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of the American Mathematical Society

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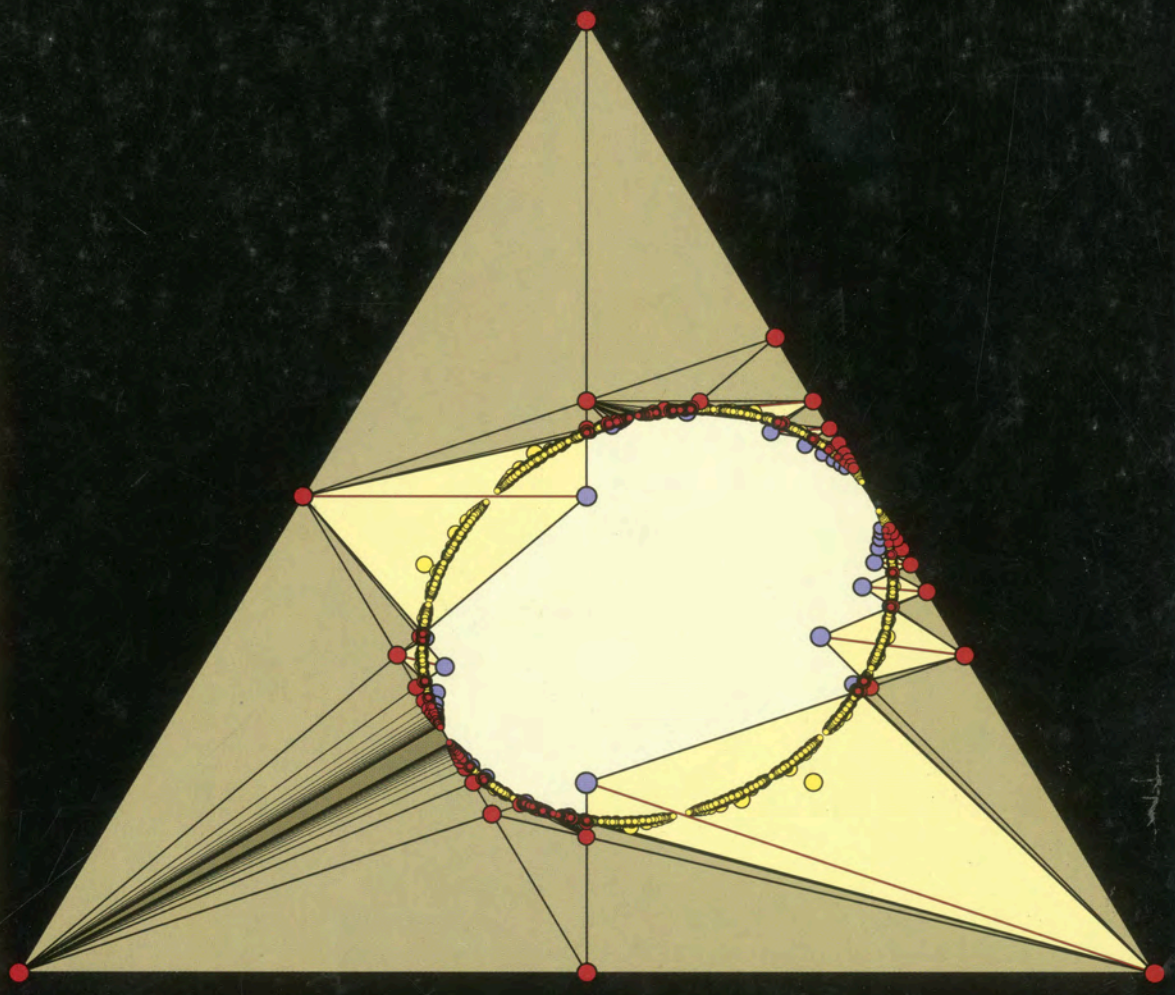

The Canonical Decomposition Configuration (see page 198)

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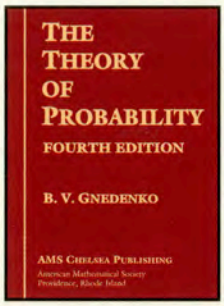

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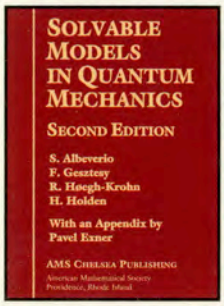

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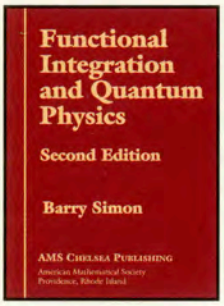

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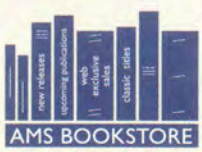

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EINSTEIN STUDIES, VOL. 11

Harmonic Analysis, Signal Processing, and Complexity

Festschrift in Honor of the 60th Birthday of Carlos A. Berenstein

IRENE SABADINI, *Politecnico di Milano, Italy; and* **DANIELE C. STRUPPA** *and* **DAVID F. WALNUT,** *both, George Mason University, Fairfax, VA (Eds.)*

Carlos A. Berenstein has had a profound influence on scholars and practitioners alike amid a distinguished mathematical career spanning nearly four decades. This volume, which celebrates his sixtieth birthday, reflects his research interests and contains original and survey articles covering topics in harmonic and complex analysis, as well as signal processing.

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Notices

of the American Mathematical Society

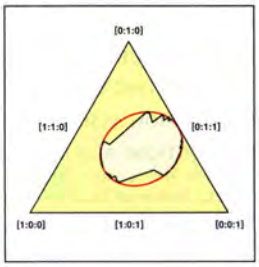
February 2005

Feature Articles

200 Quiver Representations

Harm Derksen and Jerzy Weyman

A quiver is a directed graph, and a representation of a quiver is a collection of finite dimensional vector spaces, one for each graph vertex, and linear transformations, one for each directed edge. Representations of a given quiver form a category, which, as the authors discuss, can be surprisingly rigid and rich.



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Patricia Clark Kenschaft

The author argues that societal imperatives, particularly in minority education, necessitate improving the mathematical competence of elementary school teachers, and she shares her own experiences in so doing.

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Gambling with U.S. Science

The election and its polarizing debates are over, but basic research still plays a central role in sustaining U.S. leadership in science and in creating high-wage jobs. The formula is as certain as it gets in economics: research investments spark innovation, which fosters productivity and job growth, which drive the economy. Yet budget pressures and the lack of a national science and technology strategy are driving down federal investments in research. This is a dangerous gamble at a time when the stakes could not be higher.

U.S. leadership in science and technology used to be a foregone conclusion. No longer. The European Union, China, Japan, India, Russia, and other nations are rapidly building scientific capabilities that rival ours—as evidenced by more U.S. companies moving science and engineering jobs and facilities offshore and by fewer international students applying for U.S. graduate programs in science and engineering.

Is our technological leadership slipping? If so, how will that affect our ability to generate future breakthroughs and high-wage jobs? These questions are not being asked often enough in Washington, D. C. Instead, the president's budget request cuts basic research at the Departments of Energy and of Defense, and the House of Representatives recently slashed National Science Foundation research. Because these agencies dominate federal investments in nonmedical research, our elected leaders are running a very risky national experiment at a pivotal time in U.S. history.

Like a thoroughbred in a race without a finish line, science runs nonstop for the American people. Our military supremacy, industrial strength, and quality of life depend heavily on it. However, if we leave critical areas unexplored, we will fall back in science and create a void other nations are certain to fill. To keep pace, we must make sustained and smart investments in basic research.

The trend toward flat research budgets is troubling because basic research supported by NSF and other agencies ensures a steady stream of scientific discoveries that can transform entire industries and even create new ones. While the nation's sluggish job growth is gaining much attention, too little attention is being paid to America's longstanding reliance on innovative new industries to create high-wage jobs. No one knows which next big innovation will produce a wave of new jobs, although biotechnology, nanotechnology, and renewable energy are strong contenders. But we do know that major job-producing innovations stem from strong basic research investments.

The American public believes in job growth through innovation. In fact, in a recent poll, more than 70% of Americans said the nation spends too little on basic research. If the United States is to continue to lead the way in the creation of new technologies and jobs, we can't afford to put federal research on hold. Today, federal research investment is less than 1% of GDP—less than half the rate of the 1960s. In other nations, the rate is much higher.

In a competitive global market, where corporate time horizons are measured in months rather than years, companies simply cannot provide substantial support for long-term, high-risk research. This is why the government plays such a dominant, irreplaceable role in basic research.

The current budget deficit is clearly a major concern. But cutting investments that eventually generate the growth and revenue sought by policymakers is not the way to solve deficit problems. Cutting basic research is like cutting your child's education fund during tough times: it will compound the problem over the long haul.

In 1950, *Popular Mechanics* predicted that "computers in the future may weigh no more than 1.5 tons." Today, PDAs have more computing power than NASA mission control had during the Apollo program. We simply have seen too many amazing technological advances not to anticipate the many that lie ahead.

Steps lost in scientific leadership are difficult to regain. So we must ask: Will our nation make the research investments needed to stay a competitive step ahead in the global economy? Or will we hold back and take our chances? Let's not roll the dice.

—Charles P. Casey, president
American Chemical Society

—Helen R. Quinn, president
American Physical Society

—Robert D. Wells, past president
Federation of American Societies for Experimental Biology

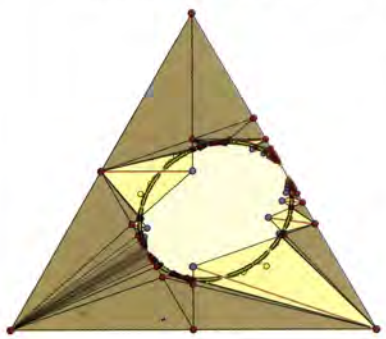
—David Eisenbud, president
American Mathematical Society

About the Cover

The Canonical Decomposition Configuration

This month's cover accompanies the article by Harm Derksen and Jerzy Weyman in this issue and amounts to an elaboration of figures in that article and also in *On the canonical decomposition of quiver representations* (Comp. Math. **133**) by the same two authors. It illustrates how the canonical decomposition of dimension vectors works in different geometrical regions of two-dimensional projective space. The interior of the ellipse (the Tits cone) represents imaginary roots. The nodes represent individual roots—yellow for ordinary real roots, red for Schur roots, blue for certain important imaginary roots. The darker outer triangles, whose vertices are Schur roots, are what Derksen and Weyman call compartments: inside one of these, the canonical decomposition involves exactly the triangle's vertices. In the lighter inner triangles the canonical decomposition is mixed real and imaginary. In the interior region the canonical decomposition is just a single imaginary root. The algorithm for generating the picture was explained to me by Derksen and is based on the principal theorem of *Exceptional sequences of representations of quivers* (Can. Math. Soc. Conf. Proc. **14**) by William Crawley-Boevey. This algorithm suitably modified seems also to be the most efficient way to generate Schur roots. Not all of the patterns seen in this diagram and similar ones for other quivers seem to be perfectly understood. One interesting problem suggested is that of describing the statistical distribution of real roots. For quivers with hyperbolic links the distribution seems to be a kind of Cantor dust spread around the Tits cone.

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



Ph.D.'s and the K–12 Classroom

At the end of Andy Magid's Letter from the Editor, p. 1184 of the November 2004 *Notices*, he mentions the issue of how mathematicians can contribute to K–12 education and invites personal experiences from readers of the *Notices*. First, I'd like to ask a question: when there are so many unemployed math Ph.D.'s and at a time when public schools are crying that they don't have enough teachers, why is it that these schools aren't making more of an effort to recruit math Ph.D.'s? I don't really want that question answered: I want to see the recruitment. It is obvious why most math Ph.D.'s would not want to teach in public schools. The conditions of such employment tend to select the kind of person who does want to teach there. I had a class nearly full of them a few years ago at Ohio State University. This was after the state legislature had enacted a reform that, among other things, required that future high school teachers display competence as majors in their own subjects and only take education courses in graduate school. Formerly, apparently, they could graduate by taking courses in how to teach mathematics without actually knowing any.

It was in everybody's interest to defeat this reform: (1) The nature of the working conditions in public schools guaranteed that the same caliber of people as before would want to teach in them and be able to survive there; (2) In particular, they were not capable of proving themselves as math majors; (3) The department nevertheless had to graduate expected numbers of them or else be yelled at by the same people who had told them to raise their standards. So, reform was cynically defeated by an unofficial policy of social promotion for math majors, even though that policy tended to pollute the very waters from which the university drew its students. I had, for example, future high school teachers who did not know how to bisect a line segment with straightedge and compass but were somehow expected to learn non-Euclidean geometry at the level of math majors.

There are some public school systems that have policies for rehabilitating Ph.D.'s to enable them to teach in their schools. It is called training, and its purpose is to render the Ph.D. indistinguishable, from the standpoint of quality control, from his/her colleague who doesn't know how to bisect a line segment. The only remaining distinctions between them have to do with salary and perhaps status. So, my second question is: why, in addition to not actively recruiting math Ph.D.'s, do schools not take advantage of their special capabilities when they do get them? I, for one, would like to see experimental programs in high schools in which they do hire math Ph.D.'s and let them educate in their own way, instead of reconstructing them in the image of what used to be their weakest students. What better preparation can the students get for college than to experience the kind of teacher they are likely to have there? Instead, many colleges are reversing the process and increasingly giving students the same kind of teachers they had in high school, both in educational philosophy and in ability.

—Allan Adler

(Received October 20, 2004)

The Two-Body Problem

I am writing in response to the pair of articles "Has the Women-in-Mathematics Problem Been Solved?" by Allyn Jackson and "Women in Academia: Are We Asking the Right Questions?" by Carolyn Gordon and Barbara Lee Keyfitz that appeared in the August 2004 *Notices*. Both articles addressed many important issues for women and for the mathematical community at large. I would like to focus attention on another issue that has a profound impact on the career decisions of women entering academia that was not mentioned in either article—the "two-body problem" faced by dual-career couples seeking employment.

I do not know of any source of hard data describing how the two-body problem affects women in mathematics. However, the experience of the physics community suggests what such data might look like. In 1998, a Web-based survey of physicists was

undertaken by Laurie McNeil and Marc Sher (http://www.physics.wm.edu/~sher/survey.html). In their article online they write, "For the profession as a whole, it is important to recognize that the dual-career problem represents a significant barrier to the enhancement of the representation of women in physics." See also "The dual-career-couple problem," McNeil and Sher, *Physics Today*, July 1999, 32–37.

The problem is complex, and there may be no simple solution. However, we do not make headway by ignoring it. The AMS could play a valuable role in beginning a discussion of the two-body problem in the mathematical community. A first step would be to gather data so that we can frame the issues with a clear picture of the scope of the problem. The 1990 American Physical Society Membership Survey found that "Eighty percent of married female physicists are married to other scientists, compared to only 16% of married male physicists." "APS survey demonstrates changing composition of membership," *American Physical Society Bulletin*, Vol. 36, No. 8, 1991, pgs. 2051–2053). What are the data in mathematics?

Other steps could also be taken. The AMS has done a wonderful service to the community in helping to make the employment process friendlier toward the applicant. For instance, the AMS publicizes the names of institutions that have agreed to let recipients of postdoctoral positions wait until a specified date in February before they must accept or reject positions. Could the AMS also help to publicize which institutions have spousal hiring policies? Ultimately, each couple must make their own personal decisions about how to balance their careers and their personal lives. The mathematical community can help by making information relevant to these decisions more easily accessible in an effort to make the process of navigating the job market more transparent for dual-career couples.

