. This free, comprehensive set of special characters, mainly mathematical or scientific, represents a significant breakthrough in scientific, technical, and medical publishing. The final production release of the STIX fonts was set to occur before the end of 2007.

The successful completion of the STIX fonts project will alleviate the need for publishers to assemble symbols from a variety of fonts. When posted to a website, documents using the STIX fonts will be properly rendered regardless of the fonts installed on a particular computer, saving editors' valuable time.

In addition to the AMS, the other publishers that collaborated to design, fund, and manage the STIX project are the American Chemical Society (ACS), the American

Institute of Physics (AIP), the American Physical Society (APS), Elsevier, and the Institute of Electrical and Electronics Engineers (IEEE).

The technical development of the STIX Fonts Project was handled by MicroPress, Inc., a respected font designer, which has created and delivered nearly 8,000 characters/glyphs required for these comprehensive fonts. Glyphs designed by Elsevier for an earlier project push the final glyph total to 8,047.

"If you've ever had to assemble scientific symbols from a variety of fonts, many of which vary in character style, positioning, or size, you'll immediately appreciate the benefits of STIX fonts," said Robert Kelly, director, Journal Information Systems, the American Physical Society. "Aside from the fact that the STIX fonts work with a wide variety of Web browsers, word processors, and other scholarly communications software, they have the ability to support widely expanded character sets and layout features which provide richer linguistic support and advanced typographic control. We hope that all operating system and application vendors move quickly to support the fonts."

By making the fonts freely available, the STIX project hopes to encourage the development of widespread applications that make use of these fonts. In particular, the STIX project will create a $\TeX$ implementation that $\TeX$ users can install and configure with minimal effort. The $\TeX$ version of the fonts is being developed by a subcontractor and should be available soon after the production version is released. For more information, visit the STIX fonts website at `http://www.stixfonts.org`.

—From a STIX news release

Program for ICM2010, Hyderabad

The next International Congress of Mathematicians (ICM) will be held in Hyderabad, India, August 19–27, 2010. The Program Committee has, based on the scientific programs of former ICMs and suggestions from mathematicians the world over, decided on the structure of the scientific program of ICM 2010.

Below is the list of sections, their descriptions, and the distribution of lectures to the sections. The program committee will finalize the descriptions in the spring of 2008 and invites comments on the section descriptions from the adhering organizations and mathematicians interested in helping make the ICM 2010 program as attractive as possible.

Proposals for changes may be submitted to Hendrik Lenstra, chair of the ICM 2010 Program Committee, `hwlicm@math.leidenuniv.nl`, by the end of January 2008.

Total number of lectures (including panel discussions): 150–176.

1. **Logic and foundations** (4–5 lectures). Model theory. Set theory. Recursion theory. Proof theory. Applications.

2. **Algebra** (6–7 lectures). Groups and their representations (except as specified in 5 and 7). Rings, algebras and modules (except as specified in 7). Algebraic K-theory. Category theory. Computational algebra and applications.

3. **Number theory** (10–12 lectures). Analytic and algebraic number theory. Local and global fields and their Galois groups. Zeta and L-functions. Diophantine equations. Arithmetic on algebraic varieties. Diophantine approximation, transcendental number theory and geometry of numbers. Modular and automorphic forms, modular curves and Shimura varieties. Langlands program. p-adic analysis. Number theory and physics. Computational number theory and applications, notably to cryptography.

4. **Algebraic and complex geometry** (9–11 lectures). Algebraic varieties, their cycles, cohomologies and motives (including positive characteristics). Schemes. Commutative algebra. Low-dimensional varieties. Singularities and classification. Birational geometry. Moduli spaces. Abelian varieties and p-divisible groups. Derived categories. Transcendental methods, topology of algebraic varieties. Complex differential geometry, Kahler manifolds and Hodge theory. Relations with mathematical physics and representation theory. Real algebraic and analytic sets. Rigid and p-adic analytic spaces. Tropical geometry.

5. **Geometry** (10–12 lectures). Local and global differential geometry. Geometric PDE and geometric flows. Geometric structures on manifolds. Riemannian and metric geometry. Geometric aspects of group theory. Convex geometry. Discrete geometry. Geometric rigidity.

6. **Topology** (10–12 lectures). Algebraic, differential and geometric topology. Floer and gauge theories. Low-dimensional including knot theory and connections with Kleinian groups and Teichmüller theory. Symplectic and contact manifolds. Topological quantum field theories.

7. **Lie theory and generalizations** (8–10 lectures). Algebraic and arithmetic groups. Structure, geometry and representations of Lie groups and Lie algebras. Related geometric and algebraic objects, e.g., symmetric spaces, buildings, vertex operator algebras, quantum groups. Noncommutative harmonic analysis. Geometric methods in representation theory. Discrete subgroups of Lie groups. Lie groups and dynamics, including applications to number theory.

8. **Analysis** (7–8 lectures). Classical analysis. Special functions. Harmonic analysis. Complex analysis in one and several variables, potential theory, geometric function theory (including quasi-conformal mappings), geometric measure theory. Applications.

9. **Functional analysis and applications** (5–6 lectures). Operator algebras. Noncommutative geometry, spectra of random matrices. K-theory of C*-algebras, structure of factors and their automorphism groups, operator-algebraic aspects of quantum field theory, linear and nonlinear functional analysis, geometry of Banach spaces, asymptotic geometric analysis. Connections to ergodic theory.

10. **Dynamical systems and ordinary differential equations** (9–11 lectures). Topological and symbolic dynamics. Geometric and qualitative theory of ODE and smooth dynamical systems, bifurcations and singularities. Hamiltonian systems and dynamical systems

of geometric origin. One-dimensional and holomorphic dynamics. Multidimensional actions and rigidity in dynamics. Ergodic theory, including applications to combinatorics and combinatorial number theory.

11. **Partial differential equations** (9–10 lectures). Solvability, regularity, stability and other qualitative properties of linear and nonlinear equations and systems. Asymptotics. Spectral theory, scattering, inverse problems. Variational methods and calculus of variations. Optimal transportation. Homogenization and multiscale problems. Relations to continuous media and control. Modeling through PDEs.

12. **Mathematical physics** (10–12 lectures). Quantum mechanics. Quantum field theory. General relativity. Statistical mechanics and random media. Integrable systems. Electromagnetism, string theory, condensed matter, fluid dynamics, multifield physics (e.g., fluid/waves, fluid/solids, etc.).

13. **Probability and statistics** (12–13 lectures). Classical probability theory, limit theorems and large deviations. Combinatorial probability. Random walks. Interacting particle systems. Stochastic networks. Stochastic geometry. Stochastic analysis. Random fields. Random matrices and free probability. Statistical inference. High-dimensional data analysis. Sequential methods. Spatial statistics. Applications.

14. **Combinatorics** (7–8 lectures). Combinatorial structures. Enumeration: exact and asymptotic. Graph theory. Probabilistic and extremal combinatorics. Designs and finite geometries. Relations with linear algebra, representation theory and commutative algebra. Topological and analytical techniques in combinatorics. Combinatorial geometry. Combinatorial number theory. Polyhedral combinatorics and combinatorial optimization.

15. **Mathematical aspects of computer science** (6–7 lectures). Complexity theory and design and analysis of algorithms. Formal languages. Computational learning. Algorithmic game theory. Cryptography. Coding theory. Semantics and verification of programs. Symbolic computation. Quantum computing. Computational geometry, computer vision.

16. **Numerical analysis and scientific computing** (5–6 lectures). Design of numerical algorithms and analysis of their accuracy, stability, and complexity. Approximation theory. Applied and computational aspects of harmonic analysis. Numerical solution of algebraic, functional, differential, and integral equations. Grid generation and adaptivity.

17. **Control theory and optimization** (6–7 lectures). Minimization problems. Controllability, observability, stability. Robotics. Stochastic systems and control. Optimal control. Optimal design, shape design. Linear, nonlinear, integer, and stochastic programming. Applications.

18. **Mathematics in science and technology** (8–10 lectures). Mathematics applied to the physical sciences, engineering sciences, life sciences, social and economic sciences, and technology. Bioinformatics. Mathematics in interdisciplinary research. The interplay of mathematical modeling, mathematical analysis and scientific computation, and its impact on the understanding of scientific phenomena and on the solution of real-life problems.

19. **Mathematics education and popularization of mathematics** (3 lectures + 3 panel discussions). All aspects of mathematics education, from elementary school to higher education. Mathematical literacy and popularization of mathematics. Ethnomathematics.

20. **History of mathematics** (3 lectures). Historical studies of all of the mathematical sciences in all periods and cultural settings.

—Martin Grötschel, Secretary, International Mathematical Union

Inside the AMS

From the AMS Public Awareness Office

This is the first in a series of columns on recent developments and highlights in the programs and services of the AMS's Public Awareness Office (PAO).

• ***Headlines & Deadlines for Students***. There are now several hundred students and faculty advisors who have subscribed to this free service, which provides email notifications of news and upcoming deadlines. Recent updates have included the 2008 Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student, as well as upcoming deadlines for AWM-NSF Travel Grants, the AMS-AAAS Mass Media Fellowship, and the PLUS New Writers Award. The items are also posted at `http://www.ams.org/news-for-students`.

• **AMS Posters**. This webpage has PDFs of small posters that promote awareness of mathematics and of AMS programs and services. Print the posters for display in common areas, offices, and classrooms; `http://www.ams.org/ams/ams-printable-posters.html`.

• **Publicity for the Joint Mathematics Meetings**. The PAO has issued news releases to reporter contacts, local media, and newswire services about the meetings, prizewinners, and *Who Wants to Be a Mathematician* game for San Diego-area high school students, and will again host a press room on site. The PAO is also offering two new ways to publicize aspects of the meetings: For the first time the PAO is producing a blog, written primarily by 2007 AMS-AAAS Media Fellow Adriana Salerno, and has posted podcasts of interviews with Invited Address speakers Fan Chung, Brian Conrey, Karen Parshall, and Terence Tao (done by PA Officer Mike Breen and MAA Editorial Assistant Ryan Miller).

• ***Who Wants to Be a Mathematician***. The game for high school students was recently held at the Arnold Ross Lecture in Boston and at the Institute for Mathematics and its Applications at the University of Minnesota, drawing a total of over four hundred students, teachers, and parents. Here's one teacher's reaction: "That was really a lot of fun.…Thank you for all your work and time and effort that went into putting on this event. I think it went very smoothly and was enjoyed by all." The game will also be held at the Joint Mathematics Meetings in San Diego. The event is open to the public, and meeting registrants are invited; `http://www.ams.org/wwtbam/`.

• **Feature Column**. Recent columns include "Strange Associations", "Taxi!", "Image Compression: Seeing What's Not There", and "The Mathematics behind Quantum Computing". David Austin's columns on Google's PageRank algorithm and the mathematics of image compression were widely read and cited, each receiving over 100,000 hits. The current column and the archive of past essays on mathematical topics by Austin, Bill Casselman, Joe Malkevitch, and Tony Phillips are at `http://www.ams.org/featurecolumn/`.

—Annette Emerson and Mike Breen, AMS Public Awareness Officers

Math in Moscow Scholarships Awarded

The AMS has made awards to four mathematics students to attend the Math in Moscow program in the fall of 2007. The following are the undergraduate students and their institutions: Dustin Clausen, Harvard University; David Cochran, Virginia Commonwealth University; Aaron Blake Mitchell, Lamar University; Timothy Speer, New York University. Each student has been awarded a US$7,500 scholarship.

Math in Moscow is a program of the Independent University of Moscow that offers foreign students (undergraduate or graduate students specializing in mathematics and/or computer science) the opportunity to spend a semester in Moscow studying mathematics. All instruction is given in English. The fifteen-week program is similar to the Research Experiences for Undergraduates programs that are held each summer across the United States.

Since 2001, each semester the AMS has awarded several scholarships for U.S. students to attend the Math in Moscow program. The scholarships are made possible through a grant from the National Science Foundation. For more information about Math in Moscow, consult `http://www.mccme.ru/mathinmoscow` and the article "Bringing Eastern European mathematical traditions to North American students", *Notices*, November 2003, pages 1250–4.

—*Elaine Kehoe*

AMS Email Support for Frequently Asked Questions

A number of email addresses have been established for contacting the AMS staff regarding frequently asked questions. The following is a list of those addresses together with a description of the types of inquiries that should be made through each address.

abs-info@ams.org for questions regarding a particular abstract.

abs-submit@ams.org for information on how to submit abstracts for AMS meetings and MAA sessions at January Joint Mathematics Meetings. Type HELP as the subject line.

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.

amsmem@ams.org to request information about membership in the AMS and 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 *Annual Survey of the Mathematical Sciences* or to request reprints of survey reports.

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 to request general information about *Employment Information in the Mathematical Sciences* (EIMS). For ad deadlines and rates go to `http://www.ams.org/eims`.

emp-info@ams.org for information regarding AMS employment and career services.

eprod-support@ams.org for technical questions regarding AMS electronic products and services.

mathcal@ams.org to send information to be included in the "Mathematics Calendar" section of the *Notices*.

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 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 and letters. 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 in 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 `http://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 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 inquire about using AMS publications as course texts.

webmaster@ams.org for general information or for assistance in accessing and using the AMS website.

—*AMS announcement*

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

January 15, 2008: Applications for AMS-AAAS Mass Media Summer Fellowships. See `http://www.aaas.org/programs/education/MassMedia/` or contact Stacey Pasco, Director, Mass Media Program, AAAS Mass Media Science and Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone 202-326-6641; fax 202-371-9849; email: `spasco@aaas.org`. Further information is also available at `http://www.ams.org/government/massmediaann.html` and through the AMS Washington Office, 1527 Eighteenth Street, NW, Washington, DC 20036; telephone

Where to Find It

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

202-588-1100; fax 202-588-1853; email: amsdc@ams.org.

January 15, 2008: Applications for Jefferson Science Fellows Program. See http://www7.nationalacademies.org/jefferson/; email: jsf@nas.edu; telephone 202-334-2643.

January 17, 2008: Proposals for NSF ADVANCE Program Partnerships for Adaptation, Implementation, and Dissemination (PAID) awards. See http://www.nsf.gov/pubs/2007/nsf07582/nsf07582.txt.

January 24, 2008: Proposals for NSF Computing Equipment and Instrumentation Programs (SCREMS). See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5616.

January 28, 2008: Nominations for Computer-Aided Verification Award. See http://www.princeton.edu/cav2008.

February 1, 2008: Applications for Math for America Foundation (MfA) Fellowships. See http://www.mathforamerica.org/.

February 1, 2008: Applications for AWM Travel Grants and AWM Mentoring Grants. See http://www.awm-math.org/travelgrants.html, telephone 703-934-0163, email: awm@awm-math.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

February 1, 2008: Applications for 2008 IPAM workshops and programs. See http://www.ipam.ucla.edu.

February 1, 2008: Applications for February review for the National Academies Postdoctoral and Senior Research Associateship Programs. See "Mathematics Opportunities" in this issue.

February 15, 2008: Nominations for Clay Mathematics Institute (CMI) Summer Liftoff Program. See the website http://claymath.org/fas/liftoff_fellows/, telephone: 617-995-2600, email: nominations@claymath.org.

February 15, 2008: Applications for IPAM Research in Industrial Projects for Students (RIPS). See http://www.ipam.ucla.edu.

February 29, 2008: Applications for the 2008 Summer Program for Women in Mathematics (SPWM2008). See "Mathematics Opportunities" in this issue.

March 1, 2008: Applications for Christine Mirzayan Science and Technology Policy Graduate Fellowship Summer Program. See http://www7.nationalacademies.org/policyfellows, or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

March 1, 2008 (tentative): Applications for Enhancing Diversity in Graduate Education (EDGE) Program. See http://www.edgeforwomen.org/enextyear.html.

March 31, 2008: Nominations for 2008 Prize for Achievement in Information-Based Complexity. See "Mathematics Opportunities" in this issue.

April 15, 2008: Applications for Math in Moscow for fall 2008. See http://www.mccme.ru/mathinmoscow, or write to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax +7095-291-65-01; email: mim@mccme.ru; or contact Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; email: student-serv@ams.org.

May 1, 2008: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html, telephone 703-934-0163, email: awm@awm-math.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

May 1, 2008: Applications for May review for the National Academies Postdoctoral and Senior Research Associateship Programs. See "Mathematics Opportunities" in this issue.

June 1, 2008: Applications for Christine Mirzayan Science and Technology Policy Graduate Fellowship Fall Program. See http://www7.nationalacademies.org/policyfellows, or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

June 10, 2008: Proposals for Enhancing the Mathematical Sciences Workforce in the Twenty-First Century. See http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf05595.

August 1, 2008: Applications for August review for the National Academies Postdoctoral and Senior Research Associateship Programs. See "Mathematics Opportunities" in this issue.

August 18, 2008: Applications for NSF Research Experiences for Undergraduates (REU) program sites. See http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf07569.

October 1, 2008: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html, telephone: 703-934-0163, email: awm@awm-math.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

November 1, 2008: Applications for November review for the National Academies Postdoctoral and Senior Research Associateship Programs. See "Mathematics Opportunities" in this issue.

MPS Advisory Committee

Following are the names and affiliations of the members of the Advisory Committee for Mathematical and Physical Sciences (MPS) of the National Science Foundation. The date of the expiration of each member's term is given after his or her name. The website for the MPS directorate may be found at http://www.nsf.gov/home/mps/. The postal address is Directorate for the Mathematical and Physical Sciences, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230.

Hector D. Abruna (10/10)
Department of Chemistry and Chemical Biology
Cornell University

Douglas N. Arnold (10/08)
Institute for Mathematics and its Applications
University of Minnesota

Cynthia J. Burrows (10/08)
Department of Chemistry
University of Utah

Claude R. Canizares (10/08)
Office of the Provost
MIT

Eric A. Cornell (10/10)
JILA
University of Colorado

Larry R. Dalton (10/08)
Department of Chemistry
University of Washington

Rhonda Hughes (10/08)
Department of Mathematics
Bryn Mawr College

Iain M. Johnstone (10/09)
Department of Statistics
Stanford University

William L. Jorgensen (10/09)
Department of Chemistry
Yale University

David E. Keyes (10/09)
Department of Applied Physics and Applied Mathematics
Columbia University

Theresa A. Maldonado (MPSAC/CEOSE Liaison) (10/09)
Department of Electrical and Computer Engineering
Texas A&M University

Dennis L. Matthews (10/10)
College of Engineering and School of Medicine
University of California, Davis

Dusa M. McDuff (10/09)
Department of Mathematics
Stony Brook University

Monica Olvera de la Cruz (10/08)
Department of Materials Science and Engineering
Northwestern University

Jose N. Onuchic (10/08)
Department of Physics
University of California, San Diego

Ian M. Robertson (10/09)
Department of Materials Science and Engineering
University of Illinois, Urbana-Champaign

Winston O. Soboyejo (10/09)
Department of Mechanical and Aerospace Engineering
Princeton University

Joel E. Tohline (10/10)
Department of Physics and Astronomy
Louisiana State University

Robert Williams (10/09)
Space Telescope Science Institute
Baltimore, MD

Michael Witherell (chair) (10/08)
Department of Physics
University of California, Santa Barbara

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.

An Abundance of Katherines, by John Green. Dutton Juvenile Books, September 2006. ISBN 0-525-47688-1.

Alfred Tarski: Life and Logic, by Anita Burdman Feferman and Solomon Feferman. Cambridge University Press, October 2004. ISBN 0-521-80240-7. (Reviewed September 2007.)

Ants, Bikes, and Clocks: Problem Solving for Undergraduates, by William Briggs. Society for Industrial and Applied Mathematics, 2005. ISBN 0-89871-574-1.

The Archimedes Codex, by Reviel Netz and William Noel. Weidenfeld and Nicolson, May 2007. ISBN-13: 978-0-29764-547-4.

The Art of Mathematics: Coffee Time in Memphis, by Béla Bollobás. Cambridge University Press, September 2006. ISBN-13: 978-0-52169-395-0.

The Artist and the Mathematician: The Story of Nicolas Bourbaki, the Genius Mathematician Who Never Existed, by Amir D. Aczel. Thunder's Mouth Press, August 2006. ISBN 1-560-25931-0. (Reviewed October 2007.)

Benjamin Franklin's Numbers: An Unsung Mathematical Odyssey, by Paul C. Pasles. Princeton University Press, October 2007. ISBN-13: 978-0-69112-956-3.

The Best of All Possible Worlds: Mathematics and Destiny, by Ivar Ekeland. University of Chicago Press, October 2006. ISBN-13: 978-0-226-19994-8.

Bourbaki, a Secret Society of Mathematicians, by Maurice Mashaal. AMS, June 2006. ISBN 0-8218-3967-5. (Reviewed October 2007.)

The Calculus Wars: Newton, Leibniz, and the Greatest Mathematical Clash of All Time, by Jason Socrates Bardi. Thunder's Mouth Press, April 2007. ISBN-13: 978-1-56025-992-3.

The Cat in Numberland, by Ivar Ekeland. Cricket Books, April 2006. ISBN-13: 978-0-8126-2744-2.

A Certain Ambiguity: A Mathematical Novel, by Gaurav Suri and Hartosh Singh Bal. Princeton University Press, June 2007. ISBN-13: 978-0-691-12709-5. (Reviewed in this issue.)

Chases and Escapes: The Mathematics of Pursuit and Evasion, by Paul J. Nahin. Princeton University Press, May 2007. ISBN-13: 978-0-69112-514-5.

Descartes: A Biography, by Desmond Clarke. Cambridge University Press, March 2006. ISBN 0-521-82301-3. (Reviewed January 2008.)

Einstein's Heroes: Imagining the World through the Language of Mathematics, by Robyn Arianrhod. Oxford University Press, July 2006. ISBN-13: 978-0-195-30890-7.

Ernst Zermelo: An Approach to His Life and Work, by Heinz-Dieter Ebbinghaus. Springer, April 2007. ISBN-13: 978-3-540-49551-2.

Flatland—The Movie: A Journey of Many Dimensions. Flatworld Productions, 2007. Special Educator Edition DVD, http://store.flatlandthemovie.com. (Reviewed November 2007.)

Fly Me to the Moon: An Insider's Guide to the New Science of Space Travel, by Edward Belbruno. Princeton University Press, January 2007. ISBN-13: 978-0-691-12822-1.

From Zero to Infinity: What Makes Numbers Interesting, by Constance Reid. Fiftieth anniversary edition, A K Peters, February 2006. ISBN 1-568-81273-6. (Reviewed February 2007.)

The Great π/e Debate: Which Is the Better Number?, DVD by Colin Adams and Thomas Garrity. Mathematical Association of America, 2007. ISBN 0-88385-900-9.

**A History of Abstract Algebra*, by Israel Kleiner. Birkhäuser, October 2007. ISBN-13: 978-0-8176-4684-4.

How Mathematicians Think: Using Ambiguity, Contradiction, and Paradox to Create Mathematics, by William Byers. Princeton University Press, May 2007. ISBN-13: 978-0-6911-2738-5. (Reviewed December 2007.)

How to Cut a Cake: And Other Mathematical Conundrums, by Ian Stewart. Oxford University Press, November 2006. ISBN 0-199-20590-6.

I Am a Strange Loop, by Douglas R. Hofstadter. Basic Books, March 2007. ISBN-13: 978-0-46503-078-1. (Reviewed August 2007.)

An Introduction to Gödel's Theorems, by Peter Smith. Cambridge University Press, August 2007. ISBN-13: 978-0-52167-453-9.

John von Neumann: Selected Letters, edited by Miklós Rédei. AMS, November 2005. ISBN 0-8218-3776-1. (Reviewed June/July 2007.)

Karl Pearson: The Scientific Life in a Statistical Age, by Theodore M. Porter. Princeton University Press, (new edition) December 2005. ISBN-13: 978-0-69112-635-7. (Reviewed December 2007.)

**The Legacy of Mario Pieri in Geometry and Arithmetic*, by Elena Anne Marchisotto and James T. Smith. Birkhäuser, May 2007. ISBN-13: 978-0-8176-3210-6.

Leonhard Euler, by Emil A. Fellmann. Birkhäuser, 2007. ISBN-13: 978-3-7643-7538-6.

Leonhard Euler, a Man to Be Reckoned With, by Andreas K. Heyne and Alice K. Heyne. Birkhäuser, 2007. ISBN-13: 978-3-7643-8332-9.

Letters to a Young Mathematician, by Ian Stewart. Perseus Books, April 2006. ISBN-13: 978-0-465-08231-5. (Reviewed May 2007.)