—Jessica Sidman
Mount Holyoke College

(Received October 27, 2004)

Hiding Homework from Google

Bob Proctor's letter (December 2004) raises some excellent issues related to the posting of homework solutions on the Web. He seems unaware of a relevant detail. The root directory of every website has a file, robots.txt, which tells search engines about content that should not be made available. To exclude your solutions from being covered by search engines, simply tell your systems administrator to add the following lines to robots.txt: Disallow: [name of the directory which contains the solutions].

I implemented this solution after I discovered that Alexa had picked up some of my homework solutions.

—Michael Renardy
Virginia Tech

(Received November 10, 2004)

Grothendieck at Queen's

I was a graduate student at Queen's University in Kingston in the 1970s. I attended Grothendieck's lectures both in mathematics and Survival. One of the members of Survival, Mr. Gordon Edwards, was so inspired by Grothendieck that he devoted his considerable talents to the antinuclear movement in Canada. Even then, though, Grothendieck expressed regret that the attitudes he abhorred in mathematics were creeping into the Survival movement. We graduate students followed him around for obvious reasons. He lived in a modest room in Kingston. Before the rental had to be formalized, the landlady made him aware of the rules of the house in rather condescending tones. In these walks through Kingston, he talked a lot about mathematics. I also went to Buffalo, New York, to attend a series of mathematics lectures he gave. One afternoon in Buffalo, he outlined various mathematical problems he wanted to solve. At one point he said, "if only I knew more about differential equations". He went on to lament the gaps in his mathematical knowledge.

—Frank Okoh
Wayne State University

(Received November 11, 2004)

Editor's Note: Queen's was misidentified in the article about Grothendieck that appeared in the November 2004 *Notices*. It is Queen's University, Kingston, Ontario, Canada.

The "What Is?" Column

I am a Ph.D. student in mathematics at Brandeis, and I find the "What Is...?" columns of *Notices* very useful. Their concise, elementary exposition of ideas is appealing. I hope that *Notices* continues to broach the plethora of mathematical concepts with this relatively new column.

—Jim Tseng
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(Received November 15, 2004)

Religion in the *Notices*

It is my understanding that the *Notices* went the "no politics" route lately. Shouldn't then that be the case with religion as well? If an article deals with some religious aspects of the life of a mathematician, I would see no problems with it since that is part of a person's total picture. However, if an obituary writer injects a sentence such as "God gave her an easy death", as done on page 1321 of the December 2004 issue of the *Notices*, I find it offensive, just as many readers of the *Notices* would feel if I elaborated on my views on religion in this letter.

—Paul Nevai
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(Received November 16, 2004)

Quiver Representations

Harm Derksen and Jerzy Weyman

Introduction

A *quiver* is just a directed graph.[1] Formally, a quiver is a pair $Q = (Q_0, Q_1)$ where Q_0 is a finite set of vertices and Q_1 is a finite set of arrows between them. If $a \in Q_1$ is an arrow, then ta and ha denote its *tail* and its *head*, respectively.

Let us fix a quiver Q and a base field K. Attach a finite dimensional vector space to each vertex of Q and a linear map to each arrow (with the appropiate domain and codomain). Then this is called a *representation of* Q. Formally, a representation V of Q is a collection

$$\{V_x \mid x \in Q_0\}$$

of finite-dimensional K-vector spaces together with a collection

$$\{V_a : V_{ta} \to V_{ha} \mid a \in Q_1\}$$

of K-linear maps. If V is a representation of Q, then its *dimension vector* d_V is the function $Q_0 \to \mathbb{N}$ defined by $d_V(x) = \dim_K(V_x)$ for all $x \in Q_0$. Here $\mathbb{N} = \{0, 1, 2, \dots\}$ denotes the set of nonnegative integers. The set of all possible dimension vectors is $\mathbb{N}^{Q_0}$. Here are a few typical examples of quiver representations.

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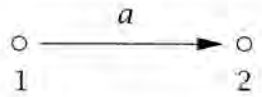
[1] *The underlying motivations of quiver theory are quite different from those in the traditional graph theory. To emphasize this distinction, it is common in our context to use the word "quivers" instead of "graphs".*

Example 1. *A representation of the quiver*

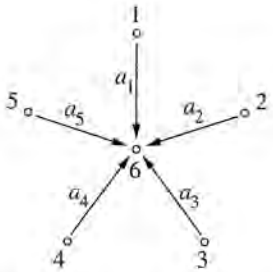


is a collection of two finite-dimensional vector spaces V_1, V_2 together with a linear map $V_a : V_1 \to V_2$.

Example 2. *A representation of the loop quiver*

is a vector space V_1 together with an endomorphism $V_a : V_1 \to V_1$.

Example 3. *A representation of the star quiver*



is a collection of six vector spaces $V_1, V_2, \dots, V_6$ together with five linear maps $V_{a_i} : V_i \to V_6$, $i = 1, 2, \dots, 5$. If all maps are injective, then we can view such a representation as a subspace configuration.

If V and W are two representations of Q, then a *morphism* $\phi : V \to W$ is a collection of K-linear maps

$$\{\phi_x : V_x \to W_x \mid x \in Q_0\}$$

such that the diagram

$$\begin{array}{ccc} V_{ta} & \xrightarrow{V_a} & V_{ha} \\ \downarrow{\scriptstyle \phi_{ta}} & & \downarrow{\scriptstyle \phi_{ha}} \\ W_{ta} & \xrightarrow[W_a]{} & W_{ha} \end{array}$$

commutes for every arrow $a \in Q_1$. That is, $W_a\phi_{ta} = \phi_{ha}V_a$ for all $a \in Q_1$.

For a quiver Q and a field K we can form the *category* $\mathrm{Rep}_K(Q)$ whose objects are representations of Q with the morphisms as defined above.

A morphism $\phi : V \to W$ is an *isomorphism* if ϕ_x is invertible for every $x \in Q_0$. One naturally wants to classify all representations of a given quiver Q up to isomorphism.

Example 4. *Consider Example 1. For a linear map $V_a : V_1 \to V_2$ we can always choose bases in V_1 and in V_2 in which V_a is given by the block matrix*

$$\begin{pmatrix} I_r & 0 \\ 0 & 0 \end{pmatrix},$$

where r is the rank of A and I_r is the $r \times r$ identity matrix. Two representations $V_a : V_1 \to V_2$ and $W_a : W_1 \to W_2$ are isomorphic if and only if $\dim V_1 = \dim W_1$, $\dim V_2 = \dim W_2$, and V_a and W_a have the same rank.

Example 5. *Consider Example 2. Assume that the base field K is algebraically closed. If $V_a : V_1 \to V_1$ is an endomorphism of the finite-dimensional K-vector space V_1, then for some choice of basis in V_1, the matrix of V_a has the form*

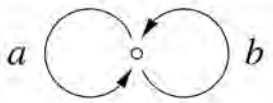
$$(1) \qquad \begin{pmatrix} J_{n_1,\lambda_1} & 0 & \cdots & 0 \\ 0 & J_{n_2,\lambda_2} & & 0 \\ \vdots & & \ddots & \vdots \\ 0 & 0 & \cdots & J_{n_r,\lambda_r} \end{pmatrix},$$

where $J_{n,\lambda}$ denotes the $n \times n$ Jordan block

$$\begin{pmatrix} \lambda & 1 & & & \\ & \lambda & 1 & \varnothing & \\ & & \ddots & \ddots & \\ & \varnothing & & \lambda & 1 \\ & & & & \lambda \end{pmatrix},$$

The matrix (1) is the well-known Jordan normal form of V_a. It is unique up to permutation of the blocks. Two representations, $V_a : V_1 \to V_1$ and $W_a : W_1 \to W_1$, of the loop quiver are isomorphic if and only if V_a and W_a have the same Jordan normal form.

As we have seen, the classifications of representations of the quivers in Examples 1 and 2 correspond to well-known problems in linear algebra. For more complicated quivers, the classification problem leads to more involved linear algebra problems. For example, for the double loop quiver



we have to classify all pairs of matrices (V_a, V_b) up to *simultaneous* conjugation, a notoriously difficult problem. The classification problem for Example 3 is equally hard. Yet there are many quivers for which the classification problem has been solved.

Indecomposable Representations

If V and W are two representations of the same quiver Q, we define their *direct sum* $V \oplus W$ by

$$(V \oplus W)_x := V_x \oplus W_x$$

for all $x \in Q_0$, and

$$(V \oplus W)_a := \begin{pmatrix} V_a & 0 \\ 0 & W_a \end{pmatrix} : V_{ta} \oplus W_{ta} \to V_{ha} \oplus W_{ha}$$

for all $a \in Q_1$.

We say that V is a *trivial representation* if $V_x = 0$ for all $x \in Q_0$. If V is isomorphic to a direct sum $W \oplus Z$, where W and Z are nontrivial representations, then V is called *decomposable*. Otherwise V is called *indecomposable*. Every representation has a unique decomposition into indecomposable representations (up to isomorphism and permutation of components). The classification problem reduces to classifying the indecomposable representations.

Example 6. *Let us go back to Examples 1 and 4. There are 3 indecomposable representations A, B, C, namely*

$$A : K \to 0, \quad B : 0 \to K, \quad C : K \xrightarrow{1} K.$$

Any representation V is isomorphic to

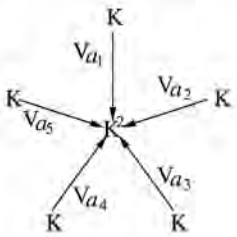
$$V \cong A^{d_1 - r} \oplus B^{d_2 - r} \oplus C^r$$

where $d_1 = \dim V_1$, $d_2 = \dim V_2$ and $r = \operatorname{rank} V_a$.

Example 7. *Consider again Examples 2 and 5. Indecomposable representations correspond to the Jordan blocks. The Jordan normal form shows how a representation decomposes into indecomposables.*

Although there are infinitely many indecomposable representations, they can still be parametrized by a discrete parameter n and a continuous parameter λ.

Example 8. *In Example 3, one can identify a 2-dimensional family of pairwise nonisomorphic indecomposable representations, namely,*



where $V_{a_1}, \ldots, V_{a_5}$ are given by the matrices

$$\begin{pmatrix}1\\0\end{pmatrix}, \begin{pmatrix}0\\1\end{pmatrix}, \begin{pmatrix}1\\1\end{pmatrix}, \begin{pmatrix}1\\\lambda\end{pmatrix}, \begin{pmatrix}1\\\mu\end{pmatrix},$$

respectively, with $\lambda, \mu \in K$.

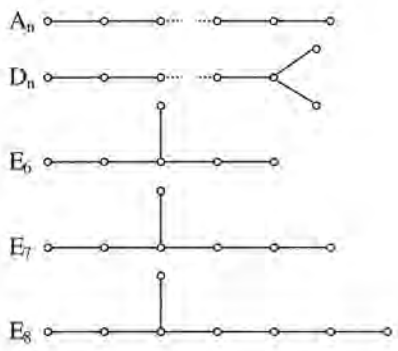
Furthermore, there exist other families of indecomposables for this particular star quiver, where the number of parameters of the family is arbitrarily large. In this example, describing explicitly the set of indecomposable representations is essentially an impossible task.

Theorems of Gabriel and Kac

We have observed different behavior of indecomposables for various quivers. If a quiver has only finitely many indecomposable representations, it is called a quiver *of finite type*. If there are infinitely many indecomposables, but they appear in families of dimension at most 1, then the quiver is called *of tame type*.[2] If the representation theory of the quiver is at least as complicated as the representation theory of the double loop quiver, then the quiver is called *of wild type*. These definitions given here are imprecise but hopefully convey the right intuition. The precise definitions of tame and wild type are omitted. It is known that every quiver is either of finite type, tame, or wild. We will later see that such a trichotomy is true in a more general setting.

Forgetting the orientations of the arrows yields the *underlying undirected graph* of a quiver. The following amazing theorem is due to Gabriel (see [8], [13]).

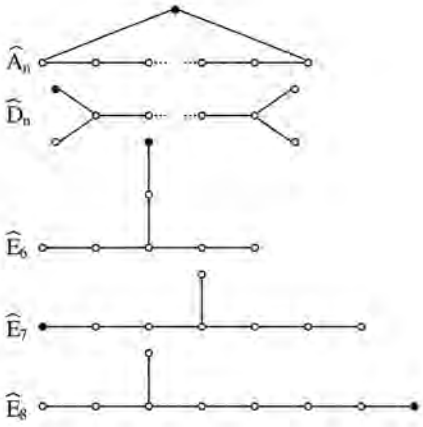
Theorem 9 *[Gabriel's Theorem, part 1]. A quiver is of finite type if and only if the underlying undirected graph is a union of Dynkin graphs of type A, D, or E, shown below:*



The Dynkin graphs play an important role in the classification of simple Lie algebras, of finite crystallographic root systems and Coxeter groups, and other objects of "finite type".

For quivers of tame type, a similar description exists, namely:

Theorem 10 *([5], [14]). A quiver Q which is not of finite type is of tame type if and only if the underlying directed graph is a union of Dynkin graphs and extended Dynkin graphs of type $\widehat{A}$, $\widehat{D}$, or $\widehat{E}$, shown below:*



Gabriel proved a stronger statement for quivers of finite type:

Theorem 11 *[Gabriel's Theorem, part 2]. The indecomposable representations are in one-to-one correspondence with the positive roots of the corresponding root system. For a Dynkin quiver Q, the dimension vectors of indecomposable representations do not depend on the orientation of the arrows in Q.*

Amazingly, this result is just the tip of an iceberg. Define the *Euler form* (or *Ringel form*) of a

[2] *In some papers, the definition of tame type includes finite type.*

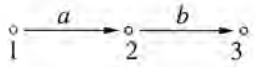
quiver Q to be the asymmetric bilinear form on $\mathbb{Z}^{Q_0}$ given by

$$\langle \alpha, \beta \rangle = \sum_{x \in Q_0} \alpha(x)\beta(x) - \sum_{a \in Q_1} \alpha(ta)\beta(ha).$$

The Euler form is represented in the coordinate basis of $\mathbb{Z}^{Q_0}$ by the matrix $E = (b_{i,j})$ where the

$$b_{i,j} = \delta_{i,j} - \#\{\, a \in Q_1 \mid ta = i,\ ha = j\},$$

where $\delta_{i,j}$ is the Kronecker delta symbol. One also defines a symmetric bilinear form



$$(\alpha, \beta) := \langle \alpha, \beta \rangle + \langle \beta, \alpha \rangle,$$

called *the Cartan form* of the quiver Q. The Cartan form does not depend on the orientation of the arrows in Q.

Example 12. *For the quiver*

the Euler matrix is

$$E = \begin{pmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ 0 & 0 & 1 \end{pmatrix}$$

and the Cartan matrix is

$$C = \begin{pmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 2 \end{pmatrix}.$$

The *Tits form* q of Q is defined by

$$q(\alpha) = \langle \alpha, \alpha \rangle = \tfrac{1}{2}(\alpha, \alpha).$$

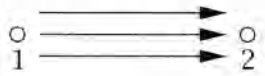
The number of continuous parameters for α-dimensional ($\alpha \neq 0$) representations is known to be at least $1 - q(\alpha)$. The Tits form plays an integral role in Gabriel's theorem. For a quiver of finite type and a nonzero dimension vector α, there are only finitely many representations up to isomorphism, so $q(\alpha) \geq 1$. From this one can prove that the Cartan form is positive definite and that the underlying undirected graph is a union of Dynkin diagrams. One can also show that a dimension vector α is a positive root if and only if $q(\alpha) = 1$.

About the same time at which Gabriel proved his theorem, Kac and Moody came up with a generalization of root systems and corresponding Lie algebras for Cartan matrices of arbitrary quivers. Kac proved in 1980 the following result (see [9]).

Theorem 13 *[Kac's Theorem]. For an arbitrary quiver Q, the set of dimension vectors of indecomposable representations of Q does not depend on the orientation of arrows in Q. The dimension vectors of indecomposable representations correspond to positive roots of the corresponding root system.*

In the theory of Kac-Moody algebras one distinguishes between *real roots* and *imaginary roots.* In Theorem 13, real roots correspond to dimension vectors for which there is exactly one indecomposable representation, while imaginary roots correspond to dimension vectors for which there are families of indecomposable representations. If a positive root α is real, then $q(\alpha) = 1$. If it is imaginary, then $q(\alpha) \leq 0$.

Example 14. *The real roots for the wild quiver*



are

$$(1,0), (3,1), (8,3), (21,8), \ldots$$
$$(0,1), (1,3), (3,8), (8,21), \ldots$$

(pairs of consecutive odd Fibonacci numbers). The imaginary roots are all $(p, q) \in \mathbb{N}^2$ with

$$\frac{3-\sqrt{5}}{2} < \frac{p}{q} < \frac{3+\sqrt{5}}{2}.$$

The connections with the theory of Lie algebras and algebraic groups can be developed much further. Ringel showed how to construct the upper triangular part of the enveloping algebra of a simple Lie algebra from the representations of the corresponding Dynkin quiver Q, using the Hall algebra associated to Q ([15]). The connections between quiver representations and canonical bases of quantum groups is an active area of current research.

Canonical Decompositions

Kac's theorem describes the dimension vectors in which indecomposable representations appear. However, this theorem does not tell us how to construct indecomposable representations. One might think that a "generic" representation of dimension α is indecomposable if α is a root. This is not the case. Because the classification of (indecomposable) representations is no longer feasible, we will set ourselves more modest goals. We will ask ourselves the following questions:

If we fix a dimension vector α and we choose all the linear maps at random, when will such a representation be indecomposable? When will such a representation be rigid? (This means: for which representations does every small enough perturbation of the linear maps result in an isomorphic representation?)

We say that a *general* representation of dimension α is indecomposable if there is a nontrivial polynomial equation in the entries of the matrices such that every decomposable representation of dimension α satisfies the polynomial equation.

Even for the loop quiver from Example 2 we see that in dimension vector (n) a representation can be indecomposable only if all its eigenvalues are the same. One might ask a different question: how does a general representation decompose? Kac showed that if V is a "sufficiently general" representation with dimension vector α, then the dimension vectors of the direct summands will not depend on V. This general decomposition of the dimension vector of α into the dimension vectors of indecomposable summands is called the *canonical decomposition of* α. This notion depends on the orientation of arrows in Q. We write

$$\alpha = \alpha_1 \oplus \ldots \oplus \alpha_r$$

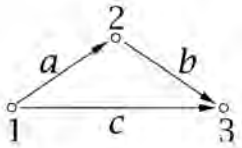
if a general representation of dimension vector α has r indecomposable summands of dimension vectors $\alpha_1, \ldots, \alpha_r$. If a general representation of dimension α is indecomposable then the canonical decomposition of α is just α itself. In this case, α is called a *Schur root.*

Example 15. *Take the loop quiver from Example 2. The dimension vector $\alpha = (n)$ is an imaginary root because there is a 1-dimensional family of indecomposables in this dimension. The canonical decomposition of α is*

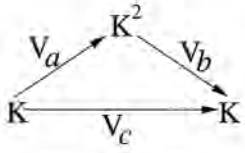
$$(n) = \underbrace{(1) \oplus (1) \oplus \cdots \oplus (1)}_{n} = (1)^{\oplus n}$$

because a general endomorphism has distinct eigenvalues and thus decomposes into Jordan blocks of size one.

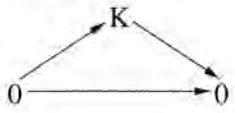
Example 16. *Consider the quiver*



A general representation of dimension $(1,2,1)$ is of the form



This representation is indecomposable if V_a is injective, V_b is surjective, V_c is an isomorphism, and $V_bV_a = 0$. The dimension vector $(1,2,1)$ is a real root (up to isomorphism there is only one indecomposable representation). For a general representation of dimension $(1,2,1)$, however, the composition V_bV_a will be nonzero, and an indecomposable summand



will split off. Thus $(1,2,1)$ is not a Schur root.

The canonical decomposition is homogeneous in the following way. If

$$\alpha = \alpha_1 \oplus \ldots \oplus \alpha_r$$

is the canonical decomposition for some dimension vector, then

$$n\alpha = [n\alpha_1] \oplus \ldots \oplus [n\alpha_r], \tag{2}$$

where $[n\alpha]$ denotes $n\alpha$ if $\langle \alpha, \alpha \rangle < 0$ and $\alpha^{\oplus n}$ if $\langle \alpha, \alpha \rangle \geq 0$.

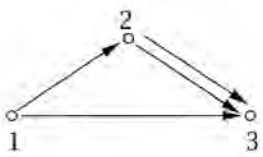
We now get back to the questions from the beginning of this section. A dimension vector α is rigid if every summand in the canonical decomposition of α is a real Schur root. An efficient combinatorial algorithm to compute the canonical decomposition of a dimension vector was given in [4] (a similar algorithm is given in [17]). Using this algorithm it is possible to check whether a given dimension vector is a Schur root or a rigid dimension vector. It is unlikely that an easy explicit description of Schur roots or dimension vectors exists, given the complex nature of these notions revealed in the next section.

An Example

We will discuss an example to visualize the notions of real and imaginary roots and Schur roots.

The sets of dimension vectors for which general representation is indecomposable have a very complicated structure, as we will see in the example below. For a quiver with three vertices, we can graph dimension vectors in the projective plane to get a two-dimensional picture. A dimension vector (x, y, z) will be drawn as the projective point $[x : y : z]$ in $\mathbb{P}^2$. This makes sense because the canonical decomposition is essentially homogeneous by (2). All dimension vectors will be contained in the triangle $[x : y : z]$, $x, y, z \geq 0$.

Let Q be the quiver



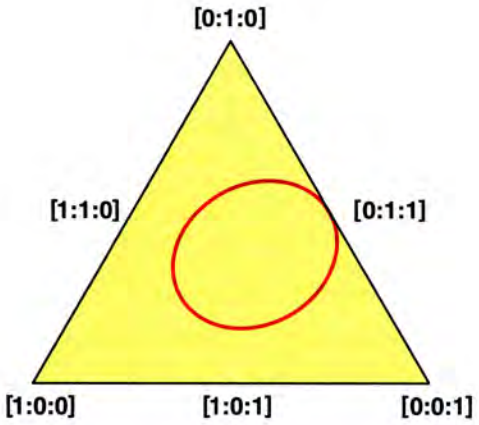


Figure 1.

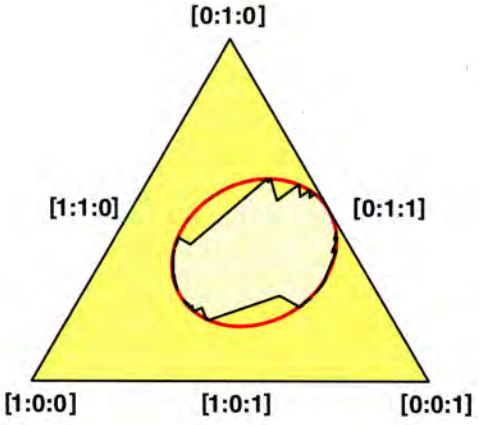


Figure 2.

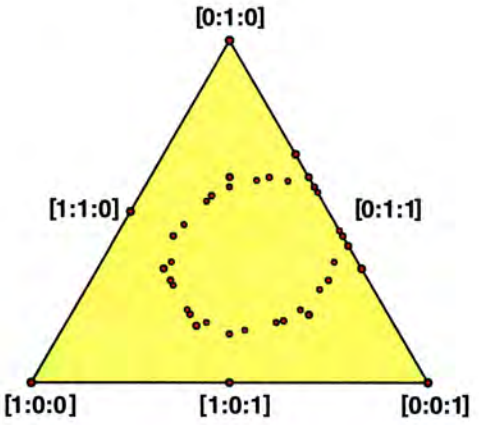


Figure 3.

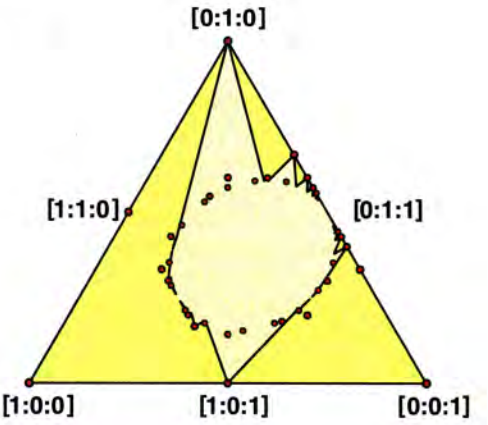


Figure 4.

For this particular quiver, the imaginary positive roots are exactly all dimension vectors α for which $q(\alpha) \leq 0$. The quadric $q(\alpha) = 0$ is plotted in Figure 1. This quadric and its interior correspond to the imaginary roots.

The imaginary Schur roots are the dimension vectors inside the nonconvex fractal-like polygon shown in Figure 2. Since the polygon is properly contained inside the quadric in Figure 1, we see that there exist imaginary roots that are not imaginary Schur roots.

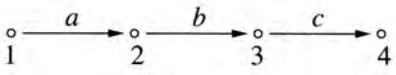
In figure 3 we plotted some real roots for this quiver. The dimension vectors α for which a general representation is rigid are those that lie outside the fractal-like polygon in the Figure 4. A real root α is a real Schur root if and only if α is a rigid dimension vector. We see that some of the real roots in Figure 3 lie inside the polygon in Figure 4. This shows that some real roots are not real Schur roots.

Representation Theory of Finite-Dimensional Algebras

There is a close connection between quivers and the representation theory of finite-dimensional algebras. In the last few decades there has been an enormous progress in the area of finite-dimensional algebras. Because of space limitations we will not be able to do justice to this subject. We will just give a glimpse of this area and its connection to quivers.

A path in a quiver Q is a sequence $a_1 a_2 \cdots a_r$ of arrows in Q_1 with $ta_i = ha_{i+1}$ for $i = 1, 2, \ldots, r-1$. We also define a trivial path e_x with $te_x = he_x = x$ for each vertex $x \in Q_0$. The *path algebra* of KQ is the vector space spanned by all paths in Q. The algebra structure of KQ is given by the concatenation of paths. There is a natural bijection between representations of the quiver Q and (left)-KQ-modules.

Example 17. *Consider the quiver*



For every i, j with $1 \leq i \leq j \leq 4$ there is a unique path from i to j. Identify this path from i to j with the matrix $E_{j,i}$ having a 1 in row j and column i and 0 everywhere else. Using this identification, we see that the path algebra for this quiver is isomorphic to the set of 4×4 lower triangular matrices.

If A is a finite-dimensional algebra over the complex numbers $\mathbb{C}$, then the category of representations of the algebra A is equivalent to the category of representations of the algebra KQ/I for some quiver Q and some two-sided ideal I of KQ. This is the reason why quivers play a central role in the theory of finite-dimensional algebras and their modules.

One can extend the notions of *finite*, *tame*, and *wild* type for finite-dimensional algebras. An important result for quivers with relations is Drozd's Theorem, which states that every finite-dimensional algebra is either finite type, tame, or wild (see [3], [7]). These possibilities are mutually exclusive.

Even though the classification of indecomposable representations of wild algebras is an almost impossible task, King showed that it is possible to construct nice moduli spaces for the representations using geometric invariant theory [12]. These moduli spaces do not parameterize all representations, but only representations that are a direct sum of indecomposable representations satisfying a certain stability condition.

Another direction in representation theory of quivers started with Auslander and Reiten's application of homological methods. They introduced what is nowadays called the Auslander-Reiten transform of a representation of a finite-dimensional algebra. For representations of a quiver Q without relations or oriented cycles, the Auslander-Reiten transform induces a map of dimension vectors. If V is a representation of dimension α for which the Auslander-Reiten transform is defined, then its transform has dimension $\tau(\alpha)$ where $\tau(\alpha) \in \mathbb{Z}^{Q_0}$ is the unique integer vector satisfying

$$\langle \tau(\alpha), \beta \rangle = -\langle \beta, \alpha \rangle$$

for all dimension vectors β. The homological properties of the Auslander-Reiten transform imply that if α is a real root/imaginary root/real Schur root/imaginary Schur root/rigid dimension vector, then so is $\tau(\alpha)$.

The Auslander-Reiten transform is visible in the figures of the previous section. In that case, the map τ is given by

$$\begin{pmatrix} 3 & 5 & -3 \\ 3 & 3 & -2 \\ 1 & 2 & -1 \end{pmatrix}.$$

Note that for example $\tau(0,1,1) = (2,1,1)$ and $\tau(1,0,1) = (0,1,0)$. Using the homological properties of the Auslander-Reiten transform, we have discovered the map τ that leaves the quadric in Figure 1, the infinite polygon in Figure 2, the real roots[3] (Figure 3), and the infinite polygon in Figure 4 invariant.

[3] *The set of positive real roots is not completely invariant under τ. If R is the set of positive real roots, then each of $\tau(R) \setminus R$ and $R \setminus \tau(R)$ consists of only three vectors.*

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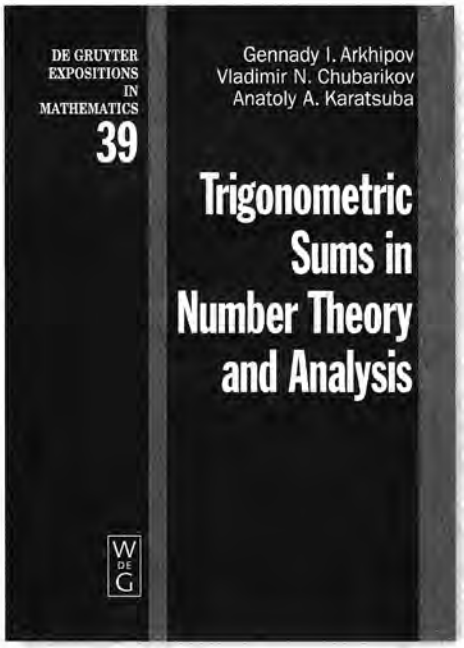

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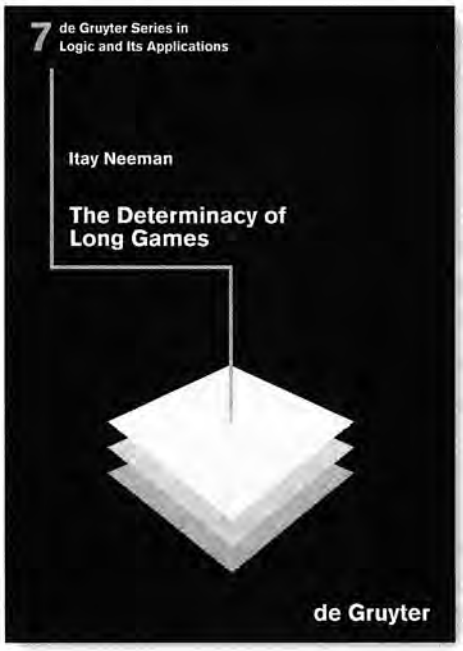

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Racial Equity Requires Teaching Elementary School Teachers More Mathematics

Patricia Clark Kenschaft

I strongly believe that the most crucial step for promoting racial equality in this country is to educate all elementary teachers mathematically. This conviction began after a survey I did in the mid-1980s of black mathematicians in New Jersey. Seventy-five black people with at least one degree in mathematics responded to a variety of questions, including, "What can be done to bring more blacks into mathematics?"