The Math behind the Music, by Leon Harkleroad. Cambridge University Press, August 2006. ISBN-13: 978-0-521-00935-5.

Math Doesn't Suck: How to Survive Middle-School Math without Losing Your Mind or Breaking a Nail, by Danica McKellar. Hudson Street Press, August 2007. ISBN-13: 978-1-5946-3039-2.

**Mathematical Mind-Benders*, by Peter Winkler. A K Peters, August 2007. ISBN-13: 978-15688-1336-3.

The Mathematician's Brain, by David Ruelle. Princeton University Press, July 2007. ISBN-13: 978-0-691-12982-2.

Mathematics and Common Sense: A Case of Creative Tension, by Philip J. Davis. A K Peters, October 2006. ISBN 1-568-81270-1.

**Mathematics at Berkeley: A History*, by Calvin C. Moore. A K Peters, February 2007. ISBN-13: 978-15688-130-28.

Measuring the World, by Daniel Kehlmann. Pantheon, November 2006. ISBN 0-375-42446-6.

The Millennium Prize Problems, edited by James Carlson, Arthur Jaffe, and Andrew Wiles. AMS, June 2006. ISBN-13: 978-0-8218-3679-8.

The Mind of the Mathematician, by Michael Fitzgerald and Ioan James. Johns Hopkins University Press, May 2007. ISBN-13: 978-0-8018-8587-7.

More Mathematical Astronomy Morsels, by Jean Meeus. Willmann-Bell, 2002. ISBN 0-943396-743.

More Sex Is Safer Sex: The Unconventional Wisdom of Economics, by Steven E. Landsburg. Free Press, April 2007. ISBN-13: 978-1-416-53221-7.

The Motion Paradox: The 2,500-Year Old Puzzle behind All the Mysteries of Time and Space, by Joseph Mazur. Dutton Adult, April 2007. ISBN-13: 978-0-52594-992-3.

Mr. Hopkins' Men: Cambridge Reform and British Mathematics in the 19th Century, by A. D. D. Craki. Springer, July 2007. ISBN-13: 978-1-8462-8790-9.

Music and Probability, by David Temperley. MIT Press, January 2007. ISBN-13: 978-0-262-20166-7.

Music: A Mathematical Offering, by David J. Benson. Cambridge University Press, December 2006. ISBN-13: 978-0-521-61999-8.

Negative Math: How Mathematics Rules Can Be Positively Bent, by Alberto A. Martinez. Princeton University Press, November 2005. ISBN-13: 978-0-691-12309-7.

New Theories of Everything, by John D. Barrow. Oxford University Press, July 2007. ISBN-13: 978-0-192-80721-2.

Nonplussed! Mathematical Proof of Implausible Ideas, by Julian Havil. Princeton University Press, May 2007. ISBN-13: 978-0-691-12056-0.

The Numbers behind NUMB3RS: Solving Crime with Mathematics, by Keith Devlin and Gary Lorden. Plume, August 2007. ISBN-13: 978-0-4522-8857-7.

Out of the Labyrinth: Setting Mathematics Free, by Robert Kaplan and Ellen Kaplan. Oxford University Press, January 2007. ISBN-13: 978-0-19514-744-5.

The Poincaré Conjecture: In Search of the Shape of the Universe, by Donal O'Shea. Walker, March 2007. ISBN-13: 978-0-8027-1532-6. (Reviewed January 2008.)

Poincaré's Prize: The Hundred-Year Quest to Solve One of Math's Greatest Puzzles, by George Szpiro. Dutton Adult, June 2007. ISBN-13: 978-0-525-95024-0. (Reviewed January 2008.)

**The Probability of God: A Simple Calculation That Proves the Ultimate Truth*, by Stephen D. Unwin. Three Rivers Press, October 2004. ISBN-13: 978-14000-5478-7. (Reviewed in this issue.)

Project Origami: Activities for Exploring Mathematics, by Thomas Hull. A K Peters, March 2006. ISBN 1-568-81258-2. (Reviewed May 2007.)

Pythagoras: His Life, Teaching and Influence, by Christoph Riedweg. Translated by Steven Rendall. Cornell University Press, March 2005. ISBN-13: 978-0-80144-240-7.

Pythagoras: The Mathemagician, by Karim El-koussa. Cloonfad Press, September 2005. ISBN-13: 978-0-97694-042-5.

The Pythagorean Theorem: A 4000-Year History, by Eli Maor. Princeton University Press, May 2007. ISBN-13: 978-0-69112-526-8.

Shadows of Reality: The Fourth Dimension in Relativity, Cubism, and Modern Thought, by Tony Robbin. Yale University Press, March 2006. ISBN 0-300-11039-1. (Reviewed April 2007.)

Solving Mathematical Problems: A Personal Perspective, by Terence Tao. Oxford University Press, September 2006. ISBN-13: 978-0-199-20560-8.

The Square Root of 2: A Dialogue Concerning a Number and a Sequence, by David Flannery. Springer, December 2005. ISBN-13: 978-0-38720-220-4.

Superior Beings: If They Exist, How Would We Know? Game-Theoretic Implications of Omnipotence, Omniscience, Immortality, and Incomprehensibility, by Steven Brams. Springer, second edition, November 2007. ISBN-13: 978-0-387-48065-7. (Reviewed in this issue.)

Symmetry and the Monster: The Story of One of the Greatest Quests of Mathematics, by Mark Ronan. Oxford University Press, May 2006. ISBN 0-192-80722-6. (Reviewed February 2007.)

Thinking about Gödel and Turing: Essays on Complexity, 1970–2007, by Gregory J. Chaitin. World Scientific, August 2007. ISBN-13: 978-9-8127-0895-3.

The Triumph of Numbers: How Counting Shaped Modern Life, by I. B. Cohen. W. W. Norton, July 2006. ISBN-13: 978-0-393-32870-7. (Reviewed December 2007.)

The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next, by Lee Smolin. Joseph Henry Press, October 2006. ISBN 0-309-10192-1. (Reviewed September 2007.)

Useless Arithmetic: Why Environmental Scientists Can't Predict the Future, by Orrin Pilkey and Linda Pilkey-Jarvis. Columbia University Press, February 2007. ISBN 0-231-13212-3.

The Volterra Chronicles: The Life and Times of an Extraordinary Mathematician, by Judith R. Goodstein. AMS, February 2007. ISBN-13: 978-0-8218-3969-0.

Why Beauty Is Truth: The Story of Symmetry, by Ian Stewart. Perseus Books Group, April 2007. ISBN-13: 978-0-46508-236-0.

Yearning for the Impossible: The Surprising Truths of Mathematics, by John Stillwell. A K Peters, May 2006. ISBN 1-568-81254-X. (Reviewed June/July 2007.)

You Failed Your Math Test, Comrade Einstein: Adventures and Misadventures of Young Mathematicians, or Test Your Skills in Almost Recreational Mathematics, edited by M. Shifman. World Scientific, June 2005. ISBN-13: 978-9-8125-6279-1.

Doctoral Degrees Conferred

2006–2007

ALABAMA

Auburn University (8)

MATHEMATICS AND STATISTICS

Castellana, Vincent, On the spectrum of minimal covers by triples.

Diawara, Norou, New classes of multivariate gamma survival and reliability models.

Nguyen, Tung, A-stability for two species competition diffusion systems.

Ozkan, Sibel, Hamilton decompositions with primitive leaves.

Pettis, Carl, The triangle intersection problem for hexagon triple systems.

Stone, Jennifer, Non-metric continua that support Whitney maps.

Trimm, Janet, On Frobenius numbers in three variables.

Tuncer, Necibe, A novel finite element discretization of domains with spheroidal geometry.

University of Alabama at Birmingham (2)

MATHEMATICS

Areeg, Abdalla, Monte-Carlo studies with random fuzzy numbers.

Childers, Douglas, Some topological results on the influence of critical points in rational dynamics.

University of Alabama-Tuscaloosa (3)

MATHEMATICS

Bulka, Yuriy, Multiple nonlinear Volterra integral equations.

Kim, Young Hee, A hysteresis model for two-dimensional input signals.

Qui, Lin, Morrey type spaces and Carleson measures.

ARIZONA

Arizona State University (9)

MATHEMATICS AND STATISTICS

Driver, Eric, A targeted Martinet search.

Imran, Mudassar, Mathematical models in biofilm and antibiotic treatment.

Infante, Nicole, Students' understanding of related rates problems in calculus.

Knapp, Jessica, Students' appropriation of proving practices in advanced calculus.

Lu, Yan, Longitudinal estimation in dual frame surveys.

Mason, Clinton, Modeling glucose dynamics leading to a diabetic state with simulations performed from data.

Shim, Eunha, Mathematical models of rotavirus transmission in the presence of maternal antibodies and vaccination.

Tridane, Abdessamad, Mathematical analysis of immunological and epidemiological models of influenza infection.

Wang, Hao, Mathematical analysis of trophic interactions: From bacteria competition of lemming cycles.

University of Arizona (9)

MATHEMATICS

Caine, John, Poisson structures on U/K and applications.

Habermas, Derek, Compact symmetric spaces, triangular factorization and Cayley coordinates.

Konstantinou, Panagiota, Homomorphisms of the fundamental group of a surface into $PSU(1,1)$ and the action of the mapping class group.

Levitt, Benjamin, Tate-Shafarevich groups of Jacobians of Fermat curves.

Lo, Assane, Witten Laplacian methods of critical phenomena.

Punosevac, Predrag, Regularization of simultaneous binary collisions in some gravitational systems.

Spiegler, Adam, Stability of generic equilibria of the $2n$-dimensional free rigid body using the energy-Casimir method.

PROGRAM IN APPLIED MATHEMATICS

Garcia-Naranjo, Luis, Almost Poisson brackets for nonholonomic systems on Lie groups.

McNicholas, Erin, Embedded tree structures and eigenvalue statistics of genus zero one-face maps.

ARKANSAS

University of Arkansas at Fayetteville (2)

MATHEMATICS AND SCIENCES

Kali, Zdenka, Two extremal problems in complex function theory.

Lewis, Camille, Homotopy techniques and polynomial roots.

CALIFORNIA

California Institute of Technology (5)

APPLIED AND COMPUTATIONAL MATHEMATICS

Bou-Rabee, Nawaf, Hamiltonian-Pontryagin integrators on Lie groups.

Dondl, Patrick Werner, Structure and evolution of Martensitic phase boundaries.

Latini, Marco, Simulations and analysis of two- and three-dimensional single-mode Richtmyer-Meshkov instability using weighted essentially non-oscillatory and vortex methods.

Zhang, Lei, Metric based upscaling for partial differential equations with a continuum of scales.

MATHEMATICS

Pelayo, Roberto, Diameter bounds on the complex of minimal genus Seifert surfaces for hyperbolic knots.

The above list contains the names and thesis titles of recipients of doctoral degrees in the mathematical sciences (July 1, 2006, to June 30, 2007) reported in the 2007 Annual Survey of the Mathematical Sciences by 197 departments in 143 universities in the United States. Each entry contains the name of the recipient and the thesis title. The number in parentheses following the name of the university is the number of degrees listed for that university. A supplementary list containing names received since compilation of this list will appear in a summer 2008 issue of the *Notices*.

Claremont Graduate University (6)

School of Mathematical Sciences

Cadwallader-Olsker, Todd, Proof schemes and proof writing.

Daneshbod, Yousef, Mathematical models in microfluidics: Capillary electrophoresis and sessile drop physics.

Gasner, Scott, Cellular pattern formation and noise in $O(2)$ symmetric systems.

Lewis, Steven, Bayesian parameter and order estimation in profile hidden Markov models.

Schmitz, Adeline, Constructive neural networks for function approximation and their application to *CFD* shape optimization.

Sunahata, Hiroki, Interaction of the quantum vacuum with an accelerated object and its contribution to inertia reaction force.

University of California, Berkeley (33)

Group in Biostatistics

Bein, Edward, Topics in causal inference: Analyzing psychotherapy outcome studies, convex-combination estimators, and G-computations model selection.

Petersen, Maya, Applications of causal inference methods to improve the treatment of antiretroviral-resistant HIV infection.

Mathematics

Alappatu, Jomy, An analysis of randomized algorithms on trees.

Anderson, Bernard, Relative properties of reals.

Assaf, Sami, Dual equivalence graphs, ribbon tableaux and MacDonald polynomials.

Berbec, Ioan, Group schemes over Artinian rings and applications.

Cameron, Maria, Seismic velocity estimation from time migration.

Carnahan, Scott, Monstrous Lie algebras and generalized moonshine.

Chen, Yanfeng, Categorification of representations of quantum groups and invariants of tangle cobordisms.

Chester, Elizabeth, Fast methods for computing all-to-all geodesic paths for the eikonal equation.

Christianson, Hans, Quantum monodromy and non-concentration near a closed semi-hyperbolic orbit.

Franklin, Johanna, Aspects of Schnorr randomness.

Goodrick, John, When are elementarily bi-embeddable models isomorphic?

Greicius, Aaron, Elliptic curves with surjective global Galois representation.

Hoyt, Crystal, Kac-Moody superalgebras of finite growth.

Huh, Jae-Seok, Implicit interface finite element method for elliptic interface problems.

Inoue, Taiyo, Organizing volumes of right-angled hyperbolic polyhedra.

Kelley, James, Homotopical syzygies in K-theory.

Kirkpatrick, Kay, Rigorous derivation of the Landau equation in the weak coupling limit.

Lyo, Grace, Semilinear actions of Galois groups and the algebraic K-theory of fields.

Marzuola, Jeremy, A stable class of perturbations for minimal mass solitons of saturated NLSE in 3d.

Medvedev, Alice, Group-like minimal sets in ACFA.

Miller, Carl, Cohomology of p-torsion sheaves on characteristic-p curves.

Morrison, Scott, A diagrammatic category for the representation theory of $U_q(\mathfrak{sl}_n)$.

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INDIANA

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Purdue University (27)

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Nicholson, Neil, On knots and their invariants.

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Schroeder, Helen, Notes on the Lawrence-Krammer-Bigelow representation.

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Xie, Huiliang, Regression with smoothly clipped absolute deviation penalty.

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Kansas State University (1)

STATISTICS

Smith, Christina, Estimation of treatment effects under combined sampling and experimental designs.

University of Kansas (2)

MATHEMATICS

Carlson, Nathan, Non-regular homogeneous spaces and gaps in the partial order of Hausdorff topologies.

Mitchell, Lon, Simplicity of C^*-algebras using unique eigenstates.

KENTUCKY

University of Kentucky (3)

MATHEMATICS

Bennewitz, Bjorn, Non-uniqueness in a free boundary problem.

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Czajkowski, Michal, Generalized brokenline logistics regression with application to anomaly detection.

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Louisiana State University, Baton Rouge (10)

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Beavers, Brian, Circuits and structure in matroids and graphs.

Becnel, Jeremy, Extension of Schor's period-finding algorithm to infinite dimensional Hilbert spaces.

Bureau, Jean, Representation properties of definite lattices in function fields.

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Louisiana Technology University (2)

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Popa, Bianca, Membrane systems with limited parallelism.

Wu, Xiaoshuo, Modeling core generation and transport phenomena of microcapsules.

Tulane University (5)

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Morgan, Leslie, An empirical study of the power and accuracy of three tests for specific clustering.

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Duncan, Christopher, Open boundary Dirichlet problems for Laplace's equation in the plane.

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Vernon, Richard, Preimages of planar continua.

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Johns Hopkins University (6)

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Dykstra, Andrew, Two equivalence relations in symbolic dynamics.

Errthum, Eric, Singular moduli of Shimura curves.

Fertig, Elana, Assimilating satellite observations with a local ensemble Kalman filter.

Howard, Tatiana, Lifting of characters p-adic orthogonal and metaplectic groups.

Howell, William, Simulation optimization of traffic light signal timings via perturbation analysis.

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Carey Cinar, Amy, Dose response models for mixed dependent outcomes in developmental toxicity.

DeSantis, Stacia, Supervised and unsupervised latent class models for high-dimensional data.

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Sanchez Loya, Brisa, Structural equation models: Fitting, diagnostics, and applications to environmental epidemiology.

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Adaska, Jason, Control of fluid queues.

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Belabbas, Mohamed, Hamiltonian systems for computation.

Cheng, Chen-Mou, AANET: Aerial ad hoc networking.

Fedorova, Alexandra, Operating system scheduling for chip multithreaded processors.

Feldman, Vitaly, Efficiency and computational limitations of learning algorithms.

Goodell, Geoffrey, Perspective access networks.

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Malagon-Lopez, Jose, Adams operations and lambda operations on classifying oriented cohomology theories.

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Greene, Mairead, On the index of cyclotomic units.

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Worcester Polytechnic Institute (1)

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Onofrei, Daniel, New results in the multiscale analysis on perforated domains and applications.

MICHIGAN

Michigan State University (8)

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Moore, Amy, Diffusion flame stability.

Zhang, Weiwei, Improved mode matching method for scattering from large cavities.

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Guo, Hongwen, Inference on long memory processes.

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Luo, Jun, High dimension and small sample size problems: Classification, gene selection and asymptotics.

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Adeboye, Ilesanmi, Volumes of hyperbolic orbifolds.

Arnold, Trevor, Anticyclotomic Iwasawa theory for modular forms.

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Okamoto, Futaba, Measures of traversability in graphs.

MINNESOTA

University of Minnesota-Twin Cities (13)

Division of Biostatistics, School of Public Health

He, Yi, Bayesian analysis of real time RT-PCR data with right censoring.

Ma, Haijun, Bayesian hierarchical boundary analysis for areal public health data.

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Stefan, Despina, Multi-block relationships in high dimensions.

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Mathematics and Statistics

Jahan, Nusrat, Applying goodness-of-fit techniques to testing time series Gaussianity and linearity.

Sun, Yijun, Global attractivity of higher order nonlinear difference equations.

Wu, Xiaoqin, Temperature effects in semiconductor equations.

MISSOURI

St. Louis University (1)

Mathematics and Computer Science

Granda, Larry, Dehn surgery on singular knots.

University of Missouri-Columbia (7)

Mathematics

Ganichev, Mikhail, Convergence of greedy algorithms in Banach spaces.

Shi, Qiang, Sharp estimates of transmission boundary value problem for Dirac operators in non-smooth domains.

Skripka, Anna, Trace formulae in finite von Neumannn algebras.

Zinchenko, Maxim, Topics in spectral and inverse spectral theory.

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Hooten, Mevin, Hierarchical spatio-temporal models for ecological processes.

Sun, Xiaoqian, Bayesian spatial data analysis with its application to the Missouri Ozark Forest Ecosystem Project.

Wang, Lianming, Statistical analysis of multivariate interval-censored failure time data.

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Mason, Eric H., Image segmentation by energy and related functional minimization methods.

Stamps, David, Markov chain Monte Carlo methods for regression splines with a penalized acceptance ratio.

Washington University (4)

Electricial and System Engineering

Ganesan, Narayan, Control of decoherence in open quantum systems using feedback.

McGregor, Nathan, Semi-global and global output regulation for classes of nonlinear systems.

Wang, Wenxue, Dynamics of the turtle visual cortex and design of sensor networks.

Xu, Min, Function approximation methods for optimal control problems.

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Montana State University-Bozeman (6)

Mathematical Sciences

Hayes, Christina, Generic properties of the infinite population genetic algorithm.

Latulippe, Christine, Environments that encourage mathematics graduate teaching assistants: The effects of institution type and availability of training.

Latulippe, Joe, Nonautonomous bursting model for neurons.

Nelson, Karma, Developing a professional learning community among mathematics teachers on two Montana indian reservations.

Szomolay, Barbara, Analysis and control of a biofilm disinfection model.

Welder, Rachael, Preservice elementary teachers' mathematical content knowledge of prerequisite algebra concepts.

University of Montana-Missoula (2)

Mathematical Sciences

Braver, Seth, Lobachevski illuminated: Content, methods, and context of the theory of parallels.

Gray, Katharine, Comparison of trend detection methods.

NEBRASKA

University of Nebraska-Lincoln (6)

Mathematics

Brown Kramer, Joshua, Two problems in extremal set theory.

Buchholz, Bobbi, Self-adjoint matrix equations on time scales.

Cokeley, Paul, Boundary and localized null controllability and corresponding blow up rates of thermoelastic and structurally damped systems.

Haataja, Steve, Amalgamation of inverse semigroups and operator algebras.

Loeb, Edward, Quantum error-correcting codes: From stabilizer codes to induced codes.

White, Diana, Proper resolutions and their applications.

NEW HAMPSHIRE

University of New Hampshire (6)

MATHEMATICS AND STATISTICS

Ghosh, Shamindra, Planar algebras: A category theoretic point of view.

Gray, David, An investigation of pre-service teachers' and professional mathematicians' perceptions of mathematical proof at the secondary school level.

Mitcheltree, Melissa, Exploring lesson study as a form of professional development for enriching teacher knowledge and classroom practices.

Naidu, Deepak, Morita equivalence for group-theoretical categories.

Titova, Anna, Understanding abstract algebra concepts.

Zarringhalam, Kourosh, Cupolets: Chaotic unstable periodic orbits, theory and application.

NEW JERSEY

New Jersey Institute of Technology (4)

MATHEMATICAL SCIENCES

Banerjee, Sibabrata, Problems related to efficacy measurement and analyses.

Cheng, Yiming, Prediction of mRNA polyadenylation sites in the human genome and mathematical modeling of alternative polyadenylation.

Kintos, Nickolas, Modeling projection neuron and neuromodulatory effects on a rhythmic neuronal network.

Roychoudhury, Satrajit, Selected problems of inference on branching process and Poisson shock model.

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Fan, Edward, Finiteness and compactness on a class of critical metrics in dimension six.

Hogadi, Amit, Topics in birational geometry.

Lv, Jinchi, High dimensional variable selection and covariance matrix estimation.

Maulik, Davesh, Gromov-Witten theory of A_n resolutions.

Milecevic, Djordje, Large values on eigenfunctions on arithmetic hyperbolic manifolds.

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Suh, Junecue, Mixed characteristic studies in arithmetic geometrycirbua.

Treumann, David, Exit paths and constructible stacks.

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Athanassoulis, Agissilaos, Smoothed Wigner transforms and homogenization of wave propagation.

Donev, Aleksandar, Jammed packings of hard particles.

Li, Dong, Mathematical analysis of molecular dynamics and related problems.

Sun, Yi, The heterogeneous multiscale methods for interface tracking.

Yang, Zhijiang, Topics in atomistic and continuum modeling and simulations of solids.

Rutgers, The State University of New Jersey (6)

MATHEMATICS

Calinescu, Corina (Nicoleta), Intertwining vertex operators and representations of affine Lie algebras.

Cuckler, William, Hamiltonian cycles in regular tournaments and Dirac graphs.

Pham, Thuy, Studies on jdeg of algebraic structures.

Vijay, Sujith, Arithmetic progressions: Combinatorial and number-theoretic perspectives.

Weingart, Michael, Spectral functions of invariant operators in skew multiplicity free spaces.

Xu, Haoyuan, Critical exponent elliptic equation: Gluing and the moving sphere method.

NEW MEXICO

University of New Mexico (4)

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Briand, Daniel, Applying Bayesian updating methods to a new combined lifecycle failure distribution.

Kang, Huining, Semiparametric estimation of the odds ratio and ROC curve of a generalized odds-rate model.

Sobol, Andrey, A Vlasov treatment of the 2DF collective beam-beam interaction: Analytical and numerical results.

Yang, Mingan, Applications of mixtures of polya trees to multivariate survival and ordinal data.

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Columbia University (17)

BIOSTATISTICS

Chen, Tai-Tsang, Assessing repeated diagnostic test accuracy with samples subject to selection bias.

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Reiss, Philip, Regression with signals and images as predictors.

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Atici, Alp, Advances in quantum computational learning theory.

Caputo, Maria, Highly degenerate harmonic mean curvature flow.

Egglezos, Nikolaos, Aspects of utility maximization with habit formation: Dynamic programming and stochastic PDEs.

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Yuster, Debbie, Triangulations, tropical geometry, and applications.

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Casey, Fergal, Prediction and optimal experimental design in systems biology models.

Cintron-Arias, Ariel, Modeling and parameter estimation of contact processes.

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Pasour, Virginia, Computational and analytical perspectives on the drift paradox problem in a freshwater embayment.

Tien, Joseph, Optimization for bursting neural models.

Wiley, Daniel, Waves in nonlocally coupled oscillators.