The second most common answer to this question was, "Publicize role models." I might have been planting that answer because I was clearly collecting role models. However, the most common answer (by far) I definitely did not plant; it came as a total surprise to me. It was, "Teach mathematics better to all American children. The way it is now, if children don't learn mathematics at home, they don't learn it at all, so any ethnic group that is underrepresented in mathematics will remain so until children are taught mathematics better in elementary school."

That answer caused me to seek opportunities to work in elementary schools. Much of what follows will be evidence corroborating the statement that was so frequent among the black mathematicians of New Jersey—and the great need to teach mathematics to elementary school teachers. Like most Americans, I found it difficult to believe how poorly prepared mathematically they are. They are well chosen. They are kind, diligent, and smart, qualities that nobody can teach. They have been failed mathematically by our system. They need to be taught. I have found them eager and quick to learn—and appallingly ignorant of the most basic mathematics.

"Teach us math! Teach us math! Teach us math!" chanted dozens of elementary school teachers during one after-school workshop. There was an amazed silence while we all absorbed what had just happened. Then one of them said, "If you taught us math the way you did just now, we could teach it to the children." They all nodded emphatically. This incident followed my statement that those of us who thrive mathematically have had some good mathematical experience early, typically at home. Someone had asked for an example out of my own childhood, and I had explained how my father had described the meaning of π to me several months before I started kindergarten. Their response was the chanting, "Teach us math!"

One study of nine hundred Texas school districts revealed that the large disparities in achievement between black and white students were almost entirely accounted for by socioeconomic status and differences in the measurable qualifications of their teachers.[1] It is no secret that minority students across the country have less mathematically educated teachers than whites. However, even in integrated districts, the lack of home preparation of

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[1] Doing What Matters Most: Investing in Quality Teaching, *National Commission on Teaching and America's Future, November 1997, page 8, quoting Ronald Ferguson in "Paying for Public Education: New Evidence on How and Why Money Matters,"* Harvard Journal of Legislation **28** *(Summer 1991), pp. 465–98.*

minority students means that they are more dependent on their teachers for their mathematical knowledge. It has been my observation that the reason that scores are higher in white districts is that some parents teach their children mathematics at home, and these children teach many of the others. It has appeared to me that the teachers are no better prepared in the high-scoring districts.

The teachers are eager and able to learn. I vividly remember one summer class when I taught why the multiplication algorithm works for two-digit numbers using base ten blocks. I have no difficulty doing this with third graders, but this particular class was all elementary school teachers. At the end of the half hour, one third-grade teacher raised her hand. "Why wasn't I told this secret before?" she demanded. It was one of those rare speechless moments for Pat Kenschaft. In the quiet that ensued, the teacher stood up.

"Did you know this secret before?" she asked the person nearest her. She shook her head. "Did you know this secret before?" the inquirer persisted, walking around the class. "Did you know this secret before?" she kept asking. Everyone shook her or his head. She whirled around and looked at me with fury in her eyes. "Why wasn't I taught this before? I've been teaching third grade for thirty years. If I had been taught this thirty years ago, I could have been such a better teacher!!!"

Indeed she could have been. The understanding of the area of a rectangle and its relationship to multiplication underlies an understanding not only of the multiplication algorithm but also of the commutative law of multiplication, the distributive law, and the many more complicated area formulas. Yet in my first visit in 1986 to a K-6 elementary school, I discovered that *not a single teacher* knew how to find the area of a rectangle.

In those innocent days, I thought that the teachers might be interested in the geometric interpretation of $(x + y)^2$. I drew a square with $(x + y)$ on a side and showed the squares of size x^2 and y^2. Then I pointed to one of the remaining rectangles. "What is the area of a rectangle that is x high and y wide?" I asked.

There was no response, so I asked the question again. "What is the area of a rectangle that is x by y?"

The teachers were very friendly people, and they know how frustrating it can be when no student answers a question. "x plus y?" said two in the front simultaneously.

"What?!!!" I said, horrified.

Then all fifty of them shouted together, "x plus y." Apparently my nonverbal reaction had not been a sufficient clue that the original answer was wrong. How can children in such a school attain a profound understanding of fundamental mathematics? I am now convinced, after visiting many schools, that this one was not unusual. Perhaps it was above average in the enthusiasm of the teachers and their loyalty to the school.

Its principal invited me to consider that school "my school". He and the teachers really wanted to help the students. Its students had a median achievement in mathematics of about the 25th percentile on the "Iowas", one of the lowest levels in Newark. I am now convinced that its rank was due to the fact that the principal did not pressure the teachers to cheat in any way on standardized tests. When I told him this years later, his eyes widened. He was president of the principals' union. "What? You are saying..." I nodded. Since then I have read numerous reports of systemic cheating on standardized tests and other forms of deception by school administrators, most notably the recent articles in *The New York Times* about Houston, while Secretary of Education Roderick Paige was superintendent.

The following year Montclair State facilitated my going once a week after school to that school to talk mathematics with whomever showed up. At least one teacher always did show up, and sometimes six or seven. It's not an effective way to make change, but we did get acquainted.

A year later I won one of the first K-3 grants from Exxon Education Foundation. This enabled me to spend twelve days on campus in the summer with five teachers from that school and to visit the school two mornings a week during the following school year. I spent those mornings teaching math to one to three first-grade classes, one to three third-grade classes, and one fifth-grade class.

During my first class teaching elementary school children, a fifth grader raised his hand and asked, "What is that word you keep using instead of take away?" Enter "minus"—for fifth graders!

The best first-grade teacher told me she never bothered to teach subtraction during the first half of the year because the children couldn't learn everything at once. I started visiting the school in October, and it seemed to me natural to teach addition and subtraction together. She told me she would not reinforce my teaching of subtraction between my weekly visits, and I said that was no problem.

One of the games I played with the children was holding five unifix blocks in front of me, putting them behind my back, and bringing forward three.

"How many are behind my back?" I asked. The children could answer correctly. Then I told them that one way of writing this was "5 - 3 = 2".

"Oh, no!" said the teacher.

"Why not?" I asked.

"Because subtraction means "take away" and you took away two blocks. So it should be written '5 - 2 = 3.'" I explained that subtraction could mean "take away", but it could also mean "missing

addend". It seemed to me that since the children could see three blocks, "5 - 3 = 2" was preferable, but "5 - 2 = 3" is not wrong. The next week we explored the "difference" meaning of subtraction and the "motion" meaning. (I walk five steps toward the window and three steps away. How many steps am I from where I began?)

She was startled when half the children passed the subtraction part of the November standardized test—without any reinforcement from her. She had never had a child pass it before. The crucial role of mathematical knowledge on the part of the teacher was becoming obvious to me.

The following year I led a team that won an Eisenhower grant and began working in an urban-suburban coalition, going to both all-black schools and all-white schools. My first time in a fifth grade in one of New Jersey's most affluent districts (white, of course), I asked where one-third was on the number line. After a moment of quiet, the teacher called out, "Near three, isn't it?" The children, however, soon figured out the correct answer; they came from homes where such things were discussed. Flitting back and forth from the richest to the poorest districts in the state convinced me that the mathematical knowledge of the teachers was pathetic in both. It appears that the higher scores in the affluent districts are not due to superior teaching in school but to the supplementary informal "home schooling" of children.

Tests encourage systemic cheating, but there is no way to deceive an educated observer about student and teacher enthusiasm. In the spring of my first year in the Newark school, Exxon sent Pat Hess to observe what was happening. The principal said, "We haven't had enough standardized tests yet to be sure of a measurable difference, but I can assure you I hear far more conversation about mathematics than I ever did before. I hear the children talking about math in the hallway. When I walk into the teachers' lunchroom, I hear *them* talking about math!"

The Eisenhower grant paid me to visit each school only once a month. During the spring of the third year that I had been visiting the original school, one of the third-grade teachers said at the beginning of the class, "Could we put aside the lesson you and I planned and just have you answer the questions of the children that I can't answer?" Think about what that question indicates about her eagerness to learn and about our relationship—and then what it indicates about the need for third-grade teachers to learn more mathematics.

The children were all African American. The school is in one of the worst neighborhoods of our country's poorest city. There were no greens growing within a block of the school except an occasional dandelion that would poke up between the sidewalk cracks. When the wind blew as I approached the school, I would feel the flying glass sting my legs. But the next hour was one of the most intellectually exciting of my life. I just answered one question after another and made sure that every child was following. An hour! With eight-year-olds! Totally focused.

At the end, the teacher, who had been on the edge of her seat the entire time, asked, "What do you call this kind of mathematics, Dr. Kenschaft?" Suddenly I began to meta-think—no longer focused on the here and now.

"This is the beginning lesson in calculus that I do with my college students!" I had considered the limit of $60/x$ as x goes to zero. The children had never heard of division before, but they learned it in that hour—all of them. I used six Cuisenaire ten-rods and asked first how many sixties there are in sixty, then how many thirties, then how many tens, and then how many ones. Then I told them about tenths. Then I asked how many tenths there are in sixty, telling them I didn't want anyone to shout out. Slowly hands were raised—and they had the right answer. I had everyone whose hand had been raised explain the reason for the answer to the entire class, and then I asked how many hundredths there were in sixty. Of course, I had to explain what a hundredth was first. This time almost half the class raised their hands fairly quickly. The concept of infinity and how it might arise had been constructed in their minds, and they were excited.

Later that spring the Iowa scores were revealed for the three third grade-classes with whom I had been working intermittently for three years. Two classes had median scores at the 60th percentile, a great increase from the 25th percentile only three years earlier. The third class had a median at the 70th percentile, with only one child below the 50th and that child in the 40s. This dramatic increase in Iowa scores was accomplished by the same teachers and a mathematician with no elementary school background whatsoever. I did have high school certification; I had one year of high school teaching experience and the background of having raised two children of my own, but no official professional preparation except a doctorate in mathematics with a specialty in functional analysis. The teachers and I shared a concern for the students. They were good teachers, and I had access to the national materials of the late 1980s. We talked with each other. I certainly was not teaching "to" the Iowas. I was trying to share my understanding of fundamental mathematics—and it seems that that was what was needed for the children to do well on the highly computational old-fashioned standardized tests.

A couple of years later I was in another city in another all-black class that was much more unruly. The teacher continually complained to me aloud about the children's misbehavior. They too were

thinking out of bounds. I watched her try to squelch the children's impudent mathematical questions, and then hesitantly asked if I could try to answer them. I told her it would take some time, and she agreed. I went through the same explanation of the limit of $60/x$ as x goes to zero, not sure if this class could pay attention well enough. But they did. The teacher was amazed not just that they all seemed to understand division lickety-split, but that they paid attention to this obviously very difficult topic.

How much are our social problems due to our not challenging children enough? Life can be boring if you just tread water intellectually. How much do humans *need* intellectual challenge? How much would providing an excellent mathematics education for our elementary school teachers help mitigate our drug and crime problems?

A couple of years ago I discovered that the problems are even more basic than I had realized earlier; teachers' understanding of addition is murky. Montclair State certifies teachers without providing a special course in either mathematics or mathematics education for them, so they are scattered in our general education courses. I had one pleasant, diligent young woman in such a class who intends to be an elementary school teacher. On the last day of her formal mathematics education she responded to my offer to answer questions before the exam by saying there was something wrong with exercise 11 on page 69 of the text (my book *Mathematics for Human Survival*[2]).

"In 1999 U.S. cars achieved an average of 28.11 mpg, but light trucks were rated a mere 20.3 mpg. Their mileage was 23.8 mpg altogether. What proportion of American vehicles were light trucks in 1999?"

"What's wrong?" I asked.

"'Altogether' means add, so the mileage altogether must be 48.41 miles per gallon." I tried to explain but to no avail. Some of the other students gave fine explanations. She is a cooperative person and realized she was outvoted, but it was clear she did not understand.

One of the other students noticed my frustration and anger—not at her, but at a system that will send people so poorly prepared into the elementary school classroom. "You know, Dr. Kenschaft. Key words. We've all been taught that 'altogether' means add." The rest of the class nodded as I sighed.

"And 'left' always means subtract," said another with a wry smile.

The student who will be an elementary school teacher earned a legitimate "B" in that course. Without a course about the fundamentals of elementary mathematics, she is woefully unprepared to face young exploring mathematical minds such as I enjoyed so much in the poorest city in our country. I wonder if she realized when she was eight that the average height of the children in her class altogether was between the average height of the boys and the average height of the girls. Was that understanding taught out of her by teachers who insist upon memorization because they themselves don't understand? Will she, kindly, well-meaning person that she is, do the same to classes of innocent children over her lifetime?

My own interest in elementary school mathematics education grew out of my equity concerns. Ever since my great-great-grandfather came north from a slave-holding family to fight on the Northern side of the Civil War, my family has been active in race relations. The men have encouraged the women to be "real people," and the women have tried to live up to the advantages we were given.

My survey of black mathematicians in New Jersey, like my earlier survey of black women with doctorates in mathematics,[3] was done by networking. I started with some former Montclair State students, and each time I reached another black mathematician, I asked for names of others. With only two (nonconsecutive) semesters of released time, while teaching three classes during those semesters, I located one hundred fifty black mathematicians in New Jersey. My subjects were surprised there were so many by the time I told them I had located thirty, but at the rate I was going when I ran out of time, I suspect there were three hundred. In my limited time I was able to get responses from only seventy-five—twenty-six written responses to my mailed inquiry, and forty-nine successful follow-up phone calls. I will be glad to send a packet of my writing about blacks in mathematics and/or women in mathematics to anyone who requests them by emailing me at `kenschaft@pegasus.montclair.edu`. An outside indicator that others appreciate my concern with minorities' participation in mathematics is indicated by the fact that in 2003 I was chosen to lead the Task Force on Equity and Diversity Integration of the National Council of Teachers of Mathematics, an organization of about 100,000 members.

I support improving pedagogy and helping minorities feel better about themselves. Indeed, my avid collecting of role models has been a major factor in providing young African Americans a mathematical heritage. I strongly approve of programs that involve families. However, none of these activities will begin to close the racial mathematics achievement gap until American elementary school

[2] *P. C. Kenschaft,* Mathematics for Human Survival, *Whittier Publications, Island Park, NY, 2002.*

[3] *P. C. Kenschaft, "Black Women in Mathematics in the United States,"* American Mathematical Monthly, **88**:*8, October 1981, 592–604.*

teachers know mathematics much better than they do now.

What can mathematicians do about this situation? There are many possibilities, but they seem to fall into three categories:

1. Structural Change: The mathematical communities need to collaborate with anyone else who will join the effort to lobby strenuously for the need for radically improved teacher knowledge. The major argument is that while once only a few people (white men?) needed to know mathematics, now a large segment (a majority) of the population need to know significant mathematics for career, citizenship, and personal reasons, and it is exceedingly wasteful to have a primary-level teaching corps with such limited knowledge; remedial mathematics learning later is more difficult and, therefore, expensive. That the current situation is also unfair to minorities may have less political clout but should also be emphasized. This change of understanding on the part of decision-makers and the public will not be easy, especially since many harbor deep math anxiety due to their own poor education and are threatened by the thought that others might learn it easily—and/or are reluctant to "inflict" on innocent children the "burden" of learning mathematics well.