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Armstrong, Drew, Generalized noncrossing partitions and combinatorics of Coxeter groups.

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Martin, Jason, Building infinite ray class towers with specific signatures and small bounded root discriminants.

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Saliola, Franco, The face semigroup algebra of a hyperplane arrangement.

Sinnott, Steve, Algebraic properties of Bayesian networks.

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Graduate Center, City University of New York (10)

PhD Program in Mathematics

Bonanome, Marianna, Quantum algorithms in combinatorial group theory.

Clement, Anthony, On the Baumslag-Solitar groups and certain generalized free products.

Gitman, Victoria, Applications of the proper forcing axiom to models of Peano arithmetic.

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Zahariev, Svetoslav, Approximation of spectra results for twisted Laplace operators.

Rensselaer Polytechnic Institute (7)

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Collis, Jon, New capabilities for parabolic equations in elastic media.

de Oliveira, Guilherme, Numerical studies of the behavior of heterogeneous explosives using the ignition-and-growth model.

Eladdadi, Amina, Mathematical modeling of the effects of Hera overexpression on cell proliferation and cell cycle in breast cancer.

Ferrara, Matthew, Radar signal processing.

Khan, Adnan, Parametrization for some multiscale problems in biology and turbulence.

Reilly-Raska, Laurel, Deterministic and stochastic interval wave effects on shallow water acoustic propagation.

Sapariuc, Ioan, A numerical study of a fractional step scheme for the reactive Euler equation.

State University of New York at Albany (2)

Mathematics and Statistics

Beecher, Amanda, Combinatorial description of a free resolution of a multigraded module.

Lance, Timothy K., Continuous control and Novikov conjectures in exact nonsplit categories.

State University of New York at Binghamton (3)

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Klein, Thomas, Filtered ends of pairs of groups.

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University of Rochester (6)

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Duke University (9)

INSTITUTE OF STATISTICS AND DECISION SCIENCE

House, Leanna, Nonparametric Bayesian models in expression proteomic applications.

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Guo, Nailong, Numerical study on the optimal coupling by evanescent whispering gallery modes between two micro-spheres by using a discontinuous spectral element method.

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Li, Henong, Semiparametric weak instrumental variables model for panel and cross-sectional data.

NORTH DAKOTA

North Dakota State University, Fargo (2)

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Dutta, Tridib, On a generalized notion of integrality and VSFT domains.

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OHIO

Bowling Green State University (10)

Mathematics and Statistics

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Case Western Reserve University (1)

Mathematics

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Ohio State University, Columbus (21)

Mathematics

Dimitrov, Youri, Polynomially divided solutions of bipartite self-differential functional equations.

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Zhao, Yanxing, Parametric inference from window censored renewal process data.

Ohio University, Athens (1)

Mathematics

Al-Ahmadi, Adel, Injectivity conditions on group rings.

University of Cincinnati (3)

Mathematical Sciences

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University of Cincinnati, Medical College (1)

Epidemiology and Biostatistics Division

Ndikintum, Nfii, Statistical considerations for paired repeated measures designs of method comparison studies: Application to pulse oximetry.

University of Toledo (2)

Mathematics

Deng, Xin, Goodness-of-fit tests of the density ration models.

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OKLAHOMA

Oklahoma State University, Stillwater (3)

Mathematics

Miller, David, Evaluating the effectiveness of a learning system for technical calculus.

Statistics

Maharry, Timothy, Proportion differences using the beta-binomial distribution.

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University of Oklahoma (5)

Mathematics

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Hands, Krista, The business calculus GMTA: An exploration of how to teach a course one has never taught.

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OREGON

Oregon State University (2)

Statistics

Alnosaier, Waseem, Kenward-Roger approximate F test for fixed effects in mixed linear models.

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Portland State University (2)

Mathematics and Statistics

Anderson, Rick, Mathematics meaning and identity: A study of the practice of mathematics education in a rural high school.

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University of Oregon (7)

MATHEMATICS

Allen, Paul, Timelike minimal submanifolds in Robertson-Walker spacetimes.

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Dolan, Peter, A $Z2$-graded generalization of Kostant's version of the Bott-Borel-Weil theorem.

Hill, David, The Jantzen-Shapovalov form and Cartan invariants of symmetric groups and Hecke algebras.

Hoover, Skip, Dimension functions of rationally dilated wavelets.

Miller, Matthew, Configuration spaces of lens spaces.

Rodriguez-Ordonez, Hugo, Topological study of nonsingular bilinear maps.

PENNSYLVANIA

Carnegie Mellon University (2)

MATHEMATICAL SCIENCE

Cudina, Milica, Asymptotic control for some time-varying stochastic networks.

Natarajan, Venkatesh, Independent sets in powers of odd cycles and the global min-cut problem.

Lehigh University (2)

MATHEMATICS

Bendjilali, Nasrine, New approaches to multiple comparisons.

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Pennsylvania State University, University Park (13)

MATHEMATICS

Gorb, Yuliya, Asymptotic analysis of effective properties of highly concentrated composites.

Meemark, Yotsanan, Operators based on double cosets of GL_2.

Mummert, Anna, Thermodynamic formalism for nonuniformly hyperbolic dynamical systems.

Ryham, Rolf, An energetic variational approach to mathematical modeling of charged fluids: Charge phases, simulation and well posedness.

Tsao, Shih-Chang, On explicit constructions and improved bounds of algebraic geometry codes.

Yuncken, Robert, Analytic structures for the index theory of $SL(3,\mathbb{C})$.

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Kang, Doh Yung, Casual inference by semiparametric imputation.

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Xu, Hong, Contributions to adaptive web sampling designs.

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University of Pennsylvania (7)

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Corry, Scott, Arithmetic and geometry of the open p-adic disc.

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Hoelscher, Jing Long, Galois extensions ramified at one prime.

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Xu, Juntian, A closed form for the harmonic-prior Bayes estimator with associated confidence sets for the means of a multivariate normal distribution.

University of Pittsburgh (13)

MATHEMATICS

Diwadkar, Jyotsna, Nilpotent conjugacy classes of reductive p-adic Lie algebras and definibility in Pas's language.

Duran, Ahmet, Overreaction behavior and optimization techniques in mathematical finance.

Gurel Kazanci, Fatma, Pattern formation in coupled networks with inhibition and gap junctions.

Hart, Gary D., A constraint-stabilized time-stepping approach for piecewise smooth multi-body dynamics.

Manica, Carolina, Numerical methods in turbulence.

Mihai, Daniela, Mathematical aspects of twistor theory.

Pencheva, Gergina, Multiblock modeling of flow in porous media and applications.

Rebholz, Leo, Helicity and physical fidelity in turbulence modeling.

Tadesse, Arebaw, Compact composition operators on the Hardy and Bergman spaces.

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Gamalo, Mark, Bounded influence approaches to constrained mixed vector autoregressive models.

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Ziegler, Melissa, Variable selection when confronted with missing data.

RHODE ISLAND

Brown University (11)

APPLIED MATHEMATICS

Cheng, Yingda, Discontinuous Galerkin methods for Hamiltonian-Jacobi equations and equations with higher order derivative.

Lian, Heng, Some topics on statistical theory and applications.

Lin, Guang, Parallel high-order methods for deterministic and stochastic CFD and MHD problems.

Oman, Peter, Enriched homotopy and calculus.

Qiu, Jingmei, High order schemes: Convergence for hyperbolic conservation laws and applications in computational cosmology.

Wan, Xiaoliang, Adaptive multi-element generalized polynomial chaos: Algorithms and applications.

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Chen, Ming, Analysis of some nonlinear dispersive waves in a compressible hyperelastic plate.

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Manes, Michelle, Arithmetic dynamics of rational maps.

University of Rhode Island (3)

MATHEMATICS

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Tiner, Gary, On the Erdős–Sós Conjecture.

SOUTH CAROLINA

Medical University of South Carolina (4)

Biostatistics, Bioinformatics, and Epidemiology

Abell, Jill, Racial disparities in cardiovascular mortality risk associated with body mass index in men and women: A subject level meta analysis.

Adelman, Aaron S., Population mixing and risk of childhood acute lymphoblastic leukemia.

Lin, Yan, Analyzing 2×2 tables with small sample sizes and possibly missing data.

McNeil, Rebecca, Development and application of the multivariate Mantel-Haenszel mean scores test.

University of South Carolina (9)

Mathematics

Beanland, Kevin, A hereditarily indecomposable Banach space and embedding of l-infinity into the space of operators.

Finch, Carrie, Topics from the irreducibility of polynomials and coverings of the integers.

Li, Shuang, Numerical methods and analyses for the fluid flow in the fractured porous media.

Liu, Xiteng, Space signal representation in redundant systems.

Wang, Kening, Domain decomposition methods for fourth order problems.

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Buckley, Brooke, Benchmark analysis under Abbott-adjusted quantal response models.

Jaki, Thomas, Maximum kernel likelihood estimation.

Wu, Yuping, Statistical methods for the analysis of mass spectrometry data.

Yates, Philip, Methods for the analysis of flood frequency data.

TENNESSEE

University of Memphis (3)

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Gal, Ciprian, Wentzell boundary conditions in the context of wave equations, Sturm-Liouville operators and Cahn-Hilliard models.

Fu, Dongyue, A comparative study of general linear mixed model and permutation tests in group-randomized trials under non-normal error distributions.

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University of Tennessee, Knoxville (4)

Mathematics

Asano, Erika, Three population models applied to competition, disease and invasion.

Ding, Wandi, Two biological applications of optimal control to hybrid differential equations and elliptic PDEs.

Mitra, Atish, Cohomological dimension with respect to nonabelian groups.

Saum, Michael, Adaptive discontinuous Galerkin finite element methods for second and fourth order elliptic partial differential equations.

Vanderbilt University (3)

Mathematics

Futamura, Fumiko, Symmetrical localized frames, localized operators and their application to the construction of localized Hilbert and Banach frames.

Leonetti, Casey, Reconstruction from error-affected data in shift-invariant spaces.

Shan, Lin, Equivariant index theory and non-positively curved manifolds.

TEXAS

Baylor University (6)

Statistical Sciences

Carlin, Patricia, Bayesian inference for correlated binary data with an application to diabetes complication progression.

Cheng, Dunlei, Topics in Bayesian sample size determination and Bayesian model selection.

McGlothlin, Anna, Logistic regression with misclassified response and covariate measurement error: A Bayesian approach.

Moore, Page, A restriction method for the analysis of discrete longitudinal missing data.

Ounpraseuth, Songthip, Selected topics in statistical discriminant analysis.

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Computational and Applied Mathematics

Guevara Vasquez, Fernando, On the parametrization of ill-posed inverse problems arising from elliptic partial differential equations.

Sabino, John, Solution of large-scale Lyapunov equations via the block modified Smith method.

Shah, Mili, A symmetry preserving singular value decomposition.

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Chuang, Jer-Chin, Transgressive chains, harmonic cycles, and subdivisions.

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Knecht, Amanda, Weak approximation for degree two delPezzo surfaces.

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Bhatti, Chad, Statistical models for intraday trading dynamics.

Paszek, Pawel, Modeling stochasticity in gene regulation.

Rossell, David, Some approaches to Bayesian design of experiments and microarray data analysis.

Yamal, Jose-Miguel, Multilevel classification: Classification of populations from measurements on members.

Southern Methodist University (3)

Mathematics

Markos, Mulugeta, Steady liquid flow and liquid-vapor interface shapes in different groove structures in micro heat pipes.

Rangelova, Marina, Error estimation for fourth order partial differential equations.

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Texas A&M University (16)

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Ambartsoumian, Gaik, Spherical radon transform and mathematical problems of thermoacoustic tomography.

Decker, Marvin, Loop spaces in motivic homotopy theory.

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Ong, Beng, Spectral problems of optical waveguides and quantum graphs theory.

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Wiggins, Alan, Singular subfactors of II_1 factors.

Zhang, Zhigang, Modeling, analysis and control of quantum electronic devices.

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Cheon, Sooyoung, Protein folding and phylogenetic tree reconstruction using stochastic approximation Monte Carlo.

Li, Bo, An analysis of Texas rainfall data and asymptotic properties of space-time covariance estimators.

Li, Yehua, Topics in functional data analysis with biological applications.

Lobach, Iryna, Case-control studies of genetic and environmental factors with error in measurement of environmental factors.

Wang, Xiaohui, Bayesian classification and survival analysis with curve predictors.

Zhang, Weimin, Topics in living cell MPLSM image analysis.

University of Houston (8)

MATHEMATICS

Abdulbala, Soha, Generalized sigma-delta quantization.

Flagg, Mary, The role of the Jacobson radical of the endomorphism ring in the Baer-Kaplansky theorem.

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University of North Texas (2)

MATHEMATICS

Edson, Marcia, Around the Fibonacci numeration system.

Yingst, Andrew, A characterization of homeomorphic Bernoulli trial measures.

University of Texas at Arlington (1)

MATHEMATICS

Cai, Jiangang, LES for wingtip vortex around an airfoil.

University of Texas at Austin (17)

INSTITUTE FOR COMPUTER ENGINEERING AND SCIENCE

Baird, John, Numerical analysis of the representer method applied to reservoir modeling.

Bazilevs, Jurijs, Isogeometric analysis of turbulence and fluid-structure interaction.

Heath, Ross, Numerical analysis of the discontinuous Galerkin method applied to plasma physics.

Kurtz, Jason, Fully automatic hp-adaptivity for acoustic and electromagnetic scattering in three dimensions.

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DeBlois, Jason, Totally geodesic surfaces in hyperbolic 3-manifolds.

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Fokam, Jean Marcel, Forced vibrations via Nash-Moser iterations.

Gagliardo, Michael, The higher flows of harmonic maps.

Haynes, Alan, Tools and techniques in Diophantine approximation.

Kent, Richard Peabody, IV, Geometry and algebra of hyperbolic 3-manifolds.

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Pekker, Alexander, Diophantine approximation in projective space and the absolute Siegel's lemma.

Rand, Betseygail, Pattern-equivariant cohomology of tiling spaces with rotations.

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Scholl, Matthew, Local elliptic boundary value problems for the Dirac operator.

Zarzar, Marcos, Error-correcting codes on low Néron-Severi rank surfaces.

University of Texas at Dallas (6)

MATHEMATICAL SCIENCES

El-Sissi, Nermine, Positive definite kernels and lattice paths.

Kshattry, Indra B., Modeling arsenic in the wells of Nepal.

Suzuki, Sumihiro, Constructive methodologies of optimal sequential plans.

Xia, Jingsi, Optimal sequentially planned change-point detection procedures.

Xiao, Peng, Contributions to multivariate L-moments: L-comoment matrices.

Zhou, Hong, Parametrizations of unitary and positive matrices in quantum information and control.

UTAH

Brigham Young University (1)

MATHEMATICS

Xie, Zhifu, The N-body problem.

University of Utah (6)

MATHEMATICS

Despotovic, Zrinka, Action dimension of mapping class groups.

Kovacevic, Domagoj, Exceptional dual pair correspondences.

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Oster, Andrew, Mathematical models of cortical development.

Zobitz, John, Mathematical approaches to partition net ecosystem exchange of CO_2 in a high elevation subalpine forest.

VIRGINIA

Old Dominion University (4)

MATHEMATICS AND STATISTICS

Deng, Yihao, Efficient unbiased estimating equations for analyzing structured correlation matrices.

Jones, Andrea, The computation of exact Green's functions in acoustic analogy by a spectral collocation boundary element method.

Slaba, Tony, Three methods for solving the low energy neutron transport equation.

Srivastava, Jayesh, Canonical correlaton analysis and correspondence analysis of longitudinal data.

University of Virginia (5)

MATHEMATICS

Hafizoglu, Cavit, Linear quadratic regulatory boundary/point control of stochastic PDE systems with unbounded coefficients.

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Taylor, David, The Bloch-Okounkov function and dimension formulas for modules of infinite-dimensional Lie algebras.

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Tuffaha, Amjad, Well-posedness, solvability, and optimal control of coupled PDEs with an interface.

Virginia Polytechnic Institute and State University (15)

MATHEMATICS

Chalmeta, Alberto, On the units and structure of the 3-Sylow subgroups of the ideal class groups of pure bicubic fields and their normal closures.

Dimitrova, Elena, Polynomial models for systems biology: Data discretization and term order effect of dynamics.

Fulton, Brian, Analysis and approximation of viscoelastic and thermoelastic joint-beam systems.

Fulton, Melanie, The quantum automorphism group and undirected trees.

Grinshpon, Mark, Universal localization and group cohomology.

Kachroo, Pushkin, Control of hyperbolic partial differential equations: Application to traffic.

Rivera-Marrero, Olgamary, The place of discrete mathematics in the school curriculum: An analysis of preservice teachers' perceptions of the integration of discrete mathematics into secondary level courses.

Vance, James, Permanent coexistence for omnivory models.

STATISTICS

Farrar, David, Some model based and nonparametric clustering methods for characterization of regional ecological stressor response patterns and regional environmental quality trends.

Joner, Michael, Univariate and multivariate surveillance methods for detecting increases in incidence rates.

Liu, Bing, Casual gene network interference from genetical genomics experiments via structural equation modeling.

Pickle, Stephanie, Semiparametric techniques for response surface methodology.

Wang, Li, Recommendations for design parameters for central composite designs with restricted randomization.

Zhang, Huizi, Classification analysis of environmental monitoring: Combining information across multiple studies.

Zhang, Ying, Efficient sampling plans for control charts when monitoring an autocorrelated process.

WASHINGTON

University of Washington (23)

APPLIED MATHEMATICS

George, David, Finite volume methods and adaptive refinement for tsunami propagation and inundation.

Jeon, Jihyoun, Mathematical modeling of pre-malignant lesions in multistage carcinogenesis.

Srivastava, Santosh, Bayesian minimum expected risk estimation of distributions for statistical learning.

Toth, Damon, Analysis of age-structured chemostat models.

BIOSTATISTICS

Li, Min, Bayesian discovery of regulatory motifs using reversible jump Markov chain Monte Carlo.

MATHEMATICS

Baek, Yeongcheon, An interior point approach to the constrained nonparametric mixture models.

Blazek, Kirk, The one-dimensional inverse problem of reflection seismology on a viscoelastic medium.

Bogart, Tristram, Problems in computational algebra and integer programming.

Doherty, Davis, On singularities of generic projections.

Jabbusch, Kelly, Notions of positivity of vector bundles.

Jin, Hai, The inverse problem of fiber Bragg gratings.

Jones, Brant, Some combinatorics on Hecke algebras of reflection groups.

Kahle, Matthew, Topology of random simplicial complexes.

Lockridge, Keir, The generating hypothesis in general stable homotopy categories.

Schwede, Karl, On F-injective and DuBois singularities.

Shmerkin, Pablo, The structure of overlapping self-affine sets.

Treisman, Zachary, Arc spaces and rational curves.

Tzou, Leo, Partial differential equations.

Zaveri, Sona, The second eigenfunction of the Neumann Laplacian on thin regions.

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Glynn, Adam, Alleviating ecological bias in generalized linear models and optimal design with subsample data.

Nugent, Rebecca, Algorithms for estimating the cluster tree of a density.

Shortreed, Susan, Learning in spectral clustering.

Westveld, Anton, Statistical methodology for longitudinal social network data.

Washington State University (4)

MATHEMATICS

David, Roden Jason A., Algorithms for the unitary eigenvalue problem.

Griffin, Kent, Solving the principal minor assignment problem and related computations.

Zhou, Haujun, Multivariate compound point processes with drifts.

Zhu, Yuntao, Stochastic semidefinite programming.

WEST VIRGINIA

West Virginia University (1)

MATHEMATICS

Aslam, Muhammad, Some new models for image compression.

WISCONSIN

Medical College of Wisconsin (1)

BIOSTATISTICS

Liu, Jingxia, Utilizing propensity scores to test treatment effects in survival data.

University of Wisconsin, Madison (44)

MATHEMATICS

Alfeld, Christopher, To branch or not to branch: Branching and non-branching in the Medvedev lattice of "Π^0_1" classes.

Anderson, Jaclyn Ann, Two problems in the theory of t-core partitions.

Bowman, John, Finite-dimensional modules for the quantum affine algebra $Uq(y)$ and its Borel subalgebra.

Chakrabarti, Debraj, Approximation of maps with values in a complex or almost complex manifold.

Funk-Neubauer, Darren, Tridiagonal pairs and their use in representation theory.

Garthwaite, Sharon, On questions of congruence and size for modular forms and Maass-Poincaré series.

Getz, Jayce, Intersection homology of Hilbert modular varieties and quadratic base change.

Griffeth, Stephen, Rational Cherednik algebras and bases for coinvariant rings.

Hartwig, Brian, Tetrahedron algebra and tridiagonal pairs.

He, Weiyong, On the Calabi flow.

Hur, Youngmi, Novel methodologies for effective wavelet constructions in high dimensions.

Kach, Asher, Characterizing the computable structures Boolean algebras and linear orders.

Kane, Benjamin, Computationally feasible bounds for representations of integers by ternary quadratic forms and CM lifts of supersingular elliptic curves.

Kim, Ahyoung, Locating absolutely continuous spectra of Jacobi operators.

Liao, Xiaomei, Computational high frequency waves in heterogeneous media.

Mahlburg, Karl, Congruence properties of modular forms and applications to number theory.

Nguyen, Xuan Hien, Construction of embedded complete self-similar surfaces Part 1.

Novak, Kyle, A semiclassical transport model for thin quantum barriers.

Oberlin, Richard, The (d, k) Kakeya problem and estimates for the X-ray transform.

Petrosyan, Nansen, Jumps in cohomology of groups periodicity and semidirect product.

Spaeth, Peter, Floer homology and engulfable Hamiltonian diffeomorphisms.

Sutton, Taliesin, Automorphic forms on quaternion algebras and central critical values of *L*-functions.

Vasquez, Elisa, Geometric partitions of definite sets and an application of the Cauchy-Crofton formula.

Weber, Brian, Moduli spaces of extremal Kohler manifolds.

STATISTICS

Carew, John, Statistical methods for magnetic resonance images.

Chen, Meng, Statistical methods for expression quantitative trait loci (eQTL) mapping.

Cheng, Guang, Higher order semiparametric frequentist inference and the profile sampler.

Cheng, Yu, Association analysis of multivariate competing risks data.

Fang, Fang, Empirical likelihood approach for stratified samples with nonresponse.

Fu, Haoda, Sparsity and smoothness for disease rate mapping via Bayesian Lasso.

Hu, Bo, Explained variation for logistic regression and linear mixed-effect model.

Jeon, Yongho, New methods for nonparametric graphical model building and state price density estimation.

Kwak, Minjung, Testing for independence of a survival time from a covariate.

Li, Jialiang, Estimation techniques for multi-dimensional effective dose under parametric and semiparametric models.

Li, Xiaolei, Bayesian analysis of cross-classified spatial data with auto-correlation.

Lu, Fan, Regularized nonparametric logistic regression and kernel regularization.

Mukherjee, Rajat, On accelerated failure time models for forward and backward recurrence times.

Mun, Jungwon, Diagnostics for repeated measurements using residual sum of squares.

Qi, Xin, The central limit theorems for space-time point processes.

Sarkar, Deepayan, On the analysis of optical mapping data.

Song, Rui, Inference for change-point transformation models.

Wei, Xiaodan, A test for non-inferiority with a mixed multiplicative additive null hypothesis.

Wu, Zhengxiao, A filtering approach to abnormal cluster identification.

Xu, Lei, Grouping methods for informative missing data in longitudinal studies.

AMERICAN MATHEMATICAL SOCIETY

AMS Award for Mathematics Programs *That Make a Difference*





Deadline: February 1, 2008

This award was established in 2005 in response to a recommendation from the AMS's Committee on the Profession that the AMS compile and publish a series of profiles of programs that:

1. aim to bring more persons from underrepresented minority backgrounds into some portion of the pipeline beginning at the undergraduate level and leading to advanced degrees in mathematics and professional success, or retain them once in the pipeline;

2. have achieved documentable success in doing so; and

3. are replicable models.

Two programs are highlighted annually.

Nomination process: Letters of nomination may be submitted by one or more individuals. Nomination of the writer's own institution is permitted. The letter should describe the specific program(s) for which the department is being nominated as well as the achievements that make the program(s) an outstanding success, and may include any ancillary documents which support the success of the program(s). The letter should not exceed two pages, with supporting documentation not to exceed an additional three pages.