The AMS can play a leadership role, but it will need collaboration from all member organizations of the Joint Policy Board for Mathematics. The Institute of Electrical and Electronic Engineers (IEEE) has expressed similar concerns, and there are doubtless other technical societies that could be recruited. The mathematical education of elementary school teachers is basic to the health of all these disciplines, as well as the economic and political health of our country.

2. Individual Actions: Those who teach in institutions that certify elementary school teachers can work to make sure adequate specific courses are provided for them and volunteer to do a conscientious job when teaching such courses. Such teaching requires patience, and a determination to direct one's anger at the system, not the victims of it. Teaching a "profound understanding of fundamental mathematics"[4] is very different from teaching traditional collegiate mathematics, but for the next few decades, some mathematically knowledgeable people must do it if all university mathematicians are to be able to teach university-level mathematics some day.

What mathematics is appropriate to teach aspiring elementary school teachers? What math do they need to know and how do they use it? There already are some adequate programs available, but further insight and improvement is needed. Hyman Bass of the University of Michigan has been working with math educator Deborah Ball, also of Michigan, to investigate these questions.

Roger Howe of Yale University has been working with current math educators to help them clarify their own mathematical knowledge and extend that of their students. Jerome Dancis of the University of Maryland at College Park has been monitoring state tests and finding appalling errors in questions that reflect either lack of mathematical knowledge or careless proofreading among those who compose high-stake tests.

3. Remedial Work: Until the current cohort of elementary school teachers retire, the mathematical competence of today's children will require that their teachers receive continual remedial programs. Hung-Hsi Wu of the University of California, Berkeley, has written about his leadership at Berkeley in summer programs jointly sponsored with a math educator. Paul Sally of the University of Chicago has done extensive work with both teachers and high school students evenings and weekends. He reports working fifty hours a week as a mathematician and another fifty as a mathematics educator. Most of us don't have that level of energy and/or commitment, but some of us will be needed for teacher remediation until the system is healed.

The above is far from an exhaustive list of either people or activities; it merely indicates examples of good beginnings. Significant efforts at remediation for teachers have taken place throughout the country. However, remediation is far from enough. All aspiring elementary school teachers must be taught appropriate mathematics before they begin teaching children.

Children who have been mathematically abused are much less able to benefit from mathematically competent teachers when they finally reach them. One lesson our current elementary school teachers convey powerfully is that math is too difficult to understand. Because knowledge of mathematics correlates strongly with economic and political achievement, the mathematical education of all elementary school teachers is the paramount equity issue. As Will Rogers said long ago, "You can't teach what you don't know any more than you can come back from where you ain't been."

[4] *This phrase was coined by Liping Ma in her important book,* Knowing and Teaching Elementary Mathematics: Teachers' Understanding of Fundamental Mathematics in China and the United States, *Lawrence Erlbaum, Mahwah, NJ, 1999.*

AMERICAN MATHEMATICAL SOCIETY

AMS AWARD FOR EXEMPLARY PROGRAMS

At its meeting in January 2004, the AMS Council approved the establishment of a new award called the AMS Award for an Exemplary Program or Achievement in a Mathematics Department. It is to be presented annually to a department that has distinguished itself by undertaking an unusual or particularly effective program of value to the mathematics community, internally or in relation to the rest of society. Examples might include a department that runs a notable minority outreach program, a department that has instituted an unusually effective industrial mathematics internship program, a department that has promoted mathematics so successfully that a large fraction of its university's undergraduate population majors in mathematics, or a department that has made some form of innovation in its research support to faculty and/or graduate students, or which has created a special and innovative environment for some aspect of mathematics research.

The prize amount is $1,200. All departments in North America that offer at least a bachelor's degree in the mathematical sciences are eligible.

The Prize Selection Committee requests nominations for the initial award, which will be presented at the Joint Mathematics Meetings in San Antonio, Texas, in January 2006. 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.

All nominations should be submitted to the AMS Secretary, Robert J. Daverman, American Mathematical Society, 312D Ayres Hall, University of Tennessee, Knoxville TN 37996-1330. Include a short description of the work that is the basis of the nomination, with complete bibliographic citations when appropriate. The nominations will be forwarded by the Secretary to the Prize Selection Committee, which will make the final decision on the award.

Deadline for nominations is April 1, 2005.

WHAT IS . . .

a Brane?

Gregory W. Moore

The term "brane" has come to mean many things to many people. Broadly speaking, it refers to a physical object appearing in field theories of gravity and strings. It can refer to widely diverse notions, from solitonic solutions of (super)gravity and (super)string theories, to local boundary conditions in two-dimensional conformal field theory, to objects in certain categories associated with sheaves on algebraic varieties.

The essential physical intuition underlying the notion of a "brane" may be captured by a few simple examples. A p-brane is simply any object of p-dimensional spatial extent. Thus a 0-brane is a point particle, whereas a string is a 1-brane. The etymological root of "brane" is "membrane", the case $p = 2$. The surface of the earth's ocean may be viewed as a 2-brane wrapping the earth and propagating in the $(3 + 1)$-dimensional spacetime of our solar system. The history of a p-brane may be described mathematically by a map $\phi : \mathcal{W} \to \mathcal{M}$, where $\mathcal{W}$ is some reference $(p+1)$-dimensional manifold, while $\mathcal{M}$ represents a "spacetime" through which the brane propagates. $\mathcal{M}$ is also referred to as the "target space", while $\phi(W)$ is referred to as the "worldvolume". Sometimes a brane can have thickness, provided this is small on the scale of the spatial extent in p-dimensions. Thus, a rope is effectively a 1-brane and the earth's ocean is effectively a 2-brane.

Branes play an important role in theories of gravity, so a key physical attribute is the tension T, the energy per unit volume of the brane. The tension of a 0-brane is its mass. Branes can have other attributes, such as "charge". The supergravity and superstring theories in which branes play prominent roles are generalizations of Einstein-Maxwell gauge theories. In addition to the gravitational field, string theories typically include a collection of gauge potentials generalizing the connection 1-form of electromagnetism. Heuristically, these may be thought of as differential form-valued fields on spacetime, although a proper description turns out to require notions of K-theory and differential cohomology theories. Charged branes are sources for these generalized gauge potentials.

Let us translate some of these physical notions into mathematics. The action principle governing a point particle of mass m and electric charge e, moving through a spacetime $\mathcal{M}$, with metric g and Maxwell connection A, is $S_{\text{particle}} = \int_{\mathcal{W}} m ds + \int_{\mathcal{W}} e\phi^*(A)$, where ds is the induced line element on the worldline. When added to the standard action for g and A, namely, $S_{\text{bulk}} = \frac{1}{16\pi G_N} \int_{\mathcal{M}} \text{vol}(g)\mathcal{R} - \int_{\mathcal{M}} \frac{1}{2e^2} F \wedge *F$ (where G_N is Newton's constant, $\mathcal{R}$ is the scalar curvature of g, and $F = dA$ is the Maxwell fieldstrength), the action S_{particle} represents a source term in the Einstein-Maxwell equations of motion. Thus the brane may be studied as a solution in field theories of gravity with *localized* energy and charge density. The generalization of the brane action to p-branes is of the form

$$S_{\text{brane}} = \int_{\mathcal{W}} T\text{vol}(\phi^*(g)) + \int_{\mathcal{W}} \varepsilon\phi^*(C) \tag{1}$$

where C is a differential form gauge potential, and ε is the "charge" (which may itself be represented by a differential form). The generalization of S_{bulk} is the action principle of a (super)gravity or (super)string theory on $\mathcal{M}$. The typical supergravity brane solution is a soliton—its stability is guaranteed by topological considerations, which are often intimately connected with supersymmetry.

A central point is that a brane has dynamics: it can wiggle and bend. The oscillations are sections of the normal bundle to $\phi(\mathcal{W}) \subset \mathcal{M}$ and hence are described by a $(p + 1)$-dimensional scalar field theory on the brane. For the earth's ocean, the scalar field would represent the height of the waves. Mathematically, these degrees of freedom arise because the soliton solutions come in families.

Physicists consider $\mathcal{W}$ and $\mathcal{M}$ of different signatures. They add various structures to both the

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target space and worldvolume, endowing them with gauge bundles and tensor fields, and generalizing them to supermanifolds. In some cases they propose to discuss the quantum behavior of branes by integrating $e^{-1/\hbar S_{\text{brane}}}$ over the space of all maps ϕ; they even boldly contemplate summing over topologies of $\mathcal{W}$. One instance in which these dreams can be realized, with some degree of rigor, is the case in which the 1-branes are the fundamental strings in a supersymmetric string theory.

One distinguished class of branes are the "D-branes" of string theory. For these one can introduce a fundamentally different viewpoint on the question: "What is a brane?" String theory describes a profound relation between a quantum conformal field theory (CFT) on a two-dimensional worldsheet $\mathcal{W}$ and a corresponding quantum field theory on the target space $\mathcal{M}$. The spacetime field theory includes gravity. In this context, D-branes correspond to CFTs on Riemann surfaces $\mathcal{W}$ with boundary. For example, suppose $\mathcal{W} = [0, \pi] \times \mathbf{R}$ so that ϕ describes the propagation of an open string through spacetime. We now select a submanifold $S \subset \mathcal{M}$ and impose the boundary condition that $\phi : \partial\mathcal{W} \to S$. For certain submanifolds, the associated two-dimensional field theory will be conformal. (Typical examples of such submanifolds include holomorphic subvarieties of complex manifolds and special Lagrangian subvarieties of symplectic manifolds.) The "D" in D-brane refers to the fact that some of the coordinate directions in ϕ thus carry Dirichlet boundary conditions. One may recover the notion of branes as solitons in supergravity via a semiclassical approximation to string field theory.

Now, purely in the context of CFT, a D-brane may be defined to be a local boundary condition preserving conformal invariance. Conformal field theories on Riemann surfaces with boundary can be described axiomatically as a functor from a geometric category to an algebraic category. Simple considerations of gluing show that the boundary conditions should be regarded as objects in an additive category. It is via this route that D-branes are identified with objects in certain categories. Moreover, some CFTs carry a special type of supersymmetry, known as $\mathcal{N} = 2$, which allows a "twisting" or association with a related topological field theory. If the target space is a Calabi-Yau manifold, then some of the branes in the CFT can be interpreted as objects in the derived category of coherent sheaves on the target. This in turn has beautiful applications in the theory of mirror symmetry.

One more crucial point is that the dynamics on the D-brane worldvolume is a *gauge theory*. In addition to the scalar field describing fluctuations of the brane in the normal directions, there is a line bundle with connection on $\mathcal{W}$. When N "elementary" branes are placed on top of each other, new nonabelian degrees of freedom are needed to describe the brane's dynamics. The normal bundle scalars become $N \times N$ hermitian matrices. The connection on a line bundle becomes a nonabelian gauge field, i.e, a connection on a rank N vector bundle over $\mathcal{W}$. This fundamental phenomenon has ultimately led to many startling new insights into gauge theory. Just one example of such an insight is the AdS/CFT correspondence, a vast generalization of the famous relation between three-dimensional Chern-Simons gauge theory and two-dimensional (rational) CFT. The replacement of the normal bundle scalars by $N \times N$ matrices leads to connections between D-branes and noncommutative geometry. Using these insights in the framework of branes within branes leads to new perspectives on hyperkähler quotient constructions and the ADHM construction of instantons.

We began by describing a brane as an object propagating through a spacetime. This puts the spacetime on a primary, and the brane on a secondary footing. However, a common theme in the study of D-branes has been the idea that in fact, the (string) field theory on the brane is the primary concept, whereas the spacetime itself is a secondary, derived, concept. This notion has been given some degree of precision in the so-called Matrix theory formulation of M-theory. A rough analogy of what physicists expect may be described in the context of purely topological branes, where the field theory on a brane is described in terms of a noncommutative Frobenius algebra, and the "spacetime" in which it propagates is derived from the Hochschild cohomology of that algebra. These ideas might ultimately lead to a profound revision of the way we regard spacetime.

The recognition of the importance of branes in string theory has been a central development, one that is still undergoing vigorous evolution. We have focused above on D-branes, but there are other important, but less well-understood, branes. For example, a deeper understanding of the "solitonic 5-branes" will lead to constructions of quantum CFTs and string theories in six-dimensional spacetimes. Further development of the theory is likely to have a wide variety of important mathematical applications.

References

[1] Virtually all relevant research and reviews on this material can be found on the e-print archive, `http://www.arxiv.org`. An example of a recent review is C. V. Johnson, D-brane primer, `http://www.arxiv.org/abs/hep-th/0007170`.

[2] *Mirror Symmetry*, K. Hori et al., AMS/Clay Mathematics Institute, 2003.

[3] *Topology, Geometry and Quantum Field Theory*, U. Tillmann, ed. Cambridge Univ. Press, 2004.

Presidential Reflections: Interview with David Eisenbud

Every other year, when a new AMS president takes office, the *Notices* publishes interviews with the incoming and outgoing president. What follows is an edited version of an interview with David Eisenbud, whose two-year term as president ends on January 31, 2005. The interview was conducted in fall 2004 by *Notices* senior writer and deputy editor Allyn Jackson. Eisenbud is director of the Mathematical Sciences Research Institute (MSRI) in Berkeley and professor of mathematics at the University of California, Berkeley.

An interview with AMS president-elect James Arthur will appear in the March 2005 issue of the *Notices*.

Notices: *The president of the AMS has two types of duties. One type consists of the things that he or she* has *to do, by virtue of the office.*

Eisenbud: Which is almost nothing, right? The unique duty that's in the Bylaws is to give the Retiring Presidential Address, which I haven't done yet!

Notices: *That's true—and still you have been very busy! The first type of duty is what the president is traditionally expected to do. The second type consists of things you do because you are interested in particular issues.*

Eisenbud: Yes. Certainly the largest part of the job that *has* to be done by the president is appointments to committees, and that has turned out to be rather fun. [AMS secretary] Bob Daverman and I get together, mostly on the phone. He has a long list of appointments that have to be made, and we talk about how to recruit people who would be interested in the topics the committees are addressing. It's gossip with a purpose.

There is also the Committee on Committees, which helps the president do this, because there are something like 300 appointments a year that have to be made. My first act as president—really as president-elect—was to gather together people who I thought would be very well connected and also who would reach into many different populations of mathematicians. One of my ambitions was to provide a diverse new group of committee members—young people and people from the minority community. I also tried hard to make sure that women are well represented on committees and slates for elections. And I am proud of what we did in that respect. That's actually the largest part of the president's job, in terms of just sheer time and engagement.

Another thing I enjoyed is running council meetings. For a long time I've felt that, if I had to be on a committee, I would prefer to be its chair. I try hard to bring out what people have to say and help them to express it. That kind of facilitator position is one that I think I have become good at and that I like.

Notices: *What meetings did you chair?*

Eisenbud: The main ones are the meetings of the Executive Committee and the meetings of the Council.

One area that's been of special interest to me is scientific meetings. Of course, MSRI runs lots of conferences, and I am also engaged in the Banff conference center. So I have a broad view of the conference scene and strong opinions about how conferences should be done. I have thought about the AMS conferences, and there are two

things that I have done that I think are interesting and that maybe will have lasting impact. One is the Special Sessions on "Current Events in Math", held at the Annual Meetings, which I organized with the help of an excellent committee. The idea came from a suggestion by Mike Artin. I thought the first session, in 2003, went well; the second, in 2004, was even better. We have a wonderful lineup for 2005 in Atlanta.

Notices: *Can you describe the format of those sessions?*

Eisenbud: The easiest way to describe it might be to say that it's like the Bourbaki Seminar, but broader and more accessible: broader in the sense that there is more applied math mixed in, because I feel that that sweep of math is part of what's exciting in our field, and more accessible in the sense that the talks aim to be comprehensible to more mathematicians. Each talk is split into two halves; the first part is supposed to be super-elementary and the second also quite accessible. Different speakers have handled this in different ways, and some of the speakers did an incredible job of making topics I considered sketchy for such presentations quite interesting and accessible. In 2003 two out of the four speakers produced writeups, and in 2004 four out of four. [AMS staff member] Raquel Storti produced a wonderful little booklet of them. They will appear in improved form in the *Bulletin of the AMS*, too.

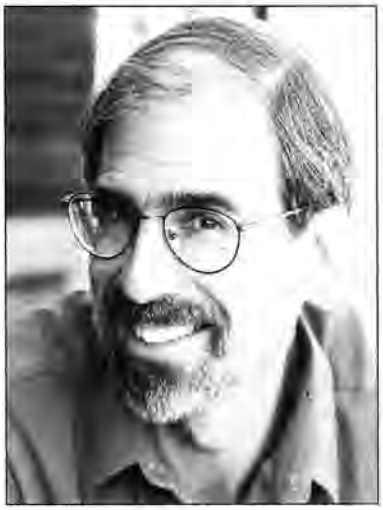
Notices: *After you stop being president will you continue organizing this Special Session?*

Eisenbud: The session doesn't yet have a long-term structure. My original idea was that after the first two years I would pass it to another chair and committee, but this hasn't happened yet. I certainly do want to give it a life beyond my tenure. By the way, I haven't been doing this alone, by any means. It would not have been nearly as good without the committee that has worked on it. That committee was loosely based on MSRI's Scientific Advisory Committee.

The other conference innovation I've worked on has to do with the Summer Research Conferences [SRCs], which are up for renewal now. Two years in a row we've experimented with a special conference for young people, in which the presenters are mostly pre- and (just) postdoctoral mathematicians. I think it's a niche that's not being filled by anyone else and one that I would like to see the AMS step into in one way or another. I am hopeful that such young people's conferences will play a large role in the grant application that the AMS and SIAM (Society for Industrial and Applied Mathematics) are about to make [for the SRCs], and I hope that application is granted.

Notices: *Usually one would want to have established leaders at a conference, but what you're describing is different.*

Eisenbud: Here a few established leaders come, and they may give survey talks, but the vast majority of the participants are very young people, just starting out in mathematics. The two conferences were run differently, and both worked well. In one of them, the young people presented their own research. In the other, the senior people decided on five big topics, and the young people ran seminars around those topics with young people as speakers and with a senior mentor in each one.



David Eisenbud

My model for such young people's conferences was a series of conferences called Géométrie Algébrique en Liberté (GAEL) started, I believe, by André Hirschowitz, that take place in Luminy, France. They are organized by and for young people, and the name refers to the fact that they are free of the control of their elders in this. The GAEL conferences have been sponsored by EAGER, the European Algebraic Geometry network. EAGER has just lost its funding from the European Community; I hope GAEL is not jeopardized.

Notices: *Bringing in a lot of young people and having them make decisions about what's on the program sounds like a good idea.*

Eisenbud: Yes, it's a heady mix, it's exciting for them, and it has worked very well. Also, it is a new way in which the AMS could make itself known to young folks.

Coming back to the AMS itself, some of the other things I've found exciting in this job have been the Washington communications, such as the Congressional Luncheons that the AMS runs every year. Sam Rankin [director of the AMS Washington Office] organizes these. I think they have the potential to have a big effect on Congressional staffers. We have had very good people speak on interesting things connected to mathematics research. It's been fun to connive with Sam in planning these events.

I've also been interested in the structure of the AMS. For example I have begun a discussion—it would be several years before the discussion could possibly lead to any action, since this would require a change in bylaws!—about the structure of the presidential elections. Typically we have a committee that works hard to find two really good candidates. One of them wins the election, and the other is usually rather put out by this—understandably enough. They are both very good people, and either could have done the job well. We often lose someone who is all primed for service and who could do a good job. So my proposal is to make the one who polls

fewer votes vice-president that year. In the current system we elect a vice-president each year. Why not have the vice-president-elect be the failed presidential candidate every second year? The failed presidential candidate usually polls about as many votes as any vice-presidential candidate. I would like to see that change. There are complexities and ramifications—it's going to be discussed, and I'm sure all these difficulties will be aired. But I think something like that would be a good idea.

Notices: *Do you think contested elections are a good thing for the AMS? We have not had them for very long.*

Eisenbud: Ten years, a little more. Well, it's mixed. There are people who simply won't serve under those circumstances, and there are people who are quite turned off by losing. On the other hand, I think it's good for the membership to feel that they have some choice, and that it's not just the old fogies on a committee who are making the decision. It gives freshness to the procedure. I think it's a mixed blessing, but I don't propose to get rid of it.

Notices: *Maybe your proposal is a good compromise.*

Eisenbud: It would make the system a little gentler.

When I was asked whether I would stand for election myself, I had quite mixed feelings—partly because of what we just talked about but, even more, I wondered: how am I going to fit this into my life? I had a sabbatical coming up, I had all kinds of plans about what research I wanted to do. I keep up some research while I am director at MSRI, but it's a struggle. I had mixed feelings about the AMS job because of that, and I think many people who are asked to consider the job of president have similar worries. I would like to record my feeling that, knowing what I know now, I would kick myself if I hadn't said yes to that nomination. It's been quite an interesting experience. I have met people I would not have met otherwise, and have learned about an organization that I think is just marvelous. It functions by and large extremely well. So I am very pleased to have done this job. Not that I'm sorry my term is ending! It's been quite intense, and I have plenty else to do. I have a wonderful successor in Jim Arthur, who has thrown himself into learning about the job, and I think he'll do extremely well.

Notices: *One thing the AMS has been considering a lot lately is membership and how to renew the stream of members. Young people who are entering the field don't automatically become members, as they used to.*

Eisenbud: When I was a graduate student I remember [Irving] Kaplansky, who was one of my teachers, said to a group of us: "Of course you should join the AMS. It's the union!" People aren't joining unions as much as they used to, either. But it really is true that the AMS does a lot of things for the community that are just not in the agenda of individual mathematicians, so it's very important for the community that the AMS remains strong. The AMS is also one of the biggest publishers of advanced mathematics books now—it may well be *the* biggest, after the shakedown of commercial publishers. It's a very important organization for the world mathematical community and for the American mathematical community in particular.

Notices: *Why aren't young people joining in greater numbers?*

Eisenbud: Across our society, professional identity and professional membership have become less important. It's a trend visible in practically every membership organization. Within our particular community, I don't know if there are special forces. The AMS has been studying this problem and trying to understand better what members want and how the Society can be of use to members, and I think there will be several initiatives appearing soon. The Membership Department is working hard to make AMS membership per se more valuable. A problem, in a way, is that the AMS is so community-spirited: the idea of making some benefit *not* available to the people who are *not* members is painful. For example, very few societies make the membership list available to everybody without being members. Very few societies make the most-read journal, which is our *Notices*, available to everybody without being members. Making those things freely available may not be in the self-interest of the Society, but at least in the short run it is good for the greater mathematical community. It is good in the long run too unless it damages the Society, whose well-being is good for the mathematical community in many ways. A new balance may have to be struck between these needs.

Notices: *Any thoughts on the future role of the AMS?*

Eisenbud: The future looks bright to me; there is a huge amount going on. I think the AMS core staff—John Ewing and Bob Daverman in particular—are wonderful, and it has been a great pleasure to work with both of them, and I admire them a lot. I really enjoyed working with each of them in different ways and learned a lot from them. And with Sam Rankin too, concerning advocacy for mathematics in Washington. All the mathematics organizations are in there pitching, and the AMS is one of the leaders. I think the Society is in good hands and will continue to be. There is a huge pool of talented and committed people the Society draws on. That impressed me a lot, how seriously people take their role in the AMS and how willing they are to spend time on committees and such, making sure the AMS functions well.

AMS Website Connects Math and the Public

Math in the Media is an online magazine posted monthly on the AMS website. Its main aim is to inform and entertain both mathematicians and interested members of the general public, by highlighting coverage of mathematics in the mainstream media. Another offering on the AMS website is the monthly *Feature Column*, which provides expositions about mathematical topics accessible to the general public. This fall, the AMS inaugurated a snazzy new design for both *Math in the Media* and the *Feature Column* that makes them even more fun and easier to use.

Each month, the main page of *Math in the Media* carries "Tony's Take", a survey of the previous month's news relating to mathematics, written by Tony Phillips of the State University of New York at Stony Brook. His brief synopses of stories appearing in print and on radio and television are witty and eloquent. As one sees in his recent summary of a story in *Nature* about how cells develop in the eyes of fruit flies, Phillips has a knack for distilling the mathematical substance in stories about all kinds of things. He has a broad view of mathematics as a subject in its own right and in its relations to art, literature, society, and science. As a way of keeping up on how the media are covering mathematics, Phillips's column is a must-read.

The "Math Digest" section takes a more comprehensive approach to following math coverage in the media. Pooling the efforts of AMS staff and AMS-AAAS Mass Media Fellows, the "Math Digest" section provides bibliographic references and short summaries of media stories about mathematics. Among the outlets systematically covered are *Science*, *Nature*, *New Scientist*, the *New York Times*, the *Chronicle of Higher Education*, and *American Scientist*. The "Math Digest" contributors also stay on the lookout for math stories in other print outlets and on radio and TV. With archives reaching back to 1995, this may be the most comprehensive resource for media coverage of mathematics available on the web.

The "Reviews" pages contain pointers to reviews of books, plays, movies, and television shows that are related to mathematics. There are references for reviews of nearly 200 books, most of them aimed at the general public. The reviews appeared in a variety of newspapers, magazines, and journals, and links to the reviews are provided where possible. One also finds here references to reviews of about ten movies and plays that feature mathematicians as main characters—a sign of the newfound appeal of mathematics as a theme in popular culture.

Another offering of the AMS website that connects math and the general public is the *Feature Column*, which each month presents a lively and accessible introduction to a mathematical topic. For the past three years, Joseph Malkevitch of York College of the City University of New York has written columns on such topics as marriage theorems, voting, bin packing problems, prime numbers, and mathematics and art. A patient and knowledgeable guide, Malkevitch strikes a good balance between providing needed details and shielding the reader from complications. These essays can be profitably read by members of the general public, as well as by mathematicians interested in broadening their horizons or finding topics to awaken their students' interest.

The *Feature Column* archives contain a total of more than 80 columns written since 1997, when this section of the AMS website was started by Steven Weintraub of Lehigh University. Tony Phillips wrote the columns for three years, and Bill Casselman of the University of British Columbia also wrote a few. Starting in February 2005, Casselman, Malkevitch, Phillips, and David Austin of Grand Valley State University will collaborate on editing the column, with pieces written by one of them or by other authors.

On the *Math in the Media* page one also finds links to AMS news, the "Headlines and Deadlines" email news service, and "This Mathematical Month," which contains vignettes about mathematics organized according to the month. Overseen by the AMS Public Awareness Office, these web offerings are excellent resources for the mathematical community and the general public. Check them out.

—*Allyn Jackson*

Feature Column
http://www.ams.org/featurecolumn

FEATURE COLUMN *Monthly Essays on Mathematical Topics*

This Month's Feature Column

Euler's Polyhedral Formula

A theorem which would make both my list of 10 favorite theorems and my list of 10 most influential theorems. . .

1. Introduction

It's coming to the end of the calendar year and a lot of people are producing lists. What were the 10 largest box-office blockbusters? What were the 10 best movies of the year? Who are the 10 best dressed men and 10 worst dressed women? One can also construct more grandiose lists. Who were the 10 best pitchers of all time or what were the 10 greatest movies? What appears on a list constructed by the same person can change dramatically with slight wording changes. Thus, the list of my 10 favorite movies might not coincide with my list of the 10 greatest movies ever made.

Does it make sense to construct lists related to mathematics? What about a list of the 10 greatest mathematicians? 10 greatest women mathematicians? The 10 most influential theorems? The 10 niftiest theorems?

On the one hand constructing lists is perhaps silly. How can one make a list of the 10 greatest composers of classical music? Must I leave Tchaikovsky out to include Mahler or Handel? Yet, from another perspective constructing lists of this kind makes one think about a wide variety of value-laden issues. What makes a composer great? Should a composer of a few great pieces be put on a short list of greats while another composer who perhaps composed nothing that rose to the heights of the first person, yet composed 100 times as many pieces at a very high level of inspiration, is omitted? This being the first of my last two columns as solo editor of the Feature Column, perhaps readers will indulge me if I write two columns about a theorem which would make both my list of 10 favorite theorems and my list of 10 most influential theorems. This

FROM THE EDITOR'S DESK

Welcome!

These web essays are designed for those who have already discovered the joys of mathematics as well as for mathematics skeptics. Mathematics is a fast growing and evolving subject. The domain of ways that mathematics is being applied is growing by leaps and bounds. (Examples include CAT scans, audio CD's, face recognition systems etc.) My goal is to share my excitement about these developments with you.
More . . .

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- **November:** Mathematical Marriages
- **October:** Voting Games II
- **September:** Voting Games I
- **July/August:** Machine Scheduling
- **June:** Bin Packing and Machine Scheduling
- **May:** Bin Packing
- **April:** Networks
- **March:** Diagonals: Part II
- **February:** Diagonals: Part I
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IT and the Riemann Hypothesis

"What is the Riemann Hypothesis and why Should I Care?" is the provocative title of a piece by Robin Bloor posted at IT-Director.com on October 5, 2004. The site "provides IT decision makers with a one stop source of all current IT news, information, analysis and advice." (IT = Information Technology). Naturally, there is no attempt at a correct statement of the Riemann Hypothesis ("Without bothering to state the details, it is a proposed formula that calculates the number of primes less than a given number") but the reason why IT decision makers might be concerned is the "worrying predictions that if the Riemann Hypothesis is confirmed mathematically, then most of the encryption schemes we use in commerce and government will suddenly be vulnerable ..." together with news of its possible confirmation by Louis de Branges and perhaps by others. The risk for IT is "if the mathematics surrounding the solution reveals quicker ways to factorize numbers. Actually even then it will only matter if it reveals much quicker ways to factorize numbers." Because public-key cryptography "is

Math Digest
Short summaries of articles about mathematics in the popular press

Recent Math Digest Summaries:
Posted here 2 December 2004:

"What Makes an Equation Beautiful," New York Times, 24 October 2004

In a column in *Physics World* magazine, philosopher and historian Robert P. Crease asked readers which equations they considered to be the greatest. He got 120 responses proposing 50 different equations. This article discusses Crease's experiment and also provides readers with a nice context to appreciate the power of mathematical equations. The top vote-getters were Maxwell's equations for electromagnetism and Euler's equation, $e^{i\pi} + 1 = 0$. A list of 18 other winners is given in a sidebar. Most of the equations relate to physics, but the Pythagorean theorem and the Riemann zeta function made it onto the list.