Send nominations to:
AMS Secretary
312D Ayres Hall
Department of Mathematics
University of Tennessee
Knoxville TN 37996-1330

Previous Winners:
Second Award, 2007: Enhancing Diversity in Graduate Education (EDGE), Bryn Mawr College and Spelman College; and Mathematical Theoretical Biology Institute (MTBI), Arizona State University.

First Award, 2006: Summer Institute in Mathematics for Undergraduates (SIMU), Universidad de Puerto Rico, Humacao; and Graduate Program, Department of Mathematics, University of Iowa.

AMS
AMERICAN MATHEMATICAL SOCIETY
www.ams.org

2007 Election Results

In the elections of 2007 the Society elected a president elect, a vice president, a trustee, five members at large of the Council, three members of the Nominating Committee, and two members of the Editorial Boards Committee.

President Elect

Elected as the new president elect is **George E. Andrews** from Pennsylvania State University. Term is one year as president elect (1 February 2008—31 January 2009), two years as president (1 February 2009—31 January 2011), and one year as immediate past president (1 February 2011—31 January 2012).

Vice President

Elected as the new vice president is **Bernd Sturmfels** from the University of California, Berkeley. Term is three years (1 February 2008—31 January 2011).

Trustee

Elected as trustee is **Karen Vogtmann** from Cornell University. Term is five years (1 February 2008—31 January 2013).

Members at Large of the Council

Elected as new members at large of the Council are

Rebecca F. Goldin from George Mason University
Bryna Kra from Northwestern University
Irena Peeva from Cornell University
Joseph H. Silverman from Brown University
Sarah J. Witherspoon from Texas A&M University

Terms are three years (1 February 2008—31 January 2011).

Nominating Committee

Elected as new members of the Nominating Committee are

Percy Deift from the Courant Institute, New York University
Louise Arakelian Raphael from Howard University
Richard A. Wentworth from Johns Hopkins University

Terms are three years (1 February 2008—31 January 2011).

Editorial Boards Committee

Elected as new members of the Editorial Boards Committee are

Alan W. Reid from the University of Texas
Catherine Sulem from the University of Toronto

Terms are three years (1 February 2008—31 January 2011).

2008 AMS Election

Nominations by Petition

Vice President or Member at Large

One position of vice president and member of the Council *ex officio* for a term of three years is to be filled in the election of 2008. The Council intends to nominate at least two candidates, among whom may be candidates nominated by petition as described in the rules and procedures.

Five positions of member at large of the Council for a term of three years are to be filled in the same election. The Council intends to nominate at least ten candidates, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

Petitions are presented to the Council, which, according to Section 2 of Article VII of the bylaws, makes the nominations. The Council of 23 January 1979 stated the intent of the Council of nominating all persons on whose behalf there were valid petitions.

Prior to presentation to the Council, petitions in support of a candidate for the position of vice president or of member at large of the Council must have at least fifty valid signatures and must conform to several rules and operational considerations, which are described below.

Editorial Boards Committee

Two places on the Editorial Boards Committee will be filled by election. There will be four continuing members of the Editorial Boards Committee.

The President will name at least four candidates for these two places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Nominating Committee

Three places on the Nominating Committee will be filled by election. There will be six continuing members of the Nominating Committee.

The President will name at least six candidates for these three places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Rules and Procedures

Use separate copies of the form for each candidate for vice president, member at large, or member of the Nominating and Editorial Boards Committees.

1. To be considered, petitions must be addressed to Robert J. Daverman, Secretary, American Mathematical Society, 312 D Ayres Hall, University of Tennessee, Knoxville, TN 37996-1330 USA, and must arrive by 25 February 2008.
2. The name of the candidate must be given as it appears in the *Combined Membership List* (`www.ams.org/cml`). If the name does not appear in the list, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the *Notices*. If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate's mailing label or by the candidate contacting the AMS headquarters in Providence (amsmem@ams.org).
3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.
4. On the next page is a sample form for petitions. Petitioners may make and use photocopies or reasonable facsimiles.
5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.
6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the *Combined Membership List* and the mailing lists. No attempt will be made to match variants of names with the form of name in the *CML*. A name neither in the *CML* nor on the mailing lists is not that of a member. (Example: The name Robert J. Daverman is that of a member. The name R. Daverman appears not to be.)
7. When a petition meeting these various requirements appears, the secretary will ask the candidate to indicate willingness to be included on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving consent.

Nomination Petition
for 2008 Election

The undersigned members of the American Mathematical Society propose the name of

____

as a candidate for the position of (check one):

- ☐ **Vice President**
- ☐ **Member at Large of the Council**
- ☐ **Member of the Nominating Committee**
- ☐ **Member of the Editorial Boards Committee**

of the American Mathematical Society for a term beginning 1 February, 2009

Return petitions by 26 February 2008 to:
Secretary, AMS, 312 D Ayres Hall, University of Tennessee, Knoxville, TN 37996-1330 USA

Name and address (printed or typed)	
	Signature
	Signature
	Signature
	Signature
	Signature
	Signature

Mathematics Calendar

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

February 2008

* 1–12 **VIII Edition of the Russian Winter Diffiety School**, Kostroma, Russia.
Description: The aim of the school is to introduce undergraduate and graduate students in Mathematics and Physics to a recently emerged area of mathematics and theoretical physics: Secondary Calculus. Secondary calculus is the result of a natural evolution of the classical geometrical theory of partial differential equations (PDE) originated by Sophus Lie. In particular, it allows the construction of a general theory of PDE, in the same manner as algebraic geometry does with respect to algebraic equations. There are strong indications that secondary calculus may become a natural language for quantum field theory, just in the same way as standard calculus is for classical physics. From the mathematical point of view, secondary calculus is a complex mathematical construction putting into a natural interrelation many parts of modern mathematics such as commutative and homological algebra, algebraic and differential topology, differential geometry, etc.
Information: http://school.diffiety.org/index.html.

* 11–16 **Conference on Commutative, Combinatorial and Computational Algebra in Honour of Pilar Pisón-Casares**, Facultad de Matemáticas, Universidad de Sevilla, Sevilla, Spain.
Programme Committee: A. Dickenstein, D. Eisenbud, G.-M. Greuel, L. Narváez Macarro, B. Sturmfels, E. Briales, A. Campillo, F. J. Castro, J. González-Meneses, I. Ojeda, R. Piedra, J. L. Vicente, A. Vigneron.
Poster Sessions: Registered participants will have the opportunity to present their mathematical work in the form of a poster. A poster presentation at the Congress will be considered, provided that participants: (a) Have registered by December 10, 2007. (b) Have submitted (to emilio@us.es) an abstract by that date. (c) Their contribution has been accepted by the Scientific Committee.
Information: Contact: Departamento de Algebra, Facultad de Matemáticas. Universidad de Sevilla, Aptdo. de Correos 1160, E-41080-Sevilla, Spain; email: secalg@algebra.us.es; phone: + 34 954 556946; fax: + 34 954 556938; http://www.departamento.us.es/da/actividades/ciaccc.htm.

* 16–18 **University of California Lie Theory Workshop in honour of Georgia Benkart**, University of California, San Diego, California.
Speakers: Susan Montgomery, Edward Frenkel, Vera Serganova, Joseph Wolf, Arun Ram, Vyacheslav Futorny, Helmut Strade, Alberto Elduque, Seok-Jin Kang, Bertram Kostant, Yuri Bahturin, Tom Halverson, Dan Britten, Kailash Misra, Sara Witherspoon.
Organizers: Geoff Mason, Susan Montgomery, Joseph Wolf, Milen Yakimov, Lance Small, Nolan Wallach, Hans Wenzl, Efim Zelmanov.
Information: http://www.math.ucsd.edu/~jfarina/gbconf.

* 22–23 **Workshop in Celebration of Mark Green's 60th Birthday: Hodge Theory and Algebraic Geometry**, UCLA, Los Angeles, California.
Description: This workshop will focus on recent work by a number of distinguished researchers in Hodge theory and algebraic geometry. It is also an opportunity to recognize Mark Green's contributions to mathematics. (Dinner Honoring Mark Green: Friday, February 22: IPAM and the UCLA department of mathematics will host a dinner

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/.

for those who wish to join the organizers to celebrate Dr. Green's contributions to the field, to UCLA, and to IPAM).

Organizers: David Gieseker, David Eisenbud, Phillip Griffiths, and Stan Osher.

Information: Limited financial support may be available for graduate students and postdocs to attend the workshop. Applications received by January 10, 2008, will receive fullest consideration. If you don't intend to apply for funding, you may simply register. The application/registration form is available online at `http://www.ipam.ucla.edu/programs/ht2008/`. Please check the webpage for more information.

March 2008

* 11–14 **Optimal Transport Tutorials**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

Description: Tutorials provide an introduction to the relevant problems and concepts from mathematics, physics, biology, engineering, economics, and other disciplines, and their applications. The goal is to familiarize participants with the issues and techniques involved in Optimal Transport and to create a common language among researchers coming from different fields.

Organizing Committee: Andrea Bertozzi, Yann Brenier, Wilfrid Gangbo, Peter Markowich, Jean-Michel Morel.

Application/Registration: An application/registration form is available at `http://www.ipam.ucla.edu/programs/ottut/`. The application part is for people requesting financial support to attend the workshop. If you don't intend to do this, you may simply register. Applications received by January 28, 2008, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.

Information: `http://www.ipam.ucla.edu/programs/ottut/`.

April 2008

* 3–4 **Logic and the Simulation of Interaction and Reasoning (Symposium at the AISB 2008 Convention "Communication, Interaction and Social Intelligence")**, Aberdeen, Scotland.

Description: In the past years, logicians have become more and more interested in the phenomenon of interaction. The area "logic and games" deals with the transition from the static logical paradigm of formal proof and derivation to the dynamic world of intelligent interaction and its logical models. While these interactive aspects are relatively new to logicians, on a rather different level, modelling intelligent interaction has been an aspect of the practical work of computer game designers, researchers in artificial intelligence, robotics, and human-machine interaction for a long time. Our symposium will explore the possibilities of joining the theoretical approach to interaction and communication with the practical approach to simulating behaviour.

Deadline: For Submission of Papers: January 9, 2008.

Information: `http://www.illc.uva.nl/GLoRiClass/index.php?page=8_1`.

* 7–8 **DIMACS Workshop on Climate and Disease**, DIMACS Center, CoRE Building, Rutgers University, Piscataway, New Jersey.

Short Description: Climate and infectious diseases: a dynamical perspective. The latest IPCC report has strongly confirmed that the climate is changing. The present and future impact of climate change on infectious disease dynamics remains an important, but still controversial subject. Malaria is a major example of a public health burden around the tropics with the potential to significantly worsen in response to climate change; temperature as a limiting factor for the pathogen, and temperature and rainfall play a crucial role in determining the population dynamics of its mosquito vector. Similar concerns apply to other vector-borne and water-borne diseases, particularly given the existing evidence for the role played by climate at seasonal and inter-annual time scales (e.g. ENSO). This workshop will explore the boundaries of current knowledge and in particular will examine what role theory and mathematical (epidemiological) models can play in advancing the understanding and prediction of the coupling between two highly nonlinear phenomena: climate and infectious disease dynamics.

Organizers: Benjamin A. Cash, Center for Ocean-Land-Atmosphere Studies, `bcash@cola.iges.org`; Andrew Dobson, Princeton University, `dobber@princeton.edu`; Jim Kinter, Center for Ocean-Land-Atmosphere Studies, `kinter@cola.iges.org`; Mercedes Pascual, University of Michigan, `pascual@umich.edu`.

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

* 20–25 **The International Conference on Group and Related Topics**, Xuzhou Normal University, Xuzhou, P. R. China.

Scientific Committee: Chair: Z. X. Wan (Beijing). Members: V. A. Artamonov (Moscow), V. V. Bludov (Irkutsk), Yu. L. Ershov (Novosibirsk), K. Feng (Beijing), M. Ferrero (Brazil), Iain Gordon (Edinburgh), M. Jambu (France), L. Kazarin (Yaroslavl), Goansu Kim (Korea), A. S. Kondratiev (Ekaterinburg), M. Levchuk (Krasnoyarsk), A. A. Makhnev (Ekaterinburg), V. D. Mazurov (Novosibirsk), R. Meninicken (Germany), A. Yu. Olshanskii (USA and Moscow), J. L. G. Pardo (Santiago), L. Small (USA), L. A. Shemetkov (Gomel), N. T. Vorobèv (Vitebsk), J. Zhang (Beijing).

Organizing Committee: Chair: Fang-Ming Xu (President of Xuzhou Normal University). Vice-Chair: Wenbin Guo (Xuzhou), K. P. Shum (Hong Kong). Members: L. Bokut (Guangzhou), Y. Q. Guo (Chongqing), V. V. Kabanov (Russia), Ki-Bong Nam (USA), Shangzhi Li (Beijing), Z. K. Miao (Xuzhou), S. M. Shi (Beijing), W. J. Shi (Suzhou), A. N. Skiba (Gomel), Yanming Wang (Guangzhou), Mingyao Xu (Beijing).

Information: `http://www.grouptheory.cn`.

May 2008

* 11–12 **Clay Research Conference 2008**, MIT, Cambridge, Massachusetts.

Description: The program features eight lectures on recent research developments and the presentation of the Clay Research Awards.

Confirmed speakers: Helmut Hofer, Assaf Naor, Rahul Pandharipande, and Scott Sheffield.

Information: The full program will be announced at a later date on the CMI website: `http://www.claymath.org`. In addition, please see CMI's website for details of last year's program.

* 16–18 **PhiMSAMP-3: "Is Mathematics Special"**, Universität Wien, Vienna, Austria.

Description: This conference is an encounter of researchers from different fields interested in the question What makes mathematics special (if anything). Even if mathematics presents itself or is presented as a (quasi-)empirical matter, the status of an epistemic exception that mathematics forms among the sciences asks for explanations. Papers are welcome from scholars of all disciplines, especially philosophy, mathematics, sociology, didactics, logic, epistemology, and the historical sciences. The conference language is English.

Information: For questions concerning local organization please contact: Stefan Götz (`stefan.goetz@univie.ac.at`), Esther Ramharter (`esther.ramharter@univie.ac.at`).

Information: `http://phaidon.philo.at/~phimsamp-3/`.

* 26–30 **Congrès à la mémoire d'Adrien Douady**, Institute of Henri Poincaré, Paris, France.

Description: This conference is dedicated to those fields most strongly marked by Adrien's work: complex analytic geometry and holomorphic dynamics. Many of the talks will focus on Adrien's influence on these subjects as well as some of the more recent results.

Information: `http://www.picard.ups-tlse.fr/adrien2008/`.

June 2008

* 3–6 **Chaotic Modeling and Simulation International Conference (CHAOS2008)**, MAICh (Mediterranean Agronomic Institute of Chania) Conference Centre, Chania, Crete, Greece.

Description: The forthcoming International Conference (Chaos2008) will focus on Chaotic Modeling, Simulation and Applications (http://www.asmda.net/chaos2008). The study of nonlinear systems and dynamics has emerged internationally as a major area of interdisciplinary research over the last two decades. This conference is intended to provide a widely selected forum among scientists and engineers to exchange ideas, methods, and techniques in the field of nonlinear dynamics, chaos, fractals and their applications in general science and in engineering sciences. Chaos2008 Conference provides a forum for bringing the various groups working in the area of nonlinear systems and dynamics, chaotic theory and application on a single platform for exchanging views and reporting research findings.

Information: http://www.asmda.net/chaos2008.

* 8–14 **34th International Conference "Applications of Mathematics in Engineering and Economics" (AMEE'08)**, The Black Sea resort of Sozopol, Bulgaria.

Description: The main goal of AMEE'08 is to bring together experts and young talented scientists from Bulgaria and world-wide to discuss the modern trends and to ensure exchange of views in various applications of mathematics and mathematical models in engineering, physics, economics, biology, etc. Keeping the main topics of the previous AMEE conferences and the big success of AMEE'07 the next issue of the Conference will be subject again to the motto "Nonlinear Phenomena—Mathematical Theory and Environmental Reality".

Information: http://www.tu-sofia.bg/fpmi/amee/index.html.

* 10–14 **Summer Symposium in Real Analysis XXXII**, Chicago State University, Chicago, Illinois.

Description: Chicago State University and the Real Analysis Exchange will host the Summer Symposium in Real Analysis XXXII. The Summer Symposia are devoted to all aspects of real analysis. This Symposium will highlight the contributions of Clifford Weil, who recently retired from Michigan State University. The program includes hour long talks by Zoltan Buczolich (Budapest), Michael Evans (Lexington) and Hajrudin Fejzic (San Bernardino). In addition to the principal lectures we have a number of slots set aside for twenty-minute talks. Young researchers are particularly encouraged to present their work. There will also be a session in which open problems will be posed.

Information: http://www.stolaf.edu/people/analysis/.

* 15–28 **Aspects of Moduli**, de Giorgi Center; Scuola Normale Superiore, Pisa, Italy.

Description: We are organizing a workshop and conference to be held June 15-28 at the de Giorgi Center at the Scuola Normale Superiore in Pisa, Italy. This activity is meant to offer a wide view of many aspects of the field. It will split into two parts. The first week will consist of a summer school, aimed at Ph.D. students and beginning researchers, featuring lecture courses by Valery Alexeev, Kai Behrend, Tom Bridgeland, Alessio Corti, and Martin Olsson. During the second week, a conference on recent advances will take place.

Information: http://math.stanford.edu/~vakil/pisa.

* 22–August 22 **Research in Industrial Projects for Students (RIPS)**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

Description: The RIPS Program offers high-achieving undergraduate students the opportunity to work in teams on a real-world research project proposed by a sponsor from industry or a national lab. The students receive direction from a faculty mentor, who is in residence at IPAM, and an industry mentor, who provides regular contact between the team and the sponsor. Ultimately, RIPS provides valuable real-world technical and managerial experience for students as well as valuable R&D for sponsors.

Financial Support: All participating students receive travel reimbursement, housing, most meals, and a stipend.

Application: Eligible applicants include undergraduate students and recent graduates (December 2007 or May/June 2008). International students are also eligible. Applications are available on http://www.ipam.ucla.edu/programs/rips2008/ and are due February 15, 2008. Please send questions to: rips2008@ipam.ucla.edu.

Information: http://www.ipam.ucla.edu/programs/rips2008/.

* 23–27 **Conference on Differential and Difference Equations and Applications 2008(CDDEA 2008)**, Strečno (close to Žilina), Slovak Republic.

Description: The Faculty of Science of University of Žilina organizes traditional conference on Differential and Difference Equations and Applications 2008 (CDDEA 2008) on the occasion of the 10th anniversary of the establishing of faculty of science.

Topics: The following sections are planned: Ordinary differential equations; functional differential equations, difference equations and dynamic equations on time scales, partial differential equations, numerical methods in differential and difference equations.

Information: http://www.fpv.uniza.sk/cddea/.

July 2008

* 2–11 **S3CM: Soria Summer School on Computational Mathematics: "Algebraic Coding Theory"**, Campus "Duques de Soria", Universidad de Valladolid, Soria, Spain.

Description: The S3CM: Soria Summer School on Computational Mathematics: "Algebraic Coding Theory" is an international school mostly intended for Ph.D. students and postdocs working on applied algebraic geometry or commutative algebra and coding theory. The meeting will consist of two independent blocks. The first one with one course and the second one with three main courses. Also, there will be afternoon working sessions where interested postgraduate students can show their work in progress.

Information: http://www.ma.uva.es/~s3cm.

* 3–5 **8th Conference on Logic and the Foundations of Game and Decision Theory (LOFT 2008)**, Universiteit van Amsterdam, Amsterdam, The Netherlands.

Description: This is the eighth in a series of conferences on the applications of logical methods to foundational issues in the theory of individual and interactive decision-making. Preference has been given to papers which bring together the work and problems of several fields, such as game and decision theory, logic, computer science and artificial intelligence, philosophy, cognitive psychology, mathematics and mind sciences. LOFT 2008 will be held at the Universiteit van Amsterdam hosted by the Institute for Logic, Language and Computation (ILLC) in from Thursday July 3 to Saturday July 5, 2008.

Invited Speakers: Cristina Bicchieri, University of Pennsylvania, United States of America; Tom Henzinger, École Polytechnique F'edérale de Lausanne, Switzerland; Christian List, London School of Economics, United Kingdom; Hervé Moulin, Rice University, United States of America; Nicole Schweikardt, Humboldt-Universität zu Berlin, Germany; Wolfgang Spohn, Universität Konstanz, Germany.

Information: http://www.illc.uva.nl/LOFT2008/.

* 6–19 **38th International Probability Summer School**, Saint-Flour, France.

Description: Three courses will be given: R. Kenyon, Dimers and random surfaces; V. Koltchinskii, Oracle inequalities in empirical risk minimization and sparse recovery problems; Y. Le Jan, Markovian paths, loops and fields. Participants will also have the possibility to give a short lecture about their work.

Information: http://math.univ-bpclermont.fr/stflour/.

* 9–13 **NSF-CBMS Conference: Knots and Topological Quantum Computing**, University of Central Oklahoma, Edmond, Oklahoma.
Description: In 1997, Freedman and Kitaev proposed a topological model of a quantum computer that performs computations by encoding information in the configurations of braids. These computers offer the promise of error rates many orders of magnitude lower than any other quantum computation scheme to date. In a series of ten lectures, Zhenghan Wang will cover the theoretical foundations of the field of topological quantum computing, the progress that has been made over the last decade, and the future challenges. In addition, Ara Basmajian will give a series of related lectures on knots and their invariants. No background in knot theory, quantum computing, or quantum physics will be assumed. Travel funds will be available to deter the expenses of participants. Advanced undergraduates, graduate students, junior faculty, women, minorities, and persons with disabilities are especially encouraged to participate and to apply for support.
Information: `http://www.math.ucok.edu/cbms/cbms.html`.

* 14–18 **Efficient Monte Carlo: From Variance Reduction to Combinatorial Optimization. A Conference on the Occasion of R. Y. Rubinstein's 70th Birthday**, Sandbjerg Estate, Sønderborg, Denmark.
Description: This conference is intended to celebrate Professor Rubinstein's 70th birthday by bringing together many of these international researchers in modern Monte Carlo methods. Professor Rubinstein has significantly advanced (or even established) the theory and application of adaptive importance sampling, rare event simulation, randomized optimization, stochastic optimization, sensitivity analysis, the score function method, stochastic counterpart method, and recently the popular cross-entropy method (see `http://www.cemethod.org`). Currently he is pursuing important research in optimization and counting problems concerning #P complete problems.
Organizing Committee: S. Amussen (Aarhus, Chair), P. W. Glynn (Stanford), J. Kreimer (Beer Sheeva), D. P. Kroese, Brisbane.
Deadline: May 1, 2008.
Information: `http://www.thiele.au.dk/Rubinstein/`.

* 14–25 **IPAM/CCB Summer School: Mathematics in Brain Imaging**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: This summer program will focus on mathematical techniques used to measure, map and model brain structure and function.
Topics: Will include modeling anatomical structures in MRI scans, mapping connectivity in diffusion tensor images, and statistical analysis of functional brain images. Current applications in radiology and neuroscience will be highlighted, as will new directions in the mathematics of structural and functional image analysis.
Organizing Committee: Michael Miller, Thomas Nichols, Russell Poldrack, Jonathan Taylor, Paul Thompson, Keith Worsley.
Application/Registration: An application/registration form is available at: `http://www.ipam.ucla.edu/programs/mbi2008/`. If you don't intend to request financial support, you may simply register. Applications received by April 1, 2008, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.
Information: `http://www.ipam.ucla.edu/programs/mbi2008/`.

* 21–25 **Fourteenth International Conference of Difference Equations and Applications**, Besiktas Campus of Bahcesehir University on the European shore of the Bosporus in Istanbul, Turkey.
Description: The purpose of ICDEA08 is to bring together both experts and novices in the theory and applications of difference equations and discrete dynamical systems. The main theme will be dynamic equations on time scales.
Main Speakers: Will be experts chosen from the many areas of difference equations, broadly defined, and experts on discrete dynamical systems and their interplay with nonlinear science. Contributed talks in any area of difference equations are welcome and will be considered.
Organizing Committee: M. Ünal (Chair), M. Bohner (Co-Chair), O. Çelebi, G. Ladas, A. Tiryaki, A. Zafer.
Scientific Committee: M. Bohner (Chair), Z. Dosla (Co-Chair), S. Elaydi, M. Gürses, G. Guseinov, B. Kaymakçalan, P. Kloeden, W. Kratz, D. Lutz, J. Mawhin, D. O'Regan, A. Peterson, A. Sharkovsky, G. Teschl. The conference will be held under the auspices of the International Society of Difference Equations.
ISDE Advisory Committee: K. Nishimura (Chair), A. Ruffing (Co-Chair), H. Oliveira, R. Sacker.
Information: `http://icdea.bahcesehir.edu.tr`.