-- Allyn Jackson

More . .

Book Review

. . . a small idea of what it is I do all day . . .

Introductions to Mathematics

Günter M. Ziegler

What Is Mathematics? An Elementary Approach to Ideas and Methods
Richard Courant and Herbert Robbins
Second edition, revised by Ian Stewart
Oxford University Press, 1996
Paperback, 592 pages, $21.50
ISBN 0-19-510519-2

The Heart of Mathematics: An Invitation to Effective Thinking
Edward B. Burger and Michael Starbird
Key College Publishing (Springer-Verlag), 2000
Hardcover, 646 pages, $69.95
ISBN 0-555953-407-9

Mathematics: A Very Short Introduction
Timothy Gowers
Oxford University Press, 2002
Paperback, 144 pages, $9.95
ISBN 0-19-285361-9

1089 and All That. A Journey into Mathematics
David Acheson
Oxford University Press, 2002
Hardcover, 178 pages, £9.95
ISBN 0-19-851623-1

What Is Mathematics?

Here are some questions for you:

1. What is mathematics?
2. What are you doing when you are "doing mathematics"?
3. Mathematical research—how does that happen? Can it be planned? Can it be cast into "projects"?
4. What are the most important problems in mathematics? And why don't all mathematicians work on these?
5. What does it mean to a mathematician that something is *proved*? And what does it mean if he *believes a proof*?
6. How and why is mathematics relevant for "the real world"?
7. Why is mathematics so unreasonably effective in some applications?
8. Why is mathematics so hard to understand? And why is most of it so hard to explain?

All these are valid questions. There are classical answers: G. H. Hardy's *A Mathematician's Apology* probably contains the most famous and the most controversial ones. But none of them are eternal or universally valid. As mathematics and the nature of mathematics develop and change, we have to come up with new explanations again and again. One may also try to come up with answers that are not even intended to be universally valid, with personal views of the world of mathematics. I believe that these are equally useful and important. So, what is mathematics *to you*?

Suggested Answers

One reason why you should look for, and provide, your own answers to such questions is that you won't like many of the answers that you'll get from others.

For example: Why is it that these days we start with *applications* whenever we try to present mathematics to the public? Perhaps this is the easiest and the most effective way, or the most convincing? The one that even politicians might understand? My own experience certainly supports this impression. I can't explain the high-dimensional geometry I do to nonmathematician friends at night at a bar, but I can tell them about mathematicians'

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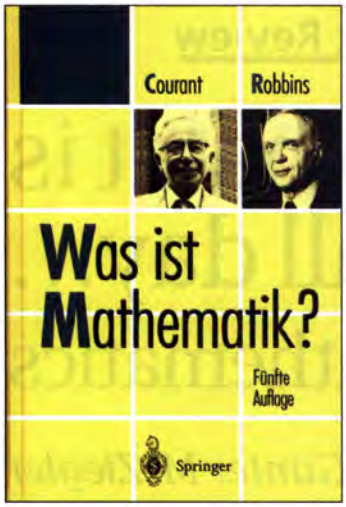

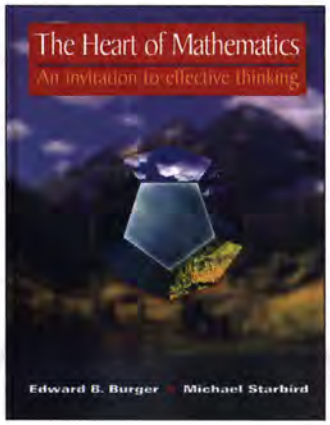

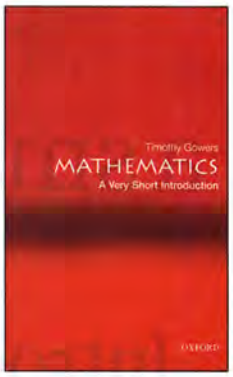

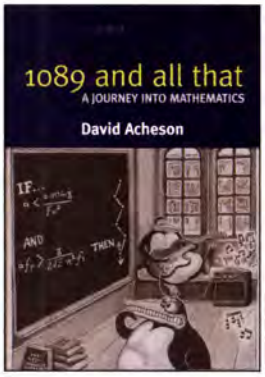

work on bus schedules and on hyperthermia cancer therapy (to mention two Berlin examples), and they'll be suitably impressed. However, although applications answers may be interesting and easy and effective, they shouldn't be the only ones!

Another example: What kind of pictures of "what mathematics is like" do your kids bring home from school? Do these pictures have anything to do with what we believe they should be? Aren't their views of mathematics very lopsided and incomplete, at best? Do they represent what mathematics "really is about"? Do kids experience the power of mathematics, the virtues of precision and abstraction, mathematical creativity and mathematical ideas? Do they learn about this in a way that we think is fair, colorful, multifaceted, exciting, and inviting? Do they get to see mathematics as we would view it? How do we view it?

Mathematics According to Courant

What Is Mathematics? is the title of a classic book by Richard Courant and Herbert Robbins from 1941, published by Oxford University Press, with successful translations into German, Italian, and Russian. Apparently Courant was quite hesitant about the title and thought that *Mathematical Discussions of Basic Elementary Problems for the General Public* might be more accurate, but also "a little bit boring."

Constance Reid tells the story that at a dinner in Princeton Courant talked to Thomas Mann, who told him about one of his books, a little novel whose German title was *Lotte in Weimar*. Mann thought that the same title might work in English, whereas his publisher Alfred Knopf (or rather Knopf's wife) had suggested *The Beloved Returns*, saying that *Lotte in Weimar* would sell 10,000 or perhaps 20,000 copies, but *The Beloved Returns* might sell 100,000—with the corresponding authors' royalties. So Thomas Mann went for *The Beloved Returns*, and Richard Courant went for *What Is Mathematics?* Courant sold more than 100,000 copies. I don't know about Mann's book.

Courant was perhaps one of the most influential "applied mathematicians" of the twentieth century. But there's no "applied math" in his book! However, there is a lot of mathematics, just very little *about* mathematics. Courant and Robbins' answer to his title question is to develop and explain mathematics, a wealth of very classical and fundamental topics: numbers and number theory, geometry, topology, calculus. The last sentence of the introduction reads

> For scholars and laymen alike it is not philosophy but active experience in mathematics itself that alone can answer the question: What is mathematics?

New Answers

What is mathematics? Is it changing? Of course it is, and so we have to ask for, and attempt to give, *new* answers to the old question.

The Heart of Mathematics: An Invitation to Effective Thinking is the title of one such answer, a book by Edward B. Burger (Williams College) and Michael Starbird (University of Texas at Austin). It is a large volume (650 pages in the first edition), with ample four-color illustrations throughout, and a bit of arrogance in the title. What a contrast to Courant's book, in style, but also in contents. This is a textbook for a "math appreciation" undergraduate class, but also fun reading and viewing for anyone else. The choice of topics is guided by what is or should be interesting to an audience of non-science majors. So some classical topics appear; after a lot of introductory drumming the book starts with the pigeon-hole principle and Fibonacci numbers. But this is not part of a systematic development. There are rope tricks, games, aperiodic tilings, fractals, lots of "modern mathematics", all of this embedded into lots of motivational talk, "fun and games", "mindscapes", "creating new ideas", "invitations to further thought", and "lessons for life". It's well done, I think it is good to have, it is

fun, but it is not my style. At forty-one, I may be too old or too old-fashioned for this.

Personally, I prefer the small and modest attempts to answer the old question. One recent such attempt is *Mathematics: A Very Short Introduction* by Tim Gowers (of 1998 Fields Medal fame). It appeared in an Oxford University Press series of "Very Short Introductions" that treats an extensive list of topics concerning nearly everything under the sun, such as religion, philosophy, and history, but also animal rights, cryptography, evolution, Heidegger, Hinduism, and linguistics. There's even "Schizophrenia: A Very Short Introduction".

An Author Needs to Be Convinced

Let's just imagine one of the friendly Oxford University Press mathematics editors knocking at Professor Gowers's office door. She would introduce herself, and say "Well, you know, we have this little book series ... it is really quite successful ... this, for example, is the little volume on atheism ... it has just appeared ... couldn't you, for example, write one for us ... about mathematics ...??" And Professor Gowers is quite thoughtful and a bit skeptical, and he doesn't want to say no right away, because somehow he *is* intrigued by the challenge, so he just promises "... to think about it ..." And then it comes as a considerable surprise (first to him, then to his editor) that he does get started on the impossible task, takes on the challenge. And *he succeeds*, with style.

Mathematics According to Gowers

The result is quite British, serious but not without humor. The preface sets the stage:

> Very little prior knowledge is needed to read this book [...] but I do presuppose some interest on the part of the reader rather than trying to drum it up myself. For this reason I have done without anecdotes, cartoons, exclamation marks, jokey chapter titles, or pictures of the Mandelbrot set. I have also avoided topics such as chaos theory and Gödel's theorem, which have a hold on the public imagination out of proportion to their impact on current mathematical research, and which are in any case well treated in many other books.

And then he gets going: There's not much space—140 *small* pages. No space to *explain* large amounts of mathematics. But Gowers gives a captivating, interesting, and quite personal[1] introduction into some mathematical questions, which surprisingly fast get surprisingly close to the "heart of mathematics", without having to do any difficult math. He speaks clearly and concretely about the role of models and about abstractions, concluding "Once one has learned to think abstractly, it can be exhilarating, a bit like suddenly being able to ride a bicycle without having to worry about keeping one's balance." He talks about limits and infinity and about dimension, and at this point even a fractal curve comes up, including a picture! And he explains why most mathematicians don't worry about foundational questions such as "whether numbers exist" or about "infinity".

Gowers' last chapter, "Some Frequently Asked Questions", treats mathematics as a human endeavor. Here's his list of questions:

1. Is it true that mathematicians are past it by the time they are thirty?
2. Why are there so few women mathematicians?
3. Do mathematics and music go together?
4. Why do so many people positively dislike mathematics?
5. Do mathematicians use computers in their work?
6. How is research in mathematics possible?
7. Are famous mathematical problems ever solved by amateurs?
8. Why do mathematicians refer to some theorems and proofs as beautiful?

Of course I won't give you his answers here. You should look at his volume: He certainly does not give "the only possible correct answers", but convincing, modest, and thoughtful ones. For example, on Question 4 he does (of course!) talk about instruction at schools, and he thinks that there's need and room for improvement, but also he says "I do not advocate any revolutionary change—mathematics has suffered from too many of them already—but a small change in emphasis could pay dividends. For example [...]". On Question 8, he thinks that "from an aesthetic point of view, a mathematician is more anonymous than an artist. While we may greatly admire a mathematician who discovers a beautiful proof, the human story behind the discovery eventually fades away." Does it? I believe that it's our duty to also record the human story, the story about what we all do, the stories about those who solve the big problems—and about those who put decades into the quest for such solutions.

Mathematics According to Acheson

David Acheson's *1089 and All That. A Journey into Mathematics* is a little volume from the same publisher as Gowers's book. It appeared in the same year, in the same small format—but what a contrast it is otherwise! This contains all the "anecdotes, cartoons, exclamation marks, jokey chapter titles" that Gowers wouldn't do. It's an amusing and entertaining roller-coaster ride into the world of mathematics, as seen by David Acheson. It is a

[1] *The title of this review quotes the last few words from the preface.*

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lively, funny, multifaceted view, with lots of pictures, drawings, cartoons: the ride starts with a magic trick based on numbers (whose result is 1089) from *I-SPY* magazine that intrigued Acheson as a boy. In the end, it leads up to an elementary discussion of differential equations, in which he now, perhaps not quite seriously, sees answers to the "mystery of life". But in any case differential equations provide useful models for the real world, and they do have applications. Probably *1089 and All That* is not an *important* book in any sense, but a fun piece to look into on a rainy afternoon.

Mathematics According to You!

If you are a mathematician, and not one of the very introverted kind, then I think you ought to give your own answers. You needn't think about it as starting to write a book. Just get a little notebook, perhaps the size in which we wrote our diaries in the good old times when people like us would still write *by hand.* To begin, put down your own list of questions that you think need good answers; you might start with "What is mathematics?"

Whatever you want to share with people, make it available. Some colleagues have a few pages of notes, views, or advice for students on their home pages. The most outspoken example I know is Doron Zeilberger's famous, wonderfully outrageous "Opinions" page.[2] Why are mathematician's professional home pages so impersonal? I don't mean that I want to see more baby photos—I'd want to see more thoughts about what you are doing, what the mathematics means to you, where the challenges are, and why this is interesting and important to you and to all of us.

[2] *"Dr. Z's opinions,"* `http://www.math.rutgers.edu/~zeilberg/OPINIONS.html`.

Interview with Michael Atiyah and Isadore Singer

Martin Raussen and Christian Skau

The interviewers were Martin Raussen, Aalborg University, Denmark; and Christian Skau, Norwegian University of Science and Technology, Trondheim, Norway. This interview took place in Oslo on May 24, 2004, during the Abel Prize celebrations. It originally appeared in the European Mathematical Society Newsletter, September 2004, pages 24-30.

The Index Theorem

Raussen & Skau: *First, we congratulate both of you for having been awarded the Abel Prize for 2004. This prize has been given to you for "the discovery and the proof of the Index Theorem connecting geometry and analysis in a surprising way and your outstanding role in building new bridges between mathematics and theoretical physics". Both of you have an impressive list of fine achievements in mathematics. Is the Index Theorem your most important result and the result you are most pleased with in your entire careers?*

Atiyah: First, I would like to say that I prefer to call it a theory, not a theorem. Actually, we have worked on it for twenty-five years, and if I include all the related topics, I have probably spent thirty years of my life working on the area. So it is rather obvious that it is the best thing I have done.

Singer: I, too, feel that the Index Theorem was but the beginning of a high point that has lasted to this very day. It's as if we climbed a mountain and found a plateau we've been on ever since.

R & S: *We would like you to give us some comments on the history of the discovery of the Index Theorem.*[1] *Were there precursors, conjectures in this direction already before you started? Were there only mathematical motivations or also physical ones?*

Atiyah: Mathematics is always a continuum, linked to its history, the past—nothing comes out of zero. And certainly the Index Theorem is simply a continuation of work that, I would like to say, began with Abel. So of course there are precursors. A theorem is never arrived at in the way that logical thought would lead you to believe or that posterity thinks. It is usually much more accidental, some chance discovery in answer to some kind of question. Eventually you can rationalize it and say that this is how it fits. Discoveries never happen as neatly as that. You can rewrite history and make it look much more logical, but actually it happens quite differently.

Singer: At the time we proved the Index Theorem we saw how important it was in mathematics, but we had no inkling that it would have such an effect on physics some years down the road. That came as a complete surprise to us. Perhaps it should not have been a surprise because it used a lot of geometry and also quantum mechanics in a way, à la Dirac.

R & S: *You worked out at least three different proofs with different strategies for the Index Theorem. Why did you keep on after the first proof? What different insights did the proofs give?*

Atiyah: I think it is said that Gauss had ten different proofs for the law of quadratic reciprocity. Any good theorem should have several proofs, the more the better. For two reasons: usually, different proofs have different strengths and weaknesses, and they generalize in different directions—they are not just repetitions of each other. And that is certainly the case with the proofs that we came up with. There are different reasons for the proofs, they have different histories and backgrounds. Some of them are good for this application, some are good for that application. They all shed light on the area. If you cannot look at a problem from different directions, it is probably

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Christian Skau is professor of mathematics at Norwegian University of Science and Technology, Trondheim, Norway. His email address is csk@math.ntnu.no.