August 2008

* 4–15 **20th European Summer School for Logic, Language and Information (ESSLLI 2008)**, Universität Hamburg, Freie und Hansestadt, Hamburg, Germany.
Description: The European Summer School in Logic, Language and Information (ESSLLI) is organized every year by the Association for Logic, Language and Information (FoLLI) in different sites around Europe. The main focus of ESSLLI is on the interface between linguistics, logic, and computation. ESSLLI offers foundational, introductory, and advanced courses, as well as workshops, covering a wide variety of topics within the three areas of interest: Language and Computation, Language and Logic, and Logic and Computation. Previous summer schools have been highly successful, attracting up to 500 students from Europe and elsewhere. The school has developed into an important meeting place and forum for discussion for students and researchers interested in the interdisciplinary study of Logic, Language, and Information. ESSLLI 2008 will offer almost 50 courses and host ten research workshops as part of the FoLLI Research Workshop Convention.
Information: `http://www.illc.uva.nl/ESSLLI2008/`.

* 4–18 **ESSLLI 2008 Student Session**, Hamburg, Germany.
Description: The aim of the Student Session is to give an opportunity to students at all levels (Bachelor-, Master- and Ph.D.-students) to present and discuss their work in progress with a possibility to get feedback from senior researchers. Each year, 18 papers are selected for oral presentation and a number of others for poster presentation. The programme committee invites submissions of papers for oral and poster presentation and for appearance in the proceedings. We welcome submissions with topics within the areas of Logic, Language, and Computation.
Submission deadline: February 15, 2008.
Information: More submission details and all relevant information at: `http://staff.science.uva.nl/~kbalogh/StuS13`.

* 5–9 **Building Bridges**, Renyi Institute of Mathematics, Budapest, Hungary.
Description: Laci Lovász turns sixty in 2008. To celebrate his enormous contribution to Discrete Mathematics and Algorithm theory, in general, and connecting Combinatorics and Computer Science in particular, with various other fields of mathematics, The János Bolyai Mathematical Society, the Eötvös Lóránd University and the Alfréd Rényi Institute of Mathematics organize an international workshop entitled Building Bridges. There will be only invited talks. The Program Committee has put together a list of outstanding mathematicians and computer scientists with the aim to create a scientific program (almost) on a par with Laci's research achievements.
Information: `http://www.renyi.hu/conferences/ll60`.

* 11–15 **Fete of Combinatorics and Computer Science**, Keszthely, Lake Balaton, Hungary.
Description: This conference immediately follows the international workshop Building Bridges. which is dedicated to celebrate the

60th birthday of Laci Lovász .
Main topics: Discrete Mathematics and Theoretical Computer Science, in general, Graph Theory, Combinatorics, Applications of Graph Theory, Algorithms.
Organizers: The János Bolyai Mathematical Society, the Eötvös Lóránd University, and the Alfréd Rényi Institute of Mathematics.
Information: http://www.renyi.hu/conferences/comb08.

* 18–22 **International Conference on Ring and Module Theory**, Hacettepe University, Ankara, Turkey.
Description: International conference on ring and module theory. Deadline for submission of an abstract is May 1, 2008.
Information: http://www.algebra2008.hacettepe.edu.tr.

* 25–29 **International Conference Approximation & Computation**, Faculty of Electronic Engineering, University of Nis, Nis, Serbia.
Description: Conference is dedicated to the 60th anniversary of professor Gradimir V. Milovanovic, corresponding member of the Serbian Academy of Sciences and Arts. It will be devoted to Numerical and Symbolic Computation and Approximation Theory. In particular, the following topics will be included: Orthogonal polynomials and systems, interpolation and quadrature processes, iterative processes for equations, polynomials (extremal problems, inequalities, zeros), approximations by polynomials and splines and related inequalities.
Information: http://euler.elfak.ni.ac.yu/appcom08.

* 25–29 **Dynamics Days Europe 2008**, TU Delft, The Netherlands.
Information: http://www.dd2008.ewi.tudelft.nl/.

September 2008

* 1–5 **Conference in Numerical Analysis (NumAn 2008) recent approaches to numerical analysis: Theory, methods and applications honoring Richard S. Varga on his 80th birthday**, Kalamata, Greece.
Description: The aims of the conference are: (1) to bring together and bequeath scientific activities, directions and pursuits of scientists on subjects that pertain to the conference, (2) to foster an exchange of views and ideas, (3) to study the theoretical background required for methods, algorithms and techniques used in applications, (4) to search directions of theoretical results towards applications, (5) to highlight open problems and future directions of numerical analysis.
Information: http://www.math.upatras.gr/numan2008/.

* 8–12 **Long Program: Internet Multi-Resolution Analysis: Foundations, Applications and Practice**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: The focus of this IPAM program will be on innovations and breakthroughs in the theoretical foundations and practical implementations of a network-centric multi-resolution analysis (MRA). Participants will learn about Internet MRA from the perspectives of mathematics, statistics, computer science, and engineering—and will meet a diverse group of people and have an opportunity to form new collaborations. There will be opening tutorials, four workshops, and a culminating workshop at Lake Arrowhead.
Organizing Committee: Paul Barford, John Doyle, Anna Gilbert, Mauro Maggioni, Craig Partridge, Matthew Roughan, and Walter Willinger.
Application: An application form is available at: http://www.ipam.ucla.edu/programs/mra2008/. Applications for individual workshops will be posted on individual workshop home pages. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.
Information: http://www.ipam.ucla.edu/programs/mra2008/.

* 16–19 **Conference on Boundary Value Problems: Mathematical Models in Engineering, Biology and Medicine**, University of Santiago de Compostela, Santiago de Compostela, Spain.
Description: The Conference on Boundary Value Problems, "Mathematical Models in Engineering, Biology and Medicine" tries to keep in touch some of the most relevant experts in these fields. It is prepared under the auspices of the International Federation of Nonlinear Analysts and is organized by the Nonlinear Analysis Group of the Department of Mathematical Analysis of the University of Santiago de Compostela.
Topics: Theory of differential and difference equations in a broad sense, with special attention to nonlinear and singular phenomena arising in the mathematical models that appear in engineering, biology and medicine.
Information: http://www.usc.es/congresos/bvp2008/.

* 22–28 **A joint conference of 5th Annual International Conference on Voronoi Diagrams in Science and Engineering and 4th International Kyiv Conference on Analytic Number Theory and Spatial Tessellations**, Drahomanov National Pedagogical University, Kyiv, Ukraine.
Main topics: a) Voronoi Diagrams. b) Fields in Pure Mathematics founded by Voronoï.
Organizers: Inst. of Mathematics of the NAS of Ukraine; Dragomanov Pedagogical University, Ukraine; Voronoi Diagram Research Center, Seoul, Korea; Inst. of Mathematics of the PAS, Warsaw, Poland; Steklov Mathematical Inst. of the RAS, Moscow, Russia.
Registration deadline: March 15, 2008. Abstract Submission deadline: March 22, 2008.
Information: email: voronoi@imath.kiev.ua; http://www.imath.kiev.ua/~voronoi.

October 2008

* 6–10 **Conference on Arithmetic Algebraic Geometry on the occasion of Michael Rapoport's 60th birthday**, Universitaet Bonn, Bonn, Germany.
Description: The conference is an activity of the Sonderforschungsbereich Mainz/Bonn/Essen on Periods, Moduli Spaces, and Arithmetic of Algebraic Varieties, and is supported by the Hausdorff Center for Mathematics (Bonn).
Information: For further information, please see the conference web site: http://aag-bonn08.sfb45.de.

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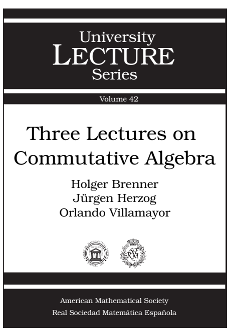
Algebra and Algebraic Geometry



Three Lectures on Commutative Algebra

Holger Brenner, *University of Sheffield, United Kingdom*, **Jürgen Herzog**, *Universität Duisburg-Essen, Germany*, **Orlando Villamayor**, *Universidad Autónoma de Madrid, Spain*, and **edited by Juan Elias, Teresa Cortadellas Benítez, Gemma Colomé-Nin**, and **Santiago Zarzuela**, *Universitat de Barcelona, Spain*

This book provides careful and detailed introductions to some of the latest advances in three significant areas of rapid development in commutative algebra and its applications. The book is based on courses at the Winter School on Commutative Algebra and Applications held in Barcelona: Tight closure and vector bundles, by H. Brenner; Combinatorics and commutative algebra, by J. Herzog; and Constructive desingularization, by O. Villamayor.

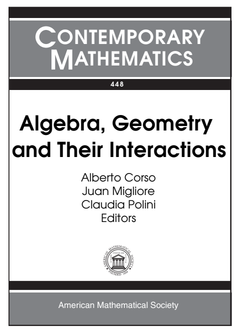
The exposition is aimed at graduate students who have some experience with basic commutative algebra or algebraic geometry but may also serve as an introduction to these modern approaches for mathematicians already familiar with commutative algebra.

This book is copublished by the Real Sociedad Matemática Española and the American Mathematical Society.

Contents: H. Brenner, Tight closure and vector bundles; **J. Herzog**, Combinatorics and commutative algebra; **O. Villamayor**, Notes on constructive desingularization.

University Lecture Series, Volume 42

April 2008, approximately 176 pages, Softcover, ISBN: 978-0-8218-4434-2, LC 2007060568, 2000 *Mathematics Subject Classification:* 13-02, 14-02, 05Cxx, 13Dxx, 13Fxx, 13Hxx, 14Bxx, 14Exx, 14Jxx, **AMS members US$31**, List US$39, Order code ULECT/42



Algebra, Geometry and Their Interactions

Alberto Corso, *University of Kentucky, Lexington, KY*, and **Juan Migliore** and **Claudia Polini**, *University of Notre Dame, IN*, Editors

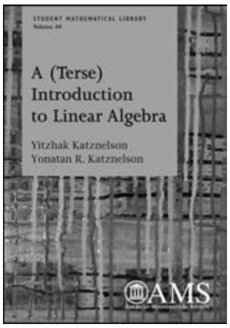
This volume's papers present work at the cutting edge of current research in algebraic geometry, commutative algebra, numerical analysis, and other related fields, with an emphasis on the breadth of these areas and the beneficial results obtained by the interactions between these fields. This collection of two survey articles and sixteen refereed research papers, written by experts in these fields, gives the reader a greater sense of some of the directions in which this research is moving, as well as a better idea of how these fields interact with each other and with other applied areas. The topics include blowup algebras, linkage theory, Hilbert functions, divisors, vector bundles, determinantal varieties, (square-free) monomial ideals, multiplicities and cohomological degrees, and computer vision.

Contents: M. Bertolini, G. M. Besana, and **C. Turrini**, Instability of projective reconstruction from 1-view near critical configurations in higher dimensions; **K. A. Chandler**, Examples and counterexamples on the conjectured Hilbert function of multiple points; **C. Ciuperca, W. Heinzer, J. Ratliff**, and **D. Rush**, Projectively full ideals in Noetherian rings, a survey; **K. Dalili** and **W. V. Vasconcelos**, Cohomological degrees and the HomAB conjecture; **J. A. Eagon**, A minimal generating set for the first syzygies of a monomial ideal; **E. Gorla**, Lifting the determinantal property; **H. T. Há** and **A. Van Tuyl**, Resolutions of square-free monomial ideals via facet ideals: A survey; **M. Hochster**, Some finiteness properties of Lyubeznik's $\mathcal{F}$-modules; **C. Huneke, J. Migliore, U. Nagel**, and **B. Ulrich**, Minimal homogeneous liaison and Licci ideals; **J. O. Kleppe** and **R. M. Miró-Roig**, Unobstructedness and dimension of families of codimension 3 ACM algebras; **A. Lanteri** and **H. Maeda**, Ample vector bundles with sections vanishing on submanifolds of sectional genus three; **Y. Lu, D. J. Bates, A. J. Sommese**, and **C. W. Wampler**, Finding all real points of a complex curve; **R. M. Miró-Roig**, On the multiplicity conjecture; **J. M. Rojas**, Efficiently detecting torsion points and subtori; **A. K. Singh** and **S. Spiroff**, Divisor class groups of graded hypersurfaces; **K. E. Smith** and **H. M. Thompson**, Irrelevent exceptional divisors for curves on a smooth surface; **M. A. van Opstall** and **R. Veliche**, Variation of hyperplane sections; **C. Yuen**, Jet schemes of determinantal varieties.

Contemporary Mathematics, Volume 448

December 2007, 270 pages, Softcover, ISBN: 978-0-8218-4094-8, LC 2007060846, 2000 *Mathematics Subject Classification:* 05C90, 13C40, 13D02, 13D07, 13D40, 14C05, 14J60, 14M12, 14N05, 65H10, 65H20, **AMS members US$63**, List US$79, Order code CONM/448

COURSE ADOPTION



A (Terse) Introduction to Linear Algebra

Yitzhak Katznelson, *Stanford University, CA*, and **Yonatan R. Katznelson**, *University of California, Santa Cruz, CA*

Linear algebra is the study of vector spaces and the linear maps between them. It underlies much of modern mathematics and is widely used in applications.

A (Terse) Introduction to Linear Algebra is a concise presentation of the core material of the subject—those elements of linear algebra that every mathematician, and everyone who uses mathematics, should know. It goes from the notion of a finite-dimensional vector space to the canonical forms of linear operators and their matrices, and covers along the way such key topics as: systems of linear equations, linear operators and matrices, determinants, duality, and the spectral theory of operators on inner-product spaces.

The last chapter offers a selection of additional topics indicating directions in which the core material can be applied.

The Appendix provides all the relevant background material.

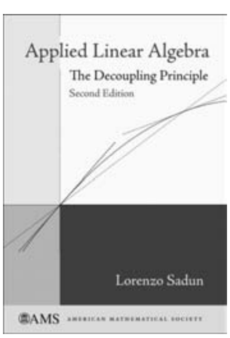
Written for students with some mathematical maturity and an interest in abstraction and formal reasoning, the book is self-contained and is appropriate for an advanced undergraduate course in linear algebra.

Contents: Vector spaces; Linear operators and matrices; Duality of vector spaces; Determinants; Invariant subspaces; Operators on inner-product spaces; Structure theorems; Additional topics; Appendix; Index; Symbols.

Student Mathematical Library, Volume 44

January 2008, 215 pages, Softcover, ISBN: 978-0-8218-4419-9, LC 2007060571, 2000 *Mathematics Subject Classification:* 15-01, **AMS members US$28**, List US$35, Order code STML/44

COURSE ADOPTION



Applied Linear Algebra

The Decoupling Principle, Second Edition

Lorenzo Sadun, *University of Texas, Austin, TX*

Linear algebra permeates mathematics, as well as physics and engineering. In this text for junior and senior undergraduates, Sadun treats diagonalization as a central tool in solving complicated problems in these subjects by reducing coupled linear evolution problems to a sequence of simpler decoupled problems. This is the Decoupling Principle.

Traditionally, difference equations, Markov chains, coupled oscillators, Fourier series, the wave equation, the Schrödinger equation, and Fourier transforms are treated separately, often in different courses. Here, they are treated as particular instances of the decoupling principle, and their solutions are remarkably similar. By understanding this general principle and the many applications given in the book, students will be able to recognize it and to apply it in many other settings.

Sadun includes some topics relating to infinite-dimensional spaces. He does not present a general theory, but enough so as to apply the decoupling principle to the wave equation, leading to Fourier series and the Fourier transform.

The second edition contains a series of *Explorations*. Most are numerical labs in which the reader is asked to use standard computer software to look deeper into the subject. Some explorations are theoretical, for instance, relating linear algebra to quantum mechanics. There is also an appendix reviewing basic matrix operations and another with solutions to a third of the exercises.

Contents: The decoupling principle; Vector spaces and bases; Linear transformations and operators; An introduction to eigenvalues; Some crucial applications; Inner products; Adjoints, Hermitian operators, and unitary operators; The wave equation; Continuous spectra and the Dirac delta function; Fourier transforms; Green's functions; Matrix operations; Solutions to selected exercises; Index.

January 2008, 371 pages, Hardcover, ISBN: 978-0-8218-4441-0, LC 2007060567, 2000 *Mathematics Subject Classification:* 15-01; 34-01, 35-01, 39-01, 42-01, **AMS members US$47**, List US$59, Order code MBK/50

Analysis

COURSE ADOPTION

Complex Function Theory

Second Edition

Donald Sarason, *University of California, Berkeley, CA*

From a review of the previous edition … The exposition is clear, rigorous, and friendly.

— Zentralblatt MATH

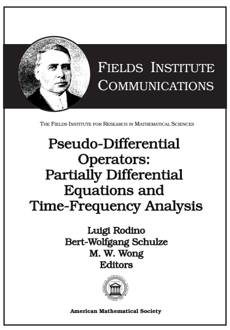
Complex Function Theory is a concise and rigorous introduction to the theory of functions of a complex variable. Written in a classical style, it is in the spirit of the books by Ahlfors and by Saks and Zygmund. Being designed for a one-semester course, it is much shorter than many of the standard texts. Sarason covers the basic material through Cauchy's theorem and applications, plus the Riemann mapping theorem. It is suitable for either an introductory graduate course or an undergraduate course for students with adequate preparation.

The first edition was published with the title *Notes on Complex Function Theory*.

Contents: Complex numbers; Complex differentiation; Linear-fractional transformations; Elementary functions; Power series; Complex integration; Core versions of Cauchy's theorem, and consequences; Laurent series and isolated singularities; Cauchy's theorem; Further development of basic complex function theory; Appendix 1: Sufficient condition for differentiability; Appendix 2: Two instances of the chain rule; Appendix 3: Groups, and linear-fractional transformations; Appendix 4: Differentiation under the integral sign; References; Index.

January 2008, 163 pages, Hardcover, ISBN: 978-0-8218-4428-1, LC 2007060552, 2000 *Mathematics Subject Classification:* 30-01, **AMS members US$31**, List US$39, Order code MBK/49

Differential Equations



Pseudo-Differential Operators: Partial Differential Equations and Time-Frequency Analysis

Luigi Rodino, *Università di Torino, Italy*, **Bert-Wolfgang Schulze**, *Universität Potsdam, Germany*, and **M. W. Wong**, *York University, Toronto, ON, Canada*, Editors

This volume is based on lectures given at the workshop on pseudo-differential operators held at the Fields Institute from December 11, 2006 to December 15, 2006. The two main themes of the workshop and hence this volume are partial differential equations and time-frequency analysis. The contents of this volume consist of five mini-courses for graduate students and post-docs, and fifteen papers on related topics. Of particular interest in this volume are the mathematical underpinnings, applications and ramifications of the relatively new Stockwell transform, which is a hybrid of the Gabor transform and the wavelet transform. The twenty papers in this volume reflect modern trends in the development of pseudo-differential operators.

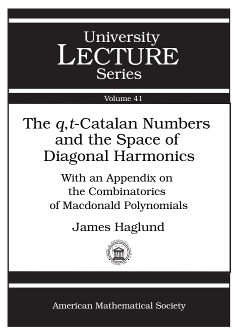
Titles in this series are co-published with the Fields Institute for Research in Mathematical Sciences (Toronto, Ontario, Canada).

Contents: P. Greiner, On Hörmander operators and non-holonomic geometry; **A. Dasgupta** and **M. W. Wong**, Weyl transforms and the inverse of the sub-Laplacian on the Heisenberg group; **B.-W. Schulze**, Pseudo-differential calculus on manifolds with geometric singularities; **C.-I. Martin**, Corner operators and applications to elliptic complexes; **N. Dines**, Ellipticity of a class of corner operators; **C. L. Epstein**, Pseudodifferential methods for boundary value problems; **V. Rabinovich**, Invertibility of parabolic Pseudodifferential operators; **M. Cappiello**, **T. Gramchev**, and **L. Rodino**, Semilinear pseudo-differential equations and travelling waves; **E. Buzano** and **J. Toft**, Continuity and compactness properties of pseudo-differential operators; **F. Concetti** and **J. Toft**, Trace ideals for Fourier integral operators with non-smooth symbols; **V. Catană**, Schatten-von Neumann norm inequalities for two-wavelet localization operators; **R. G. Stockwell**, Why use the S-transform?; **T. A. Bjarnason**, **S. Drabycz**, **D. H. Adler**, **J. G. Cairncross**, and **J. R. Mitchell**, Applying the S-transform to magnetic resonance imaging texture analysis; **Y. Liu** and **M. W. Wong**, Inversion formulas for two-dimensional Stockwell transforms; **C. R. Pinnegar**, Localization of signal and image features with the TT-transform; **K. Gröchenig**, Weight functions in time-frequency analysis; **R. R. Radha** and **S. Sivananthan**, Shannon type sampling theorems on the Heisenberg group; **A. Mohammed** and **M. W. Wong**, Rihaczek transforms and pseudo-differential operators; **P. Boggiatto**, **G. De Donno**, and **A. Oliaro**, A unified point of view on time-frequency representations and pseudo-differential operators; **R. Ashino**, **T. Mandai**, **A. Morimoto**, and **F. Sasaki**, Blind source separation using time-frequency analysis.

Fields Institute Communications, Volume 52

November 2007, 414 pages, Hardcover, ISBN: 978-0-8218-4276-8, LC 2007060553, 2000 *Mathematics Subject Classification:* 35-06, 35S05, 42-06, 47G10, 47G30, 58-06, 58J40, 65T60, 94A12, **AMS members US$95**, List US$119, Order code FIC/52

Discrete Mathematics and Combinatorics



The q, t-Catalan Numbers and the Space of Diagonal Harmonics

With an Appendix on the Combinatorics of Macdonald Polynomials

James Haglund, *University of Pennsylvania, Philadelphia, PA*

This book contains detailed descriptions of the many exciting recent developments in the combinatorics of the space of diagonal harmonics, a topic at the forefront of current research in algebraic combinatorics. These developments led in turn to some surprising discoveries in the combinatorics of Macdonald polynomials, which are described in Appendix A. The book is appropriate as a text for a topics course in algebraic combinatorics, a volume for self-study, or a reference text for researchers in any area which involves symmetric functions or lattice path combinatorics.

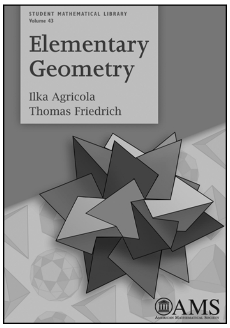
The book contains expository discussions of some topics in the theory of symmetric functions, such as the practical uses of plethystic substitutions, which are not treated in depth in other texts. Exercises are interspersed throughout the text in strategic locations, with full solutions given in Appendix C.

Contents: Introduction to q-analogues and symmetric functions; Macdonald polynomials and the space of diagonal harmonics; The q, t-Catalan numbers; The q, t-Schröder polynomial; Parking functions and the Hilbert series; The shuffle conjecture; The proof of the q, t-Schröder theorem; The combinatorics of Macdonald polynomials; The Loehr-Warrington conjecture; Solutions to exercises; Bibliography.

University Lecture Series, Volume 41

January 2008, 167 pages, Softcover, ISBN: 978-0-8218-4411-3, LC 2007060570, 2000 *Mathematics Subject Classification:* 05E05, 05A30; 05A05, **AMS members US$31**, List US$39, Order code ULECT/41

Geometry and Topology



Elementary Geometry

Ilka Agricola and **Thomas Friedrich**, *Humboldt-Universität zu Berlin, Germany*
Translated by Philip G. Spain

Elementary geometry provides the foundation of modern geometry. For the most part, the standard introductions end at the formal Euclidean geometry of high school. Agricola and Friedrich revisit geometry, but from the higher viewpoint of university mathematics. Plane geometry is developed from its basic objects and their properties and then moves to conics and basic solids, including the Platonic solids and a proof of Euler's polytope formula. Particular care is taken to explain symmetry groups, including the description of ornaments and the classification of isometries by their number of fixed points. Complex numbers are introduced to provide an alternative, very elegant approach to plane geometry. The authors then treat spherical and hyperbolic geometries, with special emphasis on their basic geometric properties.

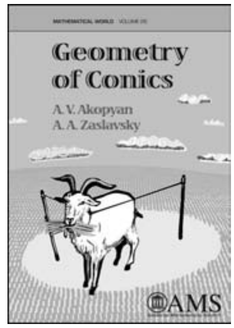
This largely self-contained book provides a much deeper understanding of familiar topics, as well as an introduction to new topics that complete the picture of two-dimensional geometries. For undergraduate mathematics students the book will be an excellent introduction to an advanced point of view on geometry. For mathematics teachers it will be a valuable reference and a source book for topics for projects.

The book contains over 100 figures and scores of exercises. It is suitable for a one-semester course in geometry for undergraduates, particularly for mathematics majors and future secondary school teachers.

Contents: Introduction: Euclidean space; Elementary geometrical figures and their properties; Symmetries of the plane and of space; Hyperbolic geometry; Spherical geometry; Bibliography; List of symbols; Index.

Student Mathematical Library, Volume 43

January 2008, approximately 246 pages, Softcover, ISBN: 978-0-8218-4347-5, LC 2007060844, 2000 *Mathematics Subject Classification:* 51M04, 51M09, 51M15, **AMS members US$31**, List US$39, Order code STML/43



Geometry of Conics

A. V. Akopyan, and **A. A. Zaslavsky**, *CEMI RAN, Moscow, Russia*

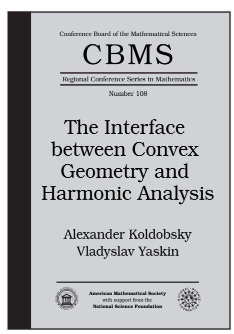
The book is devoted to the properties of conics (plane curves of second degree) that can be formulated and proved using only elementary geometry. Starting with the well-known optical properties of conics, the authors move to less trivial results, both classical and contemporary. In particular, the chapter on projective properties of conics contains a detailed analysis of the polar correspondence, pencils of conics, and the Poncelet theorem. In the chapter on metric properties of conics the authors discuss, in particular, inscribed conics, normals to conics, and the Poncelet theorem for confocal ellipses.

The book demonstrates the advantage of purely geometric methods of studying conics. It contains over 50 exercises and problems aimed at advancing geometric intuition of the reader. The book also contains more than 100 carefully prepared figures, which will help the reader to better understand the material presented.

Contents: Elementary properties of curves of second degree; Some results from classical geometry; Projective properties of conics; Euclidean properties of curves of second degree; Solutions to the problems; Bibliography; Index.

Mathematical World, Volume 26

November 2007, 134 pages, Softcover, ISBN: 978-0-8218-4323-9, LC 2007060841, 2000 *Mathematics Subject Classification:* 51-02, 51M04, **AMS members US$21**, List US$26, Order code MAWRLD/26



The Interface between Convex Geometry and Harmonic Analysis

Alexander Koldobsky, *University of Missouri, Columbia, MO*, and **Vladyslav Yaskin**, *University of Oklahoma, Norman, OK*

The study of convex bodies is a central part of geometry, and is particularly useful in applications to other areas of mathematics and the sciences. Recently, methods from Fourier analysis have been developed that greatly improve our understanding of the geometry of sections and projections of convex bodies. The idea of this approach is to express certain properties of bodies in terms of the Fourier transform and then to use methods of Fourier analysis to solve geometric problems. The results covered in the book include an analytic solution to the Busemann-Petty problem, which asks whether bodies with smaller areas of central hyperplane sections necessarily have smaller volume, characterizations of intersection bodies, extremal sections of certain classes of bodies, and a Fourier analytic solution to Shephard's problem on projections of convex bodies.

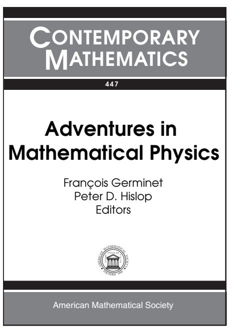
The book is written in the form of lectures accessible to graduate students. This approach allows the reader to clearly see the main ideas behind the method, rather than to dwell on technical difficulties. The book also contains discussions of the most recent advances in the subject. The first section of each lecture is a snapshot of that lecture. By reading each of these sections first, novices can gain an overview of the subject, then return to the full text for more details.

Contents: Hyperplane sections of ℓ_p-balls; Volume and the Fourier transform; Intersection bodies; The Busemann-Petty problem; Projections and the Fourier transform; Intersection bodies and L_p-spaces; On the road between polar projection bodies and intersection bodies; Open problems; Bibliography; Index.

CBMS Regional Conference Series in Mathematics, Number 108

January 2008, 107 pages, Softcover, ISBN: 978-0-8218-4456-4, LC 2007060572, 2000 *Mathematics Subject Classification:* 52A20, 42A38, 44A05, **All Individuals US$23**, List US$29, Order code CBMS/108

Mathematical Physics



Adventures in Mathematical Physics

François Germinet, *Université de Cergy-Pontoise, France*, and **Peter D. Hislop**, *University of Kentucky, Lexington, KY*, Editors

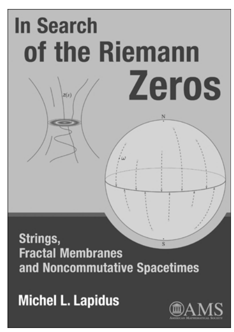
This volume consists of refereed research articles written by some of the speakers at this international conference in honor of the sixty-fifth birthday of Jean-Michel Combes. The topics span modern mathematical physics with contributions on state-of-the-art results in the theory of random operators, including localization for random Schrödinger operators with general probability measures, random magnetic Schrödinger operators, and interacting multiparticle operators with random potentials; transport properties of Schrödinger operators and classical Hamiltonian systems; equilibrium and nonequilibrium properties of open quantum systems; semiclassical methods for multiparticle systems and long-time evolution of wave packets; modeling of nanostructures; properties of eigenfunctions for first-order systems and solutions to the Ginzburg-Landau system; effective Hamiltonians for quantum resonances; quantum graphs, including scattering theory and trace formulas; random matrix theory; and quantum information theory. Graduate students and researchers will benefit from the accessibility of these articles and their current bibliographies.

Contents: **W. H. Aschbacher**, On the emptiness formation probability in quasi-free states; **V. Chulaevsky**, Wegner-Stollmann type estimates for some quantum lattice systems; **M. Combescure**, The mutually unbiased bases revisited; **H. D. Cornean**, **T. G. Pedersen**, and **B. Ricaud**, Pertubative vs. variational methods in the study of carbon nanotubes; **S. De Bièvre**, **P. Lafitte**, and **P. E. Parris**, Normal transport at positive temperatures in classical Hamiltonian open systems; **P. Exner** and **J. Lipovský**, Equivalence of resolvent and scattering resonances on quantum graphs; **S. Fournais** and **B. Helffer**, Optimal uniform elliptic estimates for the Ginzburg-Landau system; **F. Germinet** and **A. Klein**, Localization for a continuum Cantor-Anderson Hamiltonian; **F. Germinet** and **S. Tcheremchantsev**, Generalized fractal dimensions on the negative axis for non compactly supported measures; **F. Ghribi**, **P. D. Hislop**, and **F. Klopp**, Localization for Schrödinger operators with random vector potentials; **G. A. Hagedorn** and **A. Joye**, Vibrational levels associated with hydrogen bonds and semiclassical Hamiltonian normal forms; **V. Jakšić** and **C.-A. Pillet**, On the strict positivity of entropy production; **A. Jensen** and **G. Nenciu**, Uniqueness results for transient dynamics of quantum systems; **V. Kostrykin**, **J. Potthoff**, and **R. Schrader**, Heat kernels on metric graphs and a trace formula; **J. L. Lebowitz**, **A. Lytova**, and **L. Pastur**, On a random matrix model of quantum relaxation; **D. Robert**, Revivals of wave packets and Bohr-Sommerfeld quantization rules; **L. E. Thomas** and **Y. Wang**, On a linear stochastic wave equation modeling heat flow; **D. R. Yafaev**, Exponential decay of eigenfunctions of first order systems.

Contemporary Mathematics, Volume 447

December 2007, 256 pages, Softcover, ISBN: 978-0-8218-4241-6, LC 2007060847, 2000 *Mathematics Subject Classification:* 35Pxx, 35Qxx, 35Sxx, 47Axx, 81-XX, **AMS members US$63**, List US$79, Order code CONM/447

Number Theory



In Search of the Riemann Zeros

Strings, Fractal Membranes and Noncommutative Spacetimes

Michel L. Lapidus, *University of California, Riverside, CA*

Formulated in 1859, the Riemann Hypothesis is the most celebrated and multifaceted open problem in mathematics. In essence, it states that the primes are distributed as harmoniously as possible—or, equivalently, that the Riemann zeros are located on a single vertical line, called the critical line.

In this book, the author proposes a new approach to understand and possibly solve the Riemann Hypothesis. His reformulation builds upon earlier (joint) work on complex fractal dimensions and the vibrations of fractal strings, combined with string theory and noncommutative geometry. Accordingly, it relies on the new notion of a fractal membrane or quantized fractal string, along with the modular flow on the associated moduli space of fractal membranes. Conjecturally, under the action of the modular flow, the spacetime geometries become increasingly symmetric and crystal-like, hence, arithmetic. Correspondingly, the zeros of the associated zeta functions eventually condense onto the critical line, towards which they are attracted, thereby explaining why the Riemann Hypothesis must be true.

Written with a diverse audience in mind, this unique book is suitable for graduate students, experts and nonexperts alike, with an interest in number theory, analysis, dynamical systems, arithmetic, fractal or noncommutative geometry, and mathematical or theoretical physics.

This item will also be of interest to those working in mathematical physics.

Contents: Introduction; String theory on a circle and T-duality: Analogy with the Riemann zeta function; Fractal strings and fractal membranes; Noncommutative models of fractal strings: Fractal membranes and beyond; Towards an 'arithmetic site': Moduli spaces of fractal strings and membranes; Vertex algebras; The Weil conjectures and the Riemann hypothesis; The Poisson summation formula, with applications; Generalized primes and Beurling zeta functions; The Selberg class of zeta functions; The noncommutative space of Penrose tilings and quasicrystals; Bibliography; Conventions; Index of symbols; Subject index; Author index.

February 2008, 558 pages, Hardcover, ISBN: 978-0-8218-4222-5, LC 2007060845, 2000 *Mathematics Subject Classification:* 11A41, 11G20, 11M06, 11M26, 11M41, 28A80, 37N20, 46L55, 58B34, 81T30, **AMS members US$63**, List US$79, Order code MBK/51

New AMS-Distributed Publications

Analysis

Operator Theory, Structured Matrices, and Dilations

Tiberiu Constantinescu Memorial Volume

Mihaly Bakonyi, *Georgia State University, Atlanta, GA*, **Aurelian Gheondea**, *Romanian Academy, Institute of Mathematics, Bucharest, Romania*, **Mihai Putinar**, *University of California, Santa Barbara, CA*, and **James Rovnyak**, *University of Virginia, Charlottesville, VA*, Editors

The volume is a careful selection of peer-reviewed papers in operator theory, structured matrices, and dilations, dedicated to Tiberiu Constantinescu, a prominent mathematician in the field.

The extensive survey of J. W. Helton and M. Putinar on positive polynomials, spectral theorem, and optimization is a pioneering essay that, under the unifying concept of positivity, brings together ideas from algebra, algebraic geometry, complex analysis, control theory, mathematical logic, and operator theory.

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- multivariable operator theory
- interpolation and moment problems
- perturbation theory
- composition operators
- matrix completion problems
- systems theory

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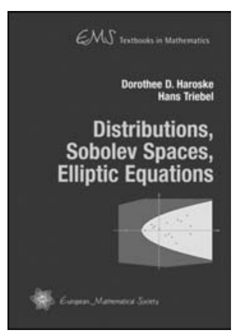
Contents: **D. Alpay**, **R. W. Buursema**, **A. Dijksma**, and **H. Langer**, The combined moment and interpolation problem for Nevanlinna functions; **D. Z. Arov** and **O. Staffans**, State/signal linear time-invariant systems theory, Part III: Transmission and impedance representations of discrete time systems; **M. Bakonyi** and **D. Timotin**, The central completion of a positive block operator matrix; **J. A. Ball**, **V. Bolotnikov**, and **Q. Fang**, Schur-class multipliers on the Fock space: de Branges-Rovnyak reproducing kernel spaces and transfer-function realizations; **H. Bercovici** and **W. S. Li**, Invariant subspaces with extremal structure for operators of class C_0; **A. K. Beros** and **D. Sarason**, Composition operators and change of variable in one real dimension; **P. A. Cojuhari**, On the spectrum of a class of block Jacobi matrices; **M. A. Dritschel** and **S. McCullough**, Test functions, kernels, realizations and interpolation; **Y. Hachez** and **H. J. Woerdeman**, The Fischer-Frobenius transformation and outer factorization; **S. Hassi**, **H. S. V. de Snoo**, **A. E. Sterk**, and **H. Winkler**, Finite-dimensional graph perturbations of selfadjoint Sturm-Liouville operators; **J. W. Helton** and **M. Putinar**, Positive polynomials in scalar and matrix variables, the spectral theorem, and optimization; **G. Popescu**, Von Neumann inequality on noncommutative domains; **J. Rovnyak** and **L. A. Sakhnovich**, Interpolation problems for matrix integro-differential operators with difference kernels and with a finite number of negative squares; **M. C. Tseng** and **V. Ramakrishna**, Dilation theoretic parametrizations of positive matrices with applications to quantum information.

International Book Series of Mathematical Texts

October 2007, 356 pages, Hardcover, ISBN: 978-973-87899-0-6, 2000 *Mathematics Subject Classification:* 00B15; 47-06, **AMS members US$46**, List US$58, Order code THETA/10

Differential Equations



Distributions, Sobolev Spaces, Elliptic Equations

Dorothee D. Haroske and **Hans Triebel**, *Friedrich-Schiller University, Jena, Germany*

It is the main aim of this book to develop at an accessible, moderate level an L_2 theory for elliptic differential operators of second order on bounded smooth domains in Euclidean n-space, including a priori estimates for boundary-value problems in terms of (fractional) Sobolev spaces on domains and on their boundaries, together with a related spectral theory.

The presentation is preceded by an introduction to the classical theory for the Laplace-Poisson equation, and some chapters provide required ingredients such as the theory of distributions, Sobolev spaces and the spectral theory in Hilbert spaces.

The book grew out of two-semester courses the authors have given several times over a period of ten years at the Friedrich Schiller University of Jena. It is addressed to graduate students and mathematicians who have a working knowledge of calculus, measure theory and the basic elements of functional analysis (as usually covered by undergraduate courses) and who are seeking an accessible introduction to some aspects of the theory of function spaces and its applications to elliptic equations.

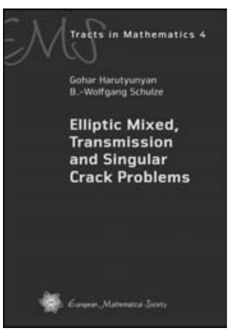
This item will also be of interest to those working in analysis.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: The Laplace-Poisson equation; Distributions; Sobolev space on $\mathbb{R}^n$ and $\mathbb{R}^n_+$; Sobolev spaces on domains; Elliptic operators in L_2; Spectral theory in Hilbert spaces and Banach spaces; Compact embeddings, spectral theory of elliptic operators; A. Domains, basic spaces, and integral formulae; B. Orthonormal bases of trigonometric functions; C. Operator theory; D. Some integral inequalities; E. Function spaces; Selected solutions; Bibliography; Author index; List of figures; Notation index; Subject index.

EMS Textbooks in Mathematics

November 2007, 303 pages, Hardcover, ISBN: 978-3-03719-042-5, 2000 *Mathematics Subject Classification:* 35-01, 46-01, 35J25, 35P15, 42B35, 46E35, 46F05, 47B06, 47F05, **AMS members US$54**, List US$68, Order code EMSTEXT/4



Elliptic Mixed, Transmission and Singular Crack Problems

Gohar Harutyunyan, *University of Oldenburg, Germany*, and **Bert-Wolfgang Schulze**, *University of Potsdam, Germany*

Mixed, transmission, or crack problems belong to the analysis of boundary value problems on manifolds with singularities. The Zaremba problem with a jump between Dirichlet and Neumann conditions along an interface on the boundary is a classical example. The central theme of this book is to study mixed problems in standard Sobolev spaces as well as in weighted edge spaces where the interfaces are interpreted as edges. Parametrices and regularity of solutions are obtained within a systematic calculus of boundary value problems on manifolds with conical or edge singularities. This calculus allows singularities on the interface and homotopies between mixed and crack problems. Additional edge conditions are computed in terms of relative index results. In a detailed final chapter, the intuitive ideas of the approach are illustrated, and there is a discussion of future challenges. A special feature of the text is the inclusion of many worked-out examples which help the reader to appreciate the scope of the theory and to treat new cases of practical interest.

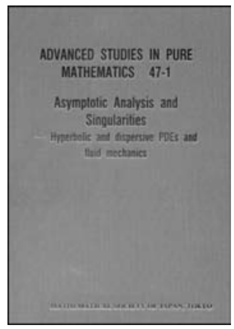
This book is addressed to mathematicians and physicists interested in models with singularities, associated boundary value problems, and their solvability strategies based on pseudo-differential operators. The material is also useful for students in higher semesters and young researchers, as well as for experienced specialists working in analysis on manifolds with geometric singularities, the applications of index theory and spectral theory, operator algebras with symbolic structures, quantisation, and asymptotic analysis.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Introduction; Boundary value problems with mixed and interface data; Symbolic structures and associated operators; Boundary value problems with the transmission property; Mixed problems in standard Sobolev spaces; Mixed problems in weighted edge spaces; Operators on manifolds with conical singularities and boundary; Operators on manifolds with edges and boundary; Corner operators and problems with singular interfaces; Operators in infinite cylinders and the relative index; Intuitive ideas of the calculus on singular manifolds; Bibliography; List of symbols; Index.

EMS Tracts in Mathematics

November 2007, 777 pages, Hardcover, ISBN: 978-3-03719-040-1, 2000 *Mathematics Subject Classification:* 35-02, 35J25, 35S15, **AMS members US$126**, List US$158, Order code EMSTM/4



Asymptotic Analysis and Singularities

Hyperbolic and Dispersive PDEs and Fluid Mechanics

Hideo Kozono and **Takayoshi Ogawa**, *Tohoku University, Sendai, Japan*, **Kazunaga Tanaka**, *Waseda University, Tokyo, Japan*, **Yoshio Tsutsumi**, *Kyoto University, Japan*, and **Eiji Yanagida**, *Tohoku University, Sendai, Japan*, Editors

This volume is the proceedings of the 14th MSJ International Research Institute "Asymptotic Analysis and Singularity", which was held at Sendai, Japan in July 2005. The proceedings contain survey papers and original research papers on nonlinear partial differential equations, dynamical systems, calculus of variations and mathematical physics.

Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

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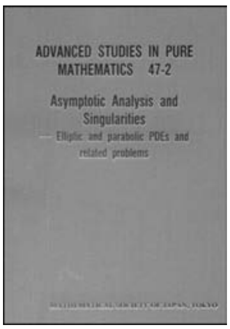
Advanced Studies in Pure Mathematics, Volume 47

October 2007, 396 pages, Hardcover, ISBN: 978-4-931469-40-2, 2000 *Mathematics Subject Classification:* 35-06; 34-06, 37-06, 46-06, 76-06, **AMS members US$48**, List US$60, Order code ASPM/47.1



Asymptotic Analysis and Singularities

Elliptic and Parabolic PDEs and Related Problems

Hideo Kozono and **Takayoshi Ogawa**, *Tohoku University, Sendai, Japan*, **Kazunaga Tanaka**, *Waseda University, Tokyo, Japan*, **Yoshio Tsutsumi**, *Kyoto University, Japan*, and **Eiji Yanagida**, *Tohoku University, Sendai, Japan*, Editors

This volume is the proceedings of the 14th MSJ International Research Institute "Asymptotic Analysis and Singularity", which was held at Sendai, Japan in July 2005. The proceedings contain survey papers and original research papers on nonlinear partial differential equations, dynamical systems, calculus of variations and mathematical physics.

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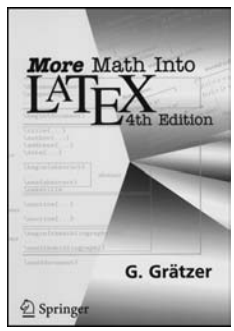
Advanced Studies in Pure Mathematics, Volume 47

October 2007, 806 pages, Hardcover, ISBN: 978-4-931469-41-9, 2000 *Mathematics Subject Classification:* 35-06; 34-06, 37-06, 46-06, 76-06, **AMS members US$50**, List US$62, Order code ASPM/47.2

General and Interdisciplinary



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George Grätzer, *University of Manitoba, Canada*

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October 2007, 650 pages, Softcover, ISBN: 978-0-387-32289-6, 2000 *Mathematics Subject Classification:* 00-XX, 68N15, **AMS members US$40**, List US$50, Order code MMLTEX

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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: March 2008–December 28, 2007; April 2008 issue–January 28, 2008; May 2008–February 28, 2008; June/July 2008 issue–April 28, 2008; August 2008 issue–May 28, 2008; September 2008 issue–June 30, 2008.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

ary 01, 2008, and will continue until both positions are filled. For more information visit the department's website at http://w3.fiu.edu/math.

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CHILE

PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE
Departamento de Matemáticas

The Department of Mathematics invites applications for two tenure-track positions at the assistant professor level beginning either March or August 2009. Applicants should have a Ph.D. in mathematics, proven research potential either in pure or applied mathematics, and a strong commitment to teaching and research. The regular teaching load for assistant professors consists of three one-semester courses per year, reduced to two during the first two years. The annual salary will be US$36,000. Please send a letter indicating your main research interests, potential collaborators in our department (http://www.mat.puc.cl), detailed curriculum vitae, and three letters of recommendation to:

Director
Departamento de Matemáticas
Pontificia Universidad Católica de Chile
Av. Vicuña Mackenna 4860
Santiago, Chile;
fax: (56-2) 552-5916;
email: mchuaqui@mat.puc.cl

For full consideration, complete application materials must arrive by May 31, 2008.

000022

GUAM

UNIVERSITY OF GUAM
Mathematics Faculty Position

Asst. Prof. Math vacancy at UOG. Ph.D. (req.) in math. Send CV, 3 ref. letters, copies of grad transcripts, GovGuam application to Chair, Math Search, HRO, UOG, Mangilao, GU 96923. Visit http://www.uog.edu/hro/GovGuamApp.pdf; http://www.uog.edu or contact Chris: crmtaita@uog9.uog.edu for app. form and more details. No email app. accepted.

000024

MEXICO

UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
Instituto de Matematicas

The Instituto de Matematicas at the Universidad Nacional Autonoma de Mexico (UNAM) in Mexico City seeks candidates for a full-time tenure-track assistant/associate professor position starting August 2008. Qualifications include two years of postdoctoral experience, effective communication skills, commitment to teaching excellence, and an active research program. Responsibilities include teaching one course each semester at the undergraduate or graduate level in a topic of interest to the candidate, and advising students. Strong research promise in one of the areas in which the Institute's members are currently active is required. Undergraduate teaching is in Spanish.

UNAM is the leading university of Mexico, among the two strongest research math institutions in Latin America. The Institute is located in the beautiful campus of UNAM in the south of Mexico City, where cultural life is intense. There are more than 60 full time researchers covering many areas of mathematics, and providing for a very pleasant atmosphere for research, which is the main activity of the Institute. More information about the Institute and the university can be found at http://www.matem.unam.mx.

Applicants are encouraged to use the service provided by AMS at http://www.mathjobs.org to submit an application consisting of AMS Cover Sheet, cover letter, curriculum vitae, teaching philosophy, professional goals, and two letters of recommendation. Letters of recommendation should be uploaded to MathJobs by the recommender, or sent directly to the address below.

Alternatively, application materials may be sent to:

Sergio Rajsbaum,
Secretaria Academica,
Instituto de Matematicas, UNAM,
Ciudad Universitaria,
D.F. 04510,
Mexico

Review of applications will begin on December 1, 2007, and will continue until the position is filled. AA/EO Employer

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SOUTH KOREA

NATIONAL INSTITUTE FOR MATHEMATICAL SCIENCES

National Institute for Mathematical Sciences (NIMS) invites applications for several postdoctorals and full-time researchers beginning in Jan, 2008, or until suitable applicants are found. We seek strong potential researchers in any field of pure and applied mathematics. The salary will be ranged from 31,000,000–39,000,000 Korean won (approx. 33,000–43,000 US$Dollars) for a postdoctoral and 49,000,000–69,000,000 Korean won (approx. 53,000–75,000 US$Dollars) for a full-time researcher. Benefits include health insurance, a family allowance, etc. and housing may be provided at no rental cost. For more information, please visit our webpage http://www.nims.re.kr.

NIMS, founded in Oct 2005, promotes interdisciplinary studies and joint research with industries as well as fundamental mathematics, aiming to contribute to our scientific technologies and industrial economic developments.

Applications should include a curriculum vitae, a publication list, and two letters of recommendation. Application materials can be submitted via email recruit@nims.re.kr or directly sent to:

Search Committee
National Institute for Mathematical Sciences
628 Daeduk-daero(385-16 Doryong-dong), 3F Tower Koreana,
Yuseong-gu, Daejeon 305-340

000012

PUBLICATIONS AVAILABLE

Introduction to Integral Equations with Applications-Revised second edition

The most applicable introductory book on integral equations "Intro to Integral Equations with Applications" by A. J. Jerri comes now in a revised second edition in 452 p. with Student's Solution Manual, both for $75.95 plus $7 S&H. Visit: http://www.stsip.org. Pay Pal payment (to Sampling Publishing account) is preferred, or email: jerria12@yahoo.com, or clarkson@bkstore.com.

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Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

New York, New York

Courant Institute of New York University

March 15–16, 2008

Saturday – Sunday

Meeting #1036

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: January 2008
Program first available on AMS website: January 31, 2008
Program issue of electronic *Notices*: March 2008
Issue of *Abstracts*: Volume 29, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 22, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Weinan E, Princeton University, *The density functional theory of electronic structure?*

William Timothy Gowers, University of Cambridge, *Title to be announced* (Erdős Memorial Lecture).

Ilya Kapovich, University of Illinois at Urbana-Champaign, *Algebraic rigidity and randomness in geometric group theory*.

Ovidiu Savin, Columbia University, *Title to be announced*.

Ravi Vakil, Stanford University, *Murphy's Law in algebraic geometry: Badly-behaved moduli spaces*.

Special Sessions

Algebraic Combinatorial Geometry (Code: SS 3A), **Julianna Tymoczko**, University of Iowa, and **Linda Chen**, Ohio State University.

Buckminster Fuller's Synergetics and Mathematics (Code: SS 5A), **Christopher J. Fearnley** and **Joe Clinton**, Synergetics Collaborative.

Computational Fluid Dynamics (Code: SS 10A), **Daljit S. Ahluwalia**, New Jersey Institute of Technology, **James G. Glimm**, State University of New York at Stony Brook, and **Jean E. Taylor**, NYU-Courant Institute.

Geometric Topology (Code: SS 7A), **Marco Varisco**, Binghamton University, SUNY, and **David Rosenthal**, St. John's University.

Isoperimetric Problems and PDE (Code: SS 6A), **Bernd Kawohl**, University of Cologne, and **Marcello Lucia**, City University of New York.

L-Functions and Automorphic Forms (Code: SS 1A), **Alina Bucur**, Massachusetts Institute of Technology, **Ashay Venkatesh**, Courant Institute of Mathematical Sciences, **Stephen D. Miller**, Rutgers University, and **Steven J. Miller**, Brown University.

Mathematics of Multiscale Phenomena (Code: SS 4A), **Peter McCoy** and **Reza Malek-Madani**, U.S. Naval Academy.

Nonlinear Elliptic Equations and Geometric Inequalities (Code: SS 2A), **Fengbo Hang**, Princeton University, and **Xiaodong Wang**, Michigan State University.

Nonlinear Waves and their Applications (Code: SS 8A), **Edward D. Farnum**, Kean University, and **Roy Goodman**, New Jersey Institute of Technology.

Northeast Hyperbolic Geometry (Code: SS 9A), **Ara Basmajian**, Hunter College and Graduate Center of the City University of New York, and **Ed Taylor**, Wesleyan University.

Baton Rouge, Louisiana

Louisiana State University, Baton Rouge

March 28–30, 2008

Friday – Sunday

Meeting #1037

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: February 2008
Program first available on AMS website: February 14, 2008
Program issue of electronic *Notices*: March 2008
Issue of *Abstracts*: Volume 29, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: February 5, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Maria Chudnovsky, Columbia University, *Even pairs in perfect graphs.*

Soren Galatius, Stanford University, *Stable homology of automorphism groups of free groups.*

Zhongwei Shen, University of Kentucky, *The celebrated Calderon-Zygmund Lemma revisited.*

Mark Shimozono, Virginia Polytechnic Institute & State University, *Schubert calculus for the affine Grassmannian.*

Special Sessions

Actions of Quantum Algebras (Code: SS 8A), **Lars Kadison**, University of Pennsylvania, and **Alexander Stolin**, University of Gothenburg/Chalmers University of Technology.

Algebraic Geometry of Matrices and Determinants (Code: SS 14A), **Zachariah C. Teitler**, Texas A&M University, and **Kent M. Neuerburg**, Southeastern Louisiana University.

Arrangements and Related Topics (Code: SS 15A), **Daniel C. Cohen**, Louisiana State University.

Current Challenges in Financial Mathematics (Code: SS 10A), **Arkadev Chatterjea**, Kenan-Flagler Business School, The University of North Carolina at Chapel Hill, and **Ambar Sengupta**, Louisiana State University.

Elementary Mathematics from an Advanced Perspective (Code: SS 11A), **James J. Madden**, Louisiana State University, and **Kristin L. Umland**, University of New Mexico.

Gauge Theory in Smooth and Symplectic Topology (Code: SS 21A), **Scott J. Baldridge** and **Brendan E. Owens**, Louisiana State University.

Geometric Group Theory (Code: SS 13A), **Noel Brady**, University of Oklahoma, **Tara E. Brendle**, Louisiana State University, and **Pallavi Dani**, University of Oklahoma.

Geometric and Combinatorial Representation Theory (Code: SS 7A), **Pramod N. Achar** and **Daniel S. Sage**, Louisiana State University.

Harmonic Analysis and Partial Differential Equations in Real and Complex Domains (Code: SS 3A), **Loredana Lanzani**, University of Arkansas, and **Zhongwei Shen**, University of Kentucky.

Knot and 3-Manifold Invariants (Code: SS 6A), **Oliver T. Dasbach** and **Patrick M. Gilmer**, Louisiana State University.

Lie Groups and Holomorphic Function Spaces: Analysis, Geometry, and Mathematical Physics (Code: SS 20A), **Brian C. Hall**, University of Notre Dame, and **Jeffrey J. Mitchell**, Robert Morris University.

Lie Groups, Lie Algebras, and Their Representations (Code: SS 18A), **Mark C. Davidson**, Louisiana State University, and **Ronald Stanke**, Baylor University.

Mathematical Modeling in Biology (Code: SS 9A), **Hongyu He**, Louisiana State University, **Sergei S. Pilyugin**, University of Florida, and **Jianjun Tian**, College of William and Mary.

Matroid Theory (Code: SS 17A), **Bogdan S. Oporowski** and **James G. Oxley**, Louisiana State University.

Nonlinear Evolution Equations of Mathematical Physics (Code: SS 5A), **Jerry L. Bona**, University of Illinois at Chicago, and **Michael M. Tom**, Louisiana State University.

Number Theory and Applications in Other Fields (Code: SS 12A), **Jorge Morales**, Louisiana State University, **Robert Osburn**, University College Dublin, and **Robert V. Perlis** and **Helena Verrill**, Louisiana State University.

Radon Transforms, Tomography, and Related Geometric Analysis (Code: SS 16A), **Fulton B. Gonzalez**, Tufts University, **Isaac Pesenson**, Temple University, **Todd Quinto**, Tufts University, and **Boris S. Rubin**, Louisiana State University.

Recent Advances in Knot Theory: Quandle Theory and Categorified Knot Invariants (Code: SS 4A), **Sam Nelson**, Pomona College, and **Alissa S. Crans**, Loyola Marymount University.

Recent Trends in Partial Differential Equations (Code: SS 23A), **Wai Yuen Chan**, Southeast Missouri State University.

Structural Graph Theory (Code: SS 2A), **Maria Chudnovsky**, Columbia University.

Wavelets, Frames, and Multi-Scale Constructions (Code: SS 22A), **Palle E. T. Jorgensen**, University of Iowa, **David R. Larson**, Texas A&M University, **Gestur Olafsson**, Louisiana State University, and **Darrin Speegle**, Saint Louis University.

White Noise Distribution Theory and Orthogonal Polynomials (Code: SS 1A), **Jeremy J. Becnel**, Stephen F. Austin State University, and **Aurel I. Stan**, The Ohio State University at Marion.

Accommodations

Participants should make their own arrangements directly with a hotel of their choice as early as possible. Special rates have been negotiated with the hotels listed below. Rates quoted do not include sales tax of 13%. The AMS is not responsible for rate changes or for the quality of the accommodations. When making a reservation, participants should state that they are with the **American Mathematical Society (AMS) Meeting at Louisiana State University (LSU)** group. Cancellation and early checkout policies vary; be sure to check when you make your reservation.

The Louisiana State University Department of Mathematics will operate a limited shuttle service from these hotels only to the meeting site (generally one trip to campus, and one return trip to the hotels per day).

Embassy Suites Hotel–Baton Rouge, 4914 Constitution Avenue, Baton Rouge, LA 70808; 225-924-6566 or 800-362-2779 (phone), 225-927-2816 (fax), US$105/two double beds or one king-sized bed; all-suites hotel with kitchen, wireless high speed Internet available, complimentary cooked-to-order breakfast and daily manager's reception, indoor pool, fitness center, full service restaurant on site; several other restaurants within walking distance; about 3.25 miles to the meeting site on campus. **Deadline for reservations is March 6, 2008**. Be sure to check cancellation and early checkout policies.

LaQuinta Inn Baton Rouge, 2333 South Acadian Thruway, Baton Rouge, LA 70808-2304, 225-924-9600 (phone), 225-924-2609 (fax); US$79/single; complimentary continental breakfast, coffee in room, outdoor pool, several restaurants within walking distance, free wireless Internet, pets welcome; about 2.25 miles to the meeting site on campus. **Deadline for reservations is March 13, 2008**. Be sure to check cancellation and early checkout policies.

Red Lion Hotel and Conference Center, 2445 South Acadian Thruway, Baton Rouge, LA 70808; 225-236-4000 (phone), 225-925-0084 (fax), US$109/single or double; free high-speed and wireless Internet, outdoor pool, fitness center, in-room coffee, restaurant/lounge on site; about 2.25 miles to the meeting site on to campus. **Deadline for reservations is February 25, 2008**. Be sure to check cancellation and early checkout policies. This is a non-smoking property.

Additionally, a very limited number of bed and breakfast type accommodations are available at the **LSU Faculty Club**, Corner of Highland Road & Raphael Semmes Drive on campus; US$70/single (one king- or queen-sized bed, twin beds upon request), suites may be available at a higher rate. Rates include continental breakfast and free parking. Call 225-578-2356 for reservations and information or send email to `fchotel@lsu.edu`.

Local Information/Maps/Restaurants

The LSU webpage is located at `http://www.lsu.edu`. You may download maps and get local information, including restaurants and campus dining. The webpage of the Department of Mathematics is `http://www.math.lsu.edu`. For dining close to campus visit `http://ligo.phys.lsu.edu/LSC2006/Restaurants.html`.

Other Activities

Book Sales: Stop by the onsite AMS Bookstore—review the newest titles from the AMS, enter the free book drawing, enjoy up to 25% off all titles or even take home the new AMS t-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS Book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

The inner part of campus has restricted access on weekdays. Parking is available at the Visitor Center, Parker Coliseums, or commuter lots off Nicholson Extension. A parking permit is required to park in these lots. Please contact the local organizer at `olafsson@math.lsu.edu` before March 1, 2008, if you are requesting a free parking permit. You will be able to pick up the permit at the Visitor Center located at the intersection of Highland Road and Dalrymple Drive upon arrival on Friday, March 28. For further parking information visit `http://appl003.lsu.edu/pubsafety/lsuparking.nsf/index`. Free parking is available close to the sessions on Saturday and Sunday

Social Event

All participants are cordially invited to a reception on Saturday evening sponsored by the Louisiana State University, Baton Rouge, Department of Mathematics. The AMS thanks the university and department for its generous hospitality.

Registration and Meeting Information

The meeting is on the main campus of Louisiana State University in Baton Rouge, Louisiana. Sessions will take place in Tureaud Hall; Invited Addresses will be in Howell-Russell.

The registration desk will be in Tureaud Hall and will be open Friday, March 28, noon–4:30 p.m. and Saturday, March 29, 7:30 a.m.–4:30 p.m. Fees are US$40 for AMS or CMS members, US$60 for nonmembers; and US$5 for students/unemployed/emeritus, payable on site by cash, check or credit card.

Travel

The nearest airport is Baton Rouge Metro/Ryan Field Airport (BTR) (8 miles away) and about a 20-minute drive from the hotels.

The directions below offer the easiest routes to the campus from the interstate.

We recommend that you visit the Visitor Information Center to obtain detailed campus directions, a parking permit, and parking instructions. **The Visitors Information Center is located at the corner of Highland Road and Dalrymple Drive**.

From I-10:

Route 1: Exit at Nicholson Dr./Highland Rd. (Exit 155A). Take Highland Rd. to Dalrymple Dr. (about 1.4 miles).

Route 2: Exit at Dalrymple Dr. (Exit 156B). Both eastbound and westbound traffic will take a right onto Dalrymple Dr. from the off-ramp. Take Dalrymple Dr. to Highland Rd. (about 0.5 mile).

Route 3: Exit at Acadian Thruway (Exit 157B). If exiting from the eastbound off-ramp you will take a right onto Acadian Thruway; if exiting from the westbound off-ramp you will take a left onto Acadian Thruway. Take Acadian Thruway (which turns into Stanford Avenue and then into LSU Avenue) to Highland Rd. Take a right onto Highland Rd. Take Highland Rd. to Dalrymple Dr. (about 1.8 miles)

Car rental

Avis is the official car rental company for the sectional meeting in Baton Rouge, Louisiana. All rates include unlimited free mileage. Special rates for this meeting are effective March 21–April 6, 2008 and begin at US$30/day for a subcompact car at the weekend rate (available from noon Thursday through Monday at 11:59 p.m.). Should a lower qualifying rate become available at the time of booking, Avis is pleased to offer a 5% discount off the lower qualifying rate or the meeting rate, whichever is lowest. Rates do not include any state or local surcharges, tax, optional coverages or gas refueling charges. Renters must meet Avis' age, driver, and credit requirements. Reservations can be made by calling 800-331-1600 or online at `http://www.avis.com`. Be sure to cite the meeting Avis Discount Number **J098887**.

Weather

Weather conditions in March in Baton Rouge are usually pleasant. Temperatures are between 50° and 70° F, and the average rainfall is five inches for the month.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at `http://www7.nationalacademies.org/visas/Traveling_to_US.html` and `http://travel.state.gov/visa/index.html`. If you need a preliminary conference invitation in order to secure a visa, please send your request to `dls@ams.org`.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

- family ties in home country or country of legal permanent residence

- property ownership

- bank accounts

- employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the websites above for the most up-to-date information.

Bloomington, Indiana

Indiana University

April 5–6, 2008

Saturday – Sunday

Meeting #1038

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2008
Program first available on AMS website: February 21, 2008
Program issue of electronic *Notices*: April 2008
Issue of *Abstracts*: Volume 29, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: February 12, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Shi Jin, University of Wisconsin, *Title to be announced.*

Michael J. Larsen, Indiana University, *Solving equations in finite groups.*

Mircea Mustata, University of Michigan, *Title to be announced.*

Margaret H. Wright, New York University-Courant Institute, *Non-derivative optimization: Mathematics, heuristics, or hack?*

Special Sessions

Algebraic Aspects of Coding Theory (Code: SS 5A), **Heide Gluesing-Luerssen**, University of Kentucky, and **Roxana Smarandache**, San Diego State University.

Algebraic K-theory and Nil groups in Algebra and Topology (Code: SS 20A), **James F. Davis**, Indiana University, and **Christian Haesemeyer**, University of Illinois at Chicago.

Applications of Ring Spectra (Code: SS 16A), **Randy McCarthy**, University of Illinois at Urbana-Champaign, and **Ayelet Lindenstrauss**, Indiana University.

Birational Algebraic Geometry (Code: SS 3A), **Mircea I. Mustata**, University of Michigan, and **Mihnea Popa**, University of Illinois at Chicago.

Combinatorial Representation Theory, Topological Combinatorics, and Interactions Between Them (Code: SS 13A), **Patricia Hersh**, Indiana University, **Cristian P. Lenart**, State University of New York at Albany, and **Michelle Wachs**, University of Miami.

Combinatorial and Geometric Aspects of Commutative Algebra (Code: SS 1A), **Juan Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

D-modules (Code: SS 14A), **Mathias Schulze**, Oklahoma State University, and **Hans Ulrich Walther**, Purdue University.

Discrete Structures in Conformal Dynamics and Geometry (Code: SS 11A), **Kevin M. Pilgrim**, Indiana University, and **William J. Floyd**, Virginia Polytech Institute & State University.

Financial Mathematics (Code: SS 22A), **Victor Goodman**, Indiana University, and **Kiseop Lee**, University of Louisville.

Finite Element Methods and Applications (Code: SS 9A), **Nicolae Tarfulea**, Purdue University Calumet, and **Sheng Zhang**, Wayne State University.

Geometry and Dynamics (Code: SS 7A), **Chris Connell**, **David M. Fisher**, and **Marlies Gerber**, Indiana University.

Graph Theory (Code: SS 17A), **Jozsef Balogh**, University of Illinois at Urbana-Champaign, **Hemanshu Kaul**, Illinois Institute of Technology, and **Tao Jiang**, Miami University.

Harmonic Analysis Methods in Mathematical Fluid Dynamics (Code: SS 21A), **Zoran Grujic** and **Irina Mitrea**, University of Virginia.

Harmonic Analysis and Related Topics (Code: SS 8A), **Ciprian Demeter**, Institute for Advance Study, and **Nets Katz**, Indiana University.

Hyperbolic and Kinetic Equations (Code: SS 2A), **Shi Jin** and **Marshall Slemrod**, University of Wisconsin.

Mathematical Modeling of Cell Motility: From Molecular Events to Mechanical Movement (Code: SS 18A), **Anastasios Matzavinos**, Ohio State University, and **Nicoleta Eugenia Tarfulea**, Purdue University Calumet.

Minimal and CMC Surfaces (Code: SS 19A), **Bruce Michael Solomon** and **Matthias Weber**, Indiana University, and **Adam Weyhaupt**, Southern Illinois University.

Operator Algebras and Applications (Code: SS 12A), **Hari Bercovici**, Indiana University, **Marius Dadarlat**, Purdue University, and **Mihai Popa**, Indiana University.

Probability and Spatial Systems (Code: SS 10A), **Russell D. Lyons**, Indiana University, and **Alexander Holroyd**, University of British Columbia.

Recent Advances in Classical and Geophysical Fluid (Code: SS 15A), **Roger Temam** and **Shouhong Wang**, Indiana University.

Some Mathematical Problems in Biology, from Macromolecules to Ecosystems (Code: SS 6A), **Santiago David Schnell** and **Roger Temam**, Indiana University.

Weak Dependence in Probability and Statistics (Code: SS 4A), **Richard C. Bradley** and **Lahn T. Tran**, Indiana University.

Accommodations

Participants should make their own arrangements directly with the property listed below. Special rates for the meeting are available at the property shown below for the period of April 4–6. The AMS is not responsible for rate changes or for the quality of the accommodations

A block of sleeping rooms has been reserved in the Indiana Memorial Union (IMU) Hotel. The IMU Hotel is located at 900 East Seventh Street, Bloomington, Indiana. The hotel is a completely modern facility located in the center of the Indiana University campus. To make your reservation, please telephone 800-209-8145. When you call please indicate that you are attending the **American Mathematical Society (AMS) Sectional Meeting at Indiana University** so that your reservation will be made within the block of rooms reserved for the meeting. Rates range from US$109 - US$249 depending on room selection plus tax. We encourage you to make your reservation by **Tuesday, March 4, 2008**, after that date any unreserved rooms will be released for sale to the general public. The IMU Hotel accepts all major credit cards.

Food Service

The Indiana Memorial Union provides a variety of food service options including six eateries and three snack shops. Food service outlets range from fast-food type service to the elegant Tudor Room for a relaxing buffet lunch.

For a city of its size, Bloomington, Indiana, has a delightful selection of ethnic restaurants. In the area immediately west of campus you will find a unique blend of ethnic restaurants including Moroccan, Indian, Japanese, Italian, Korean, in addition to several casual pubs. All are within easy walking distance of the Indiana Memorial Union

Local Information

The following webpages will prove useful as you plan your travel to Indiana University and the Bloomington community:

American Mathematical Society `http://www.ams.org`

Indiana University Bloomington `http://www.iub.edu`

Indiana Memorial Union `http://www.imu.indiana.edu`

Bloomington Community `http://www.visitbloomington.com`

Bloomington Shuttle Service `http://www.bloomingtonshuttle.com`

Indiana University is often cited as one of the most beautiful college campuses in the nation. The 1,930-acre woodland setting is a harmonious blend of natural landscape and campus buildings constructed predominantly of native limestone. More than a hundred years ago the Board of Trustees selected this woodland site to become the home of the university. The university has actively worked to preserve portions of the original woods and maintain them in their natural state. As late as the 1980's the university designated a large central campus area to the development of an arboretum. During your visit in early April spring will just be beginning.

Other Activities

AMS Book Sale: Stop by the on-site AMS Bookstore—review the newest titles from the AMS, enter the FREE book drawing, enjoy up to 25% off all titles or even take home the new AMS T-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

Parking is available in two lots adjacent to the Indiana Memorial Union, one immediately to the east of the IMU and a second just across Seventh Street to the north. Both of these lots are complimentary for IMU Hotel guests. The daily charge for non-IMU Hotel guests is currently a maximum of US$20/day.

Registration and Meeting Information

The meeting will be held in the Indiana Memorial Union (IMU) situated in the heart of the woodland campus of Indiana University-Bloomington. The IMU is the world's largest student union.

The registration desk will be located in the Conference Lounge on the Mezzanine Level of the Indiana Memorial Union. The desk will be open Saturday, April 5, from 7:30 a.m. until 4:00 p.m. and Sunday, April 6, from 7:30 a.m. until noon. Fees are US$40 for AMS or CMS members, US$60 for nonmembers; and US$5 for students/unemployed/emeritus, payable on site by cash, check or credit card.

Transportation

The nearest major commercial airport is the Indianapolis International Airport. The Indianapolis Airport is located approximately 45 miles from Indiana University. Travel time to the Indianapolis Airport is about one hour to one hour and fifteen minutes. All major auto rental agencies are represented at the Indianapolis Airport.

Shuttle service from the Indianapolis Airport to the Indiana Memorial Union (IMU) is conveniently provided via Bloomington Shuttle Service. Bloomington Shuttle Service operates on a fixed schedule arriving and departing the IMU nine times each day. The shuttle departs from the Ground Transportation Center located on the baggage claim level of the Indianapolis Airport. To make your reservation please telephone 800-589-6004. The current charge is US$25 one way. Travel time from the airport is approximately one hour and fifteen minutes. To view a complete schedule and make your reservation online, please visit the Bloomington Shuttle Service webpage at `http://www.Bloomingtonshuttle.com`.

If your travel schedule does not permit the use of the Bloomington Shuttle Service, you may arrange door-to-door service through Signature Limousine Service. This service is also operated by Bloomington Shuttle Service at the number listed above.

Car rental: Special rates have been negotiated with Avis Rent A Car for the period March 28 to April 13, 2008, beginning at US$30/day for a subcompact car at the weekend rate (the weekend rate is available from noon Thursday until midnight Monday) All rates include unlimited free mileage. Rates do not include state or local surcharges, tax, optional coverages, or gas refueling charges. Renter must meet Avis' age, driver, and credit requirements, and return to the same renting location. Make reservations by calling 800-331-1600 or online at `http://www.avis.com`. Please quote Avis Discount Number **JO98887** when making reservations.

Driving to Indiana University

From the South: The best route is from Louisville, Kentucky. Take I-65, the four-lane interstate, north from Louisville to Columbus, Indiana. (Approximately a one hour drive.)

From Columbus, take Indiana Highway 46 west to Bloomington. (State highway is two-lane and winds through the hills.) Travel east approximately one hour to Bloomington. Upon entering the commercial and residential district, Highway 46 becomes East Third Street. Continue heading west on Third Street through the stoplights at K-Mart/Marsh Supermarket, College Mall Road (Shell Station/Red Lobster), Eastland Plaza, High Street, Jordan Avenue. (Third Street becomes one-way street heading west between the High Street and Jordan Avenue stoplights.) Turn right (north) at Indiana Avenue, the next stoplight. Indiana is a one-way street going north. Go three blocks to the second stop sign (3-way stop), which is intersection of Seventh and Indiana. Turn right (east) on Seventh. Turn right at the second stop sign, into the Indiana Memorial Union circle drive/parking lot.

From the West: From St. Louis and points west, take Interstate 70 east to Terre Haute.

From Terre Haute, take Indiana Highway 46 east to Bloomington. (State highway is two-lane and winds through the hills.) Travel east approximately one hour to Bloomington. Westbury Village will be on the left (north) of the road as it crosses over Highway 37 and leads into Bloomington. Highway 46 becomes 17th Street at this point. Once you have entered Bloomington, continue to the second stoplight (College Avenue). College is one-way going south. Turn right on College and continue to 7th Street. Turn left (east) on 7th Street. Continue through the four-way and three-way stops (approximately eight blocks) to the Indiana Memorial Union.

From Evansville, IN, take Highway 41 north to Terre Haute. See directions above.

From the North: From Chicago, take Interstate 65 to Indianapolis. Take 465 Bypass southwest to Highway 37. From Detroit/Lansing areas, take Highway 69 to Indianapolis. Take 465 Bypass southeast to Highway 37.

From Indianapolis, take Indiana Highway 37 (four-lane state highway with many series of stoplights) south. Travel south for approximately one hour to the first Bloomington exit (College Avenue/Business 37 exit). Continue south on College as it becomes one-way. Turn left (east) on 7th Street. Follow directions listed above in Terre Haute entry.

From the East: From Columbus, OH, take Interstate 70 to Indianapolis. Take 465 Bypass south to Highway 37. From Cincinnati, OH, take Interstate 74 to Indianapolis. Take 465 Bypass south to Highway 37. Follow directions listed above from Indianapolis.

Weather

Early April temperatures normally range from a daily high of 63° F to a low of 42° F. Spring also tends to be a rainy time of year, so be sure and bring an umbrella or raincoat.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at `http://www7.nationalacademies.org/visas/Traveling_to_US.html` and `http://travel.state.gov/visa/index.html`. If you need a preliminary conference invitation in order to secure a visa, please send your request to `dls@ams.org`.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

- family ties in home country or country of legal permanent residence
- property ownership
- bank accounts
- employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the websites above for the most up-to-date information.

Claremont, California

Claremont McKenna College

May 3–4, 2008

Saturday – Sunday

Meeting #1039

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: March 2008
Program first available on AMS website: March 20, 2008
Program issue of electronic *Notices*: May 2008
Issue of *Abstracts*: Volume 29, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: January 15, 2008
For abstracts: March 11, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael Bennett, University of British Columbia, *Title to be announced.*

Chandrashekhar Khare, University of Utah, *Title to be announced.*

Huaxin Lin, University of Oregon, *Title to be announced.*

Anne Schilling, University of California Davis, *Title to be announced.*

Special Sessions

Algebraic Combinatorics (Code: SS 9A), **Anne Schilling**, University of California Davis, and **Michael Zabrocki**, York University.

Applications of Delay-Differential Equations to Models of Disease (Code: SS 8A), **Ami Radunskaya**, Pomona College.

Combinatorics of Partially Ordered Sets (Code: SS 6A), **Timothy M. Hsu**, San Jose State University, **Mark J. Logan**, University of Minnesota-Morris, and **Shahriar Shahriari**, Pomona College.

Diophantine Problems and Discrete Geometry (Code: SS 3A), **Matthias Beck**, San Francisco State University, and **Lenny Fukshansky**, Texas A&M University.

Dynamical Systems and Differential Equations (Code: SS 1A), **Adolfo Rumbos**, Pomona College, **Mario Martelli**, Claremont McKenna College, and **Alfonso Castro**, Harvey Mudd College.

Hopf Algebras and Quantum Groups (Code: SS 5A), **Gizem Karaali**, Pomona College, **M. Susan Montgomery**, University of Southern California, and **Serban Raianu**, California State University Dominguez Hills.

Knot Theory and the Topology of 3-manifolds (Code: SS 7A), **Sam Nelson**, Pomona College, **David Bachman**, Pitzer College, **Erica Flapan**, Pomona College, **Jim Hoste**, Pitzer College, and **Patrick Shanahan**, Loyola Marymount University.

Operators, Functions and Linear Spaces (Code: SS 2A), **Asuman G. Aksoy**, Claremont McKenna College, **Stephan R. Garcia**, Pomona College, **Michael Davlin O'Neill**, Claremont McKenna College, and **Winston C. Ou**, Scripps College.

Recent Developments in Riemannian and Kaehlerian Geometry (Code: SS 4A), **Hao Fang**, University of Iowa, **Zhiqin Lu**, University of California, Irvine, **Dragos-Bogdan Suceava**, California State University Fullerton, and **Mihaela B. Vajiac**, Chapman University.

Rio de Janeiro, Brazil

Instituto Nacional de Matemática Pura e Aplicada (IMPA)

June 4–7, 2008

Wednesday – Saturday

Meeting #1040

First Joint International Meeting between the AMS and the Sociedade Brasileira de Matemática (SBM).
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: February 2008
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: January 31, 2008
For abstracts: January 31, 2008
The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

AMS Invited Addresses

Ruy Exel, Universidade Federal de Santa Catarina, *Noncommutative dynamics*.

Velimir Jurdjevic, University of Toronto, *Integrable Hamiltonian systems on symmetric spaces*.

Andre Nachbin, IMPA, *Wave dynamics: Asymptotics with differential operators and solutions*.

Richard M. Schoen, Stanford University, *Riemannian manifolds of positive curvature*.

Ivan P. Shestakov, University of Sao Paulo, *Automorphisms of free algebras*.

Amie Wilkinson, Northwestern University, *Partially hyperbolic dynamics*.

AMS Special Sessions

Commutative Algebra and Algebraic Geometry, **Izzet Coskun**, University of Illinois at Chicago, and **Israel Vainsencher**, UFMG.

Complexity, **Gregorio Malajovich**, Universidade Federal do Rio de Janeiro, **J. Maurice Rojas**, Texas A&M University.

Control and Related Topics, **Jair Koiller**, FGV, and **Velimir Jurdgevic**, University of Toronto.

Extremal and Probablistic Combinatorics, **Bela Bollobas**, The University of Memphis, and **Yoshiharu Kohayakawa**, University of Sao Paulo.

Geometry, Representation Theory, and Mathematical Physics, **Henrique Bursztyn**, IMPA, **Anthony Licata**, Stanford University, and **Alistair Savage**, University of Ottawa.

Group Theory, **Rostislav I. Grigorchuk**, **Volodymyr Nekrashevych**, and **Zoran Sunic**, Texas A&M University, and **Said N. Sidki** and **Pavel Zalesskii**, University of Brasilia.

History and Philosophy of Mathematics, **Sergio Nobre**, Universidade Estadual Paulista-Rio Claro, and **James J. Tattersall**, Providence College.

Lie and Jordan Algebras and Their Applications, **Ivan K. Dimitrov**, Queen's University, **Vyacheslav Futorny**, University of Sao Paulo, and **Vera Serganova**, University of California Berkeley.

Low Dimensional Dynamics, **Andre de Carvalho**, University of Sao Paulo, and **Misha Lyubich** and **Marco Martens**, SUNY at Stony Brook.

Low Dimensional Topology, **Louis H. Kauffman**, University of Illinois at Chicago, and **Pedro M. Lopes**, Instituto Superior Tecnico, Technical University of Lisbon.

Mathematical Fluid Dynamics, **Susan J. Friedlander**, University of Southern California, **Milton Lopes Filho** and **Helena Nussenzveig Lopes**, University of Campinus, and **Maria Elena Schonbek**, University of California Santa Cruz.

Mathematical Methods in Image Processing, **Stacey Levine**, Duquesne University, and **Celia A. Zorzo Barcelos**, Federal University of Uberlândia.

Nonlinear Dispersive Equations, **Felipe Linares**, Institute for Pure-Applied Mathematics, and **Gustave A. Ponce**, University of California Santa Barbara.

Partial Differential Equations, Harmonic Analysis, and Related Questions, **Haroldo R. Clark**, Universidade Federal Fluminense, **Michael Stessin**, University at Albany, and **Geraldo Soares de Souza**, Auburn University.

Several Complex Variables and Partial Differential Equations, **Shiferaw Berhanu**, Temple University, and **Jorge Hounie**, Federal University of San Carlos.

Please watch the website maintained by the local organizers for the most up-to-date information. Please note that when dialing the telephone numbers listed below from the U.S., one should dial 011 to connect to the international network, then 55 (country code for Brazil), then 21 (Rio de Janeiro city code).

Abstracts Submission

Talks in Special Sessions are generally by invitation of the organizers. It is recommended that you contact an organizer before submitting an abstract for a Special Session. Talks should be of 30 minutes duration, unless an invitation to give a longer plenary or keynote talk has been given. For those not speaking in a Special Session, there will be a poster session.

Abstracts for talks and posters must be submitted through the AMS website at http://www.ams.org/cgi-bin/abstracts/abstract.pl. The submission deadline for all abstracts is January 31.

Conference Location

All scientific sessions and events will take place at the Instituto Nacional de Matemática Pura e Aplicada (IMPA), Estrada D. Castorina 110, Jardim Botanico, Rio de Janeiro, RJ 22460-320, Brazil, telephone 011-55-21-2529-5000, fax: 011-55-21-2512-4115, email: info@impa.br; from Wednesday through Saturday, June 4–7, 2008. IMPA is located near the lovely botanical gardens in Rio.

Local Information/Tourism

See http://www.impa.br/opencms/en/institucional/localizacao.html for a local map. There are many websites that offer general information about Brazil and Rio de Janeiro: its history, culture, and traveler's tips. You may wish to view several of the links found at http://www.fodors.com, http://www.lonelyplanet.com/worldguide/destinations/south-america/brazil/rio-de-janeiro/, http://www.world66.com/southamerica/brazil/riodejaneiro, http://www.wikitravel.org/en/Rio_de_Janeiro_(city).

Exchange rates at the time this announcement went to press were US$1= R$1.78 (Brazilian Real). See http://www.oanda.com/convert/classic for up-to-date rates.

The majority of ATMs only accept Brazilian-issued credit and debit cards. The ATMs at the international airport work, sometimes, but if they don't, you should exchange cash for the local currency (reals) at the airport kiosk to get taxi fare. Banks usually give the best rates; however, as in any large, metropolitan world-class city, it is not advisable to carry large amounts of cash on your person.

Accommodations, Registration, and Conference Dinner

On-line registration is available at http://www.impa.br/opencms/pt/eventos/store/evento_0021.html. The registration fee will be US$50 (or R$90) for post-docs or professors and US$20 (or R$36) for students to be paid at the conference site. Unfortunately no credit cards or international checks can be accepted. All participants are encouraged to register in advance and as early as possible so that appropriate arrangements can be made for hotel accommodations. See http://www.impa.br/opencms/pt/institucional/informacoes_hoteis (in Portuguese) for general information about hotels. Details on the official meeting hotels will be published at a later date. Hotel reservations for the duration of the event may be contracted through micheleleite@cmoeventos.com.br.

During the conference, complete meals at various prices are available during lunchtime in the IMPA cafeteria. Snack foods and sandwiches are available throughout the day.

The conference dinner will be held on Thursday, June 5. Location and cost will be announced at a later date.

Travel

Visitors from North America (Canada, Mexico, and the United States) who are not citizens of the European Union or Mercosur (Southern Common Market) countries are required to have visas to enter Brazil; the cost for a visa is US$100, subject to change. You should contact the Brazilian Consulate nearest to you (see http://www.brasilemb.org/consulado/consular_jurisdictions.shtml for the current list) as soon as possible, as procedures vary by consulate. If you find that you need a letter of invitation, please request one from Mrs. Suely Lima at IMPA at dac@impa.br.

Participants should plan to arrive at Galeão-Antonio Carlos Jobim International Airport (GIG). See http://www.worldairportguide.com/airport/405/airport_guide/South-America/Rio-de-Janeiro-Gale%E3o-Antonio-Carlos-Jobim-International-Airport.html for information about the airport and its services.

It is suggested that you take a taxi to IMPA or your hotel. You are advised to use the official taxis available at the airport booths before exiting the restricted area just after customs. The cost is about R$80.

Weather

While June is the beginning of the winter in Brazil, temperatures usually range from 66° F to 77° F, with rainfall of about 3.2 inches for the month, so there are lots of sunny days without much humidity.

Vancouver, Canada

University of British Columbia and the Pacific Institute of Mathematical Sciences (PIMS)

October 4–5, 2008
Saturday – Sunday

Meeting #1041
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2008
Program first available on AMS website: August 21, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines
For organizers: March 9, 2008
For consideration of contributed papers in Special Sessions: June 17, 2008
For abstracts: August 12, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses
Freeman Dyson, Institute for Advanced Study, *Birds and Frogs* (Einstein Public Lecture in Mathematics).

Richard Kenyon, University of British Columbia, *Title to be announced*.

Alexander S. Kleshchev, University of Oregon, *Title to be announced*.

Mark Lewis, University of Alberta, *Title to be announced*.

Audrey A. Terras, University of California San Diego, *Title to be announced*.

Special Sessions
Algebraic Topology and Related Topics (Code: SS 3A), **Alejandro Adem**, University of British Columbia, and **Stephen Ames Mitchell**, University of Washington.

Combinatorial Representation Theory (Code: SS 1A), **Sara C. Billey**, University of Washington, **Alexander S. Kleshchev**, University of Oregon, and **Stephanie Jane Van Willigenburg**, University of British Columbia.

Hilbert Functions and Free Resolutions (Code: SS 4A), **Susan Cooper**, California Polytechnic State University, **Christopher A. Francisco**, Oklahoma State University, and **Benjamin P. Richert**, California Polytechnic State University.

Special Functions and Orthogonal Polynomials (Code: SS 2A), **Mizanur Rahman**, Carleton University, and **Diego Dominici**, State University of New York New Paltz.

Wavelets, Fractals, Tilings and Spectral Measures (Code: SS 5A), **Dorin Ervin Dutkay**, University of Central Florida, **Palle E. T. Jorgensen**, University of Iowa, **Ozgur Yilmaz**, University of British Columbia.

Middletown, Connecticut

Wesleyan University

October 11–12, 2008
Saturday – Sunday

Meeting #1042
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2008
Program first available on AMS website: August 28, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines
For organizers: March 11, 2008
For consideration of contributed papers in Special Sessions: June 24, 2008
For abstracts: August 19, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Special Sessions
Algebraic Geometry (Code: SS 1A), **Eyal Markman** and **Jenia Tevelev**, University of Massachusetts, Amherst.

Complex geometry and partial differential equations. (Code: SS 3A), **Zhiqin Lu**, University of California, Irvine, and **Jacob Sturm**, Rutgers University.

Number Theory (Code: SS 4A), **Wai Kiu Chan** and **David Pollack**, Wesleyan University.

Riemannian and Lorentzian Geometries (Code: SS 2A), **Ramesh Sharma**, University of New Haven, and **Philippe Rukimbira**, Florida International University.

Kalamazoo, Michigan

Western Michigan University

October 17–19, 2008
Friday – Sunday

Meeting #1043
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2008
Program first available on AMS website: September 4, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines
For organizers: March 17, 2008

For consideration of contributed papers in Special Sessions: July 1, 2008
For abstracts: August 26, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

M. Carme Calderer, University of Minnesota, *Title to be announced.*

Alexandru Ionescu, University of Wisconsin, *Title to be announced.*

Boris S. Mordukhovich, Wayne State University, *Title to be announced.*

David Nadler, Northwestern University, *Title to be announced.*

Special Sessions

Nonlinear Analysis and Applications (Code: SS 1A), **S. P. Singh**, University of Western Ontario, and **Bruce B. Watson**, Memorial University.

Huntsville, Alabama

University of Alabama, Huntsville

October 24–26, 2008

Friday – Sunday

Meeting #1044

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: August 2008
Program first available on AMS website: September 11, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines

For organizers: March 24, 2008
For consideration of contributed papers in Special Sessions: July 8, 2008
For abstracts: September 2, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Mark Behrens, Massachusetts Institute of Technology, *Title to be announced.*

Anthony Michael Bloch, University of Michigan, Ann Arbor, *Title to be announced.*

Roberto Camassa, University of North Carolina, Chapel Hill, *Title to be announced.*

Mark V. Sapir, Vanderbilt University, *Title to be announced.*

Shanghai, People's Republic of China

Fudan University

December 17–21, 2008

Wednesday – Sunday

Meeting #1045

First Joint International Meeting Between the AMS and the Shanghai Mathematical Society
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: June 2008
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: February 1, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses

L. Craig Evans, University of California Berkeley, *Title to be announced.*

Zhi-Ming Ma, Chinese Academy of Sciences, *Title to be announced.*

Richard Schoen, Stanford University, *Title to be announced.*

Richard Taylor, Harvard University, *Title to be announced.*

Xiaoping Yuan, Fudan University, *Title to be announced.*

Weiping Zhang, Chern Institute, *Title to be announced.*

Special Sessions

Biomathematics: Newly Developed Applied Mathematics and New Mathematics Arising from Biosciences, **Banghe Li**, Chinese Academy of Sciences, **Reinhard C. Laubenbacher**, Virginia Bioinformatics Institute, and **Jianju Tian**, College of William and Mary.

Combinatorics and Discrete Dynamical Systems, **Reinhard C. Laubenbacher**, Virginia Bioinformatics Institute, **Klaus Sutner**, Carnegie Mellon University, and **Yaokun Wu**, Shanghai Jiao Tong University.

Dynamical Systems Arising in Ecology and Biology, **Qishao Lu**, Beijing University of Aeronautics & Astronautics, and **Zhaosheng Feng**, University of Texas-Pan American.

Harmonic Analysis and Partial Differential Equations with Applications, **Yong Ding**, Beijing Normal University, and **Guo-Zhen Lu**, Wayne State University.

Integrable System and Its Applications, **En-Gui Fan**, Fudan University, **Sen-Yue Lou**, Shanghai Jiao Tong University and Ningbo University, and **Zhi-Jun Qiao**, University of Texas-Pan American.

Integral and Convex Geometric Analysis, **Deane Yang**, Polytechnic University, and **Jiazu Zhou**, Southwest University.

Nonlinear Systems of Conservation Laws and Related Topics, **Gui-Qiang Chen**, Northwestern University, and **Shuxing Chen** and **Yi Zhou**, Fudan University.

Quantum Algebras and Related Topics, **Naihuan N. Jing**, North Carolina State University, **Quanshui Wu**, Fudan University, and **James J. Zhang**, University of Washington.

Recent Developments in Nonlinear Dispersive Wave Theory, **Jerry Bona**, University of Illinois at Chicago, **Bo Ling Guo**, Institute of Applied Physics and Computational Mathematics, **Shu Ming Sun**, Virginia Polytech Institute and State University, and **Bingyu Zhang**, University of Cincinnati.

Stochastic Analysis and its Application, **Jiangang Ying**, Fudan University, and **Zhenqing Chen**, University of Washington.

Washington, District of Columbia

Marriott Wardman Park Hotel and Omni Shoreham Hotel

January 5–8, 2009

Monday – Thursday

Meeting #1046

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), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Bernard Russo
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 1, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Urbana, Illinois

University of Illinois at Urbana-Champaign

March 27–29, 2009

Friday – Sunday

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 29, 2008
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

Geometric Group Theory (Code: SS 2A), **Sergei V. Ivanov**, **Ilya Kapovich**, **Igor Mineyev**, and **Paul E. Schupp**, University of Illinois at Urbana-Champaign.

q-Series and Partitions (Code: SS 1A), **Bruce Berndt**, University of Illinois at Urbana-Champaign.

Raleigh, North Carolina

North Carolina State University

April 4–5, 2009

Saturday – Sunday

Southeastern Section
Associate secretary: Matthew Miller
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 4, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

San Francisco State University

April 25–26, 2009

Saturday – Sunday

Western Section

Associate secretary: Michel L. Lapidus

Announcement issue of *Notices*: To be announced

Program first available on AMS website: To be announced

Program issue of electronic *Notices*: To be announced

Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 25, 2008

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Worcester, Massachusetts

Worcester Polytechnic Institute

April 25–26, 2009

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 25, 2008

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Waco, Texas

Baylor University

October 16–18, 2009

Friday – Sunday

Central Section

Associate secretary: Susan J. Friedlander

Announcement issue of *Notices*: To be announced

Program first available on AMS website: To be announced

Program issue of electronic *Notices*: To be announced

Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 17, 2009

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Boca Raton, Florida

Florida Atlantic University

October 30 – November 1, 2009

Friday – Sunday

Southeastern Section

Associate secretary: Matthew Miller

Announcement issue of *Notices*: To be announced

Program first available on AMS website: To be announced

Program issue of electronic *Notices*: To be announced

Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 30, 2009

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Riverside, California

University of California

November 7–8, 2009

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: April 6, 2009

For consideration of contributed papers in Special Sessions: To be announced
For abstracts: 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), with sessions contributed by the Society of Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
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 1, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lexington, Kentucky

University of Kentucky

March 27–28, 2010
Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 28, 2009
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 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), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
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 1, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Boston, Massachusetts

John B. Hynes Veterans Memorial Convention Center, Boston Marriott Hotel, and Boston Sheraton Hotel

January 4–7, 2012, *Wednesday – Saturday*
Joint Mathematics Meetings, including the 118th Annual Meeting of the AMS, 95th 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), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2011
Program first available on AMS website: November 1, 2011
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 33, Issue 1

Deadlines

For organizers: April 1, 2011

For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 9–12, 2013, *Wednesday – Saturday*

Joint Mathematics Meetings, including the 119th Annual Meeting of the AMS, 96th 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), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

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: April 1, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center

January 15–18, 2014, *Wednesday – Saturday*

Joint Mathematics Meetings, including the 120th Anual Meeting of the AMS, 97th 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, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Matthew Miller
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 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: susan@math.nwu.edu; telephone: 312-996-3041.

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: Matthew Miller, Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001, e-mail: miller@math.sc.edu; telephone: 803-777-3690.

2009 Washington, DC, Meeting: Bernard Russo, Department of Mathematics, University of California, Irvine, CA 92697-3875, e-mail: brusso@math.uci.edu; telephone: 949-824-5505.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at www.ams.org/meetings/.**

Meetings:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 95 in the January 2008 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

Co-sponsored conferences:

February 14–18, 2008: AAAS Meeting, Boston MA.

June 30–July 3, 2008: Tenth Conference on p-adic and Non-Archimedean Analysis, Michigan State University. See http://bt.pa.msu.edu/NA08/ for more information.


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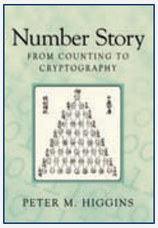

Number Story

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P. M. Higgins, University of Essex, UK

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2008. XII, 324 p. 33 illus. (Copernicus) Hardcover
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Complex Analysis

In the Spirit of Lipman Bers

J. P. Gilman, Rutgers University, Newark, NJ, USA; **I. Kra**, Math for America, New York, NY, USA; **R. E. Rodriguez**, Pontificia Università Catolica de Chile, Santiago, Chile

The authors' aim is to present a precise and concise treatment of those parts of complex analysis that should be familiar to every research mathematician. They follow a path in the tradition of Ahlfors and Bers by dedicating the book to a very precise goal: the statement and proof of the Fundamental Theorem for functions of one complex variable. They discuss the many equivalent ways of understanding the concept of analyticity, and offer a leisure exploration of interesting consequences and applications.

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S. M. Srivastava, Indian Statistical Institute, Kolkata, India

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The Interactive Geometry

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U. H. Kortenkamp, Pädagogische Hochschule, Schwäbisch Gmünd, Germany;
J. Richter-Gebert, Technische Universität, München, Germany

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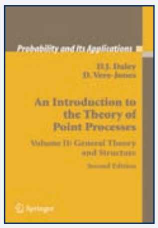

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