[1] *More details were given in the laureates' lectures.*

Photograph by Anne Lise Flavikl.

Abel Prize winners Michael Atiyah (left) and Isadore Singer.

not very interesting; the more perspectives, the better!

Singer: There isn't just one theorem; there are generalizations of the theorem. One is the families index theorem using K-theory; another is the heat equation proof that makes the formulas that are topological more geometric and explicit. Each theorem and proof has merit and has different applications.

Collaboration

R & S: *Both of you contributed to the Index Theorem with different expertise and visions—and other people had a share as well, I suppose. Could you describe this collaboration and the establishment of the result a little more closely?*

Singer: Well, I came with a background in analysis and differential geometry, and Sir Michael's expertise was in algebraic geometry and topology. For the purposes of the Index Theorem, our areas of expertise fit together hand in glove. Moreover, in a way, our personalities fit together, in that "anything goes": Make a suggestion—and whatever it was, we would just put it on the blackboard and work with it; we would both enthusiastically explore it; if it didn't work, it didn't work. But often enough, some idea that seemed far-fetched did work. We both had the freedom to continue without worrying about where it came from or where it would lead. It was exciting to work with Sir Michael all these years. And it is as true today as it was when we first met in '55—that sense of excitement and "anything goes" and "let's see what happens".

Atiyah: No doubt: Singer had a strong expertise and background in analysis and differential geometry. And he knew certainly more physics than I did; it turned out to be very useful later on. My background was in algebraic geometry and topology, so it all came together. But of course there are a lot of people who contributed in the background to the buildup of the Index Theorem—going back to Abel, Riemann, much more recently Serre, who got the Abel Prize last year, Hirzebruch, Grothendieck, and Bott. There was lots of work from the algebraic geometry side and from topology that prepared the ground. And of course there are also a lot of people who did fundamental work in analysis and the study of differential equations: Hörmander, Nirenberg.... In my lecture I will give a long list of names[2]; even that one will be partial. It is an example of international collaboration; you do not work in isolation, neither in terms of time nor in terms of space—especially in these days. Mathematicians are linked so much, people travel around much more. We two met at the Institute at Princeton. It was nice to go to the Arbeitstagung in Bonn every year, which Hirzebruch organized and where many of these other people came. I did not realize that at the time, but looking back, I am very surprised how quickly these ideas moved.

R & S: *Collaboration seems to play a bigger role in mathematics than earlier. There are a lot of conferences, we see more papers that are written by two, three, or even more authors—is that a necessary and commendable development or has it drawbacks as well?*

Atiyah: It is not like in physics or chemistry where you have fifteen authors because they need an enormous big machine. It is not absolutely necessary or fundamental. But particularly if you are dealing with areas that have rather mixed and interdisciplinary backgrounds, with people who have different expertise, it is much easier and faster. It is also much more interesting for the participants. To be a mathematician on your own in your office can be a little bit dull, so interaction is stimulating, both psychologically and mathematically. It has to be admitted that there are times when you go solitary in your office, but not all the time! It can also be a social activity with lots of interaction. You need a good mix of both; you can't be talking all the time. But talking some of the time is very stimulating. Summing up, I think that it is a good development—I do not see any drawbacks.

Singer: Certainly computers have made collaboration much easier. Many mathematicians collaborate by computer instantly; it's as if they were talking to each other. I am unable to do that. A sobering counterexample to this whole trend is Perelman's results on the Poincaré conjecture: He worked alone for ten to twelve years, I think, before putting his preprints on the Net.

Atiyah: Fortunately, there are many different kinds of mathematicians, they work on different subjects, they have different approaches and different personalities—and that is a good thing. We do not want all mathematicians to be isomorphic,

[2] *Among those: Newton, Gauss, Cauchy, Laplace, Abel, Jacobi, Riemann, Weierstrass, Lie, Picard, Poincaré, Castelnuovo, Enriques, Severi, Hilbert, Lefschetz, Hodge, Todd, Leray, Cartan, Serre, Kodaira, Spencer, Dirac, Pontrjagin, Chern, Weil, Borel, Hirzebruch, Bott, Eilenberg, Grothendieck, Hörmander, Nirenberg.*

we want variety: different mountains need different kinds of techniques to climb.

Singer: I support that. Flexibility is absolutely essential in our society of mathematicians.

R & S: *Perelman's work on the Poincaré conjecture seems to be another instance in which analysis and geometry apparently get linked very much together. It seems that geometry is profiting a lot from analytic perspectives. Is this linkage between different disciplines a general trend—is it true that important results rely on this interrelation between different disciplines? And a much more specific question: What do you know about the status of the proof of the Poincaré conjecture?*

Singer: To date, everything is working out as Perelman says. So I learn from Lott's seminar at the University of Michigan and Tian's seminar at Princeton. Although no one vouches for the final details, it appears that Perelman's proof will be validated. As to your first question: When any two subjects use each other's techniques in a new way, frequently, something special happens. In geometry, analysis is very important; for existence theorems, the more the better. It is not surprising that some new [at least to me] analysis implies something interesting about the Poincaré conjecture.

Atiyah: I prefer to go even further—I really do not believe in the division of mathematics into specialities; already if you go back into the past, to Newton and Gauss.... Although there have been times, particularly post-Hilbert, with the axiomatic approach to mathematics in the first half of the twentieth century, when people began to specialize, to divide up. The Bourbaki trend had its use for a particular time. But this is not part of the general attitude to mathematics: Abel would not have distinguished between algebra and analysis. And I think the same goes for geometry and analysis for people like Newton.

It is artificial to divide mathematics into separate chunks and then to say that you bring them together as though this is a surprise. On the contrary, they are all part of the puzzle of mathematics. Sometimes you would develop some things for their own sake for a while, e.g., if you develop group theory by itself. But that is just a sort of temporary convenient division of labor. Fundamentally, mathematics should be used as a unity. I think the more examples we have of people showing that you can usefully apply analysis to geometry, the better. And not just analysis; I think that some physics came into it as well: many of the ideas in geometry use physical insight as well—take the example of Riemann! This is all part of the broad mathematical tradition, which sometimes is in danger of being overlooked by modern, younger people who say "we have separate divisions". We do not want to have any of that kind, really.

Singer: The Index theorem was in fact instrumental in breaking barriers between fields. When it first appeared, many old-timers in special fields were upset that new techniques were entering their fields and achieving things they could not do in the field by old methods. A younger generation immediately felt freed from the barriers that we both view as artificial.

Atiyah: Let me tell you a little story about Henry Whitehead, the topologist. I remember that he told me that he enjoyed very much being a topologist: he had so many friends within topology, and it was such a great community. "It would be a tragedy if one day I would have a brilliant idea within functional analysis and would have to leave all my topology friends and to go out and work with a different group of people." He regarded it to be his duty to do so, but he would be very reluctant. Somehow, we have been very fortunate. Things have moved in such a way that we got involved with functional analysts without losing our old friends; we could bring them all with us. Alain Connes was in functional analysis, and now we interact closely. So we have been fortunate to maintain our old links and move into new ones—it has been great fun.

Mathematics and Physics

R & S: *We would like to have your comments on the interplay between physics and mathematics. There is Galilei's famous dictum from the beginning of the scientific revolution, which says that the laws of nature are written in the language of mathematics. Why is it that the objects of mathematical creation, satisfying the criteria of beauty and simplicity, are precisely the ones that time and time again are found to be essential for a correct description of the external world? Examples abound; let me just mention group theory and, yes, your Index Theorem!*

Singer: There are several approaches in answer to your questions; I will discuss two. First, some parts of mathematics were created in order to describe the world around us. Calculus began by explaining the motion of planets and other moving objects. Calculus, differential equations, and integral equations are a natural part of physics because they were developed for physics. Other parts of mathematics are also natural for physics. I remember lecturing in Feynman's seminar, trying to explain anomalies. His postdocs kept wanting to pick coordinates in order to compute; he stopped them, saying: "The laws of physics are independent of a coordinate system. Listen to what Singer has to say, because he is describing the situation without coordinates." Coordinate-free means geometry. It is natural that geometry appears in physics, whose laws are independent of a coordinate system.

Symmetries are useful in physics for much the same reason they're useful in mathematics. Beauty aside, symmetries simplify equations, in physics and in mathematics. So physics and math have in common geometry and group theory, creating a close connection between parts of both subjects.

Second, there is a deeper reason, if your question is interpreted as in the title of Eugene Wigner's essay *The Unreasonable Effectiveness of Mathematics in the Natural Sciences.*[3] Mathematics studies coherent systems which I will not try to define. But it studies coherent systems, the connections between such systems, and the structure of such systems. We should not be too surprised that mathematics has coherent systems applicable to physics. It remains to be seen whether there is an already developed coherent system in mathematics that will describe the structure of string theory. [At present, we do not even know what the symmetry group of string field theory is.] Witten has said that 21st-century mathematics has to develop new mathematics, perhaps in conjunction with physics intuition, to describe the structure of string theory.

Atiyah: I agree with Singer's description of mathematics having evolved out of the physical world; it therefore is not a big surprise that it has a feedback into it. More fundamentally: to understand the outside world as a human being is an attempt to reduce complexity to simplicity. What is a theory? A lot of things are happening in the outside world, and the aim of scientific inquiry is to reduce this to as simple a number of principles as possible. That is the way the human mind works, the way the human mind wants to see the answer.

If we were computers, which could tabulate vast amounts of all sorts of information, we would never develop theory—we would say, just press the button to get the answer. We want to reduce this complexity to a form that the human mind can understand, to a few simple principles. That's the nature of scientific inquiry, and mathematics is a part of that. Mathematics is an evolution from the human brain, which is responding to outside influences, creating the machinery with which it then attacks the outside world. It is our way of trying to reduce complexity into simplicity, beauty, and elegance. It is really very fundamental; simplicity is in the nature of scientific inquiry—we do not look for complicated things.

I tend to think that science and mathematics are ways the human mind looks and experiences—you cannot divorce the human mind from it. Mathematics is part of the human mind. The question whether there is a reality independent of the human mind has no meaning—at least, we cannot answer it.

[3] *Comm. Pure App. Math.*, **13**(1), 1960.

R & S: *Is it too strong to say that the mathematical problems solved and the techniques that arose from physics have been the life blood of mathematics in the past; or at least for the last twenty-five years?*

Atiyah: I think you could turn that into an even stronger statement. Almost all mathematics originally arose from external reality, even numbers and counting. At some point, mathematics then turned to ask internal questions, e.g., the theory of prime numbers, which is not directly related to experience but evolved out of it. There are parts of mathematics about which the human mind asks internal questions just out of curiosity. Originally it may be physical, but eventually it becomes something independent. There are other parts that relate much closer to the outside world with much more interaction backward and forward. In that part of it, physics has for a long time been the life blood of mathematics and inspiration for mathematical work. There are times when this goes out of fashion or when parts of mathematics evolve purely internally. Lots of abstract mathematics does not directly relate to the outside world. It is one of the strengths of mathematics that it has these two and not a single life blood: one external and one internal, one arising as response to external events, the other to internal reflection on what we are doing.

Singer: Your statement *is* too strong. I agree with Michael that mathematics is blessed with both an external and internal source of inspiration. In the past several decades, high-energy theoretical physics has had a marked influence on mathematics. Many mathematicians have been shocked at this unexpected development: new ideas from outside mathematics so effective in mathematics. We are delighted with these new inputs, but the "shock" exaggerates their overall effect on mathematics.

Newer Developments

R & S: *Can we move to newer developments with impact from the Atiyah-Singer Index Theorem? That is, string theory and Edward Witten on the one hand, and on the other hand, noncommutative geometry represented by Alain Connes. Could you describe the approaches to mathematical physics epitomized by these two protagonists?*

Atiyah: I tried once in a talk to describe the different approaches to progress in physics like different religions. You have prophets, you have followers—each prophet and his followers think that they have the sole possession of the truth. If you take the strict point of view that there are several different religions, and that the intersection of all these theories is empty, then they are all talking nonsense. Or you can take the view of the mystic, who thinks that they are all talking of different aspects of reality, and so all of them are correct. I tend

to take the second point of view. The main "orthodox" view among physicists is certainly represented by a very large group of people working with string theory, such as Edward Witten. There are a small number of people who have different philosophies; one of them is Alain Connes, and the other is Roger Penrose. Each of them has a very specific point of view; each of them has very interesting ideas. Within the last few years, there has been nontrivial interaction between all of these.

They may all represent different aspects of reality and, eventually, when we understand it all, we may say "Ah, yes, they are all part of the truth". I think that that will happen. It is difficult to say which will be dominant when we finally understand the picture—we don't know. But I tend to be open-minded. The problem with a lot of physicists is that they have a tendency to "follow the leader": as soon as a new idea comes up, ten people write ten or more papers on it, and the effect is that everything can move very fast in a technical direction. But big progress may come from a different direction; you do need people who are exploring different avenues. And it is very good that we have people like Connes and Penrose with their own independent line from different origins. I am in favor of diversity. I prefer not to close the door or to say "they are just talking nonsense."

Singer: String theory is in a very special situation at the present time. Physicists have found new solutions on their landscape—so many that you cannot expect to make predictions from string theory. Its original promise has not been fulfilled. Nevertheless, I am an enthusiastic supporter of super string theory, not just because of what it has done in mathematics, but also because as a coherent whole, it is a marvelous subject. Every few years new developments in the theory give additional insight. When that happens, you realize how little one understood about string theory previously. The theory of D-branes is a recent example. Often there is mathematics closely associated with these new insights. Through D-branes, K-theory entered string theory naturally and reshaped it. We just have to wait and see what will happen. I am quite confident that physics will come up with some new ideas in string theory that will give us greater insight into the structure of the subject, and along with that will come new uses of mathematics.

Alain Connes's program is very natural—if you want to combine geometry with quantum mechanics, then you really want to quantize geometry, and that is what noncommutative geometry means. Noncommutative geometry has been used effectively in various parts of string theory explaining what happens at certain singularities, for example. I think it may be an interesting way of trying to describe black holes and to explain the Big Bang. I would encourage young physicists to understand noncommutative geometry more deeply than they presently do. Physicists use only parts of noncommutative geometry; the theory has much more to offer. I do not know whether it is going to lead anywhere or not. But one of my projects is to try and redo some known results using noncommutative geometry more fully.

Photograph by Knut Falch/Scanpix.

Abel Prize winners Isadore Singer and Michael Atiyah with Queen Sonja and King Harald of Norway at the royal palace in Oslo, May 2004.

R & S: *If you should venture a guess, which mathematical areas do you think are going to witness the most important developments in the coming years?*

Atiyah: One quick answer is that the most exciting developments are the ones that you cannot predict. If you can predict them, they are not so exciting. So, by definition, your question has no answer.

Ideas from physics, e.g., quantum theory, have had an enormous impact so far, in geometry, some parts of algebra, and in topology. The impact on number theory has still been quite small, but there are some examples. I would like to make a rash prediction that it will have a big impact on number theory as the ideas flow across mathematics—on one extreme number theory, on the other physics, and in the middle geometry: the wind is blowing, and it will eventually reach to the farthest extremities of number theory and give us a new point of view. Many problems that are worked upon today with old-fashioned ideas will be done with new ideas. I would like to see this happen: it could be the Riemann hypothesis, it could be the Langlands program, or a lot of other related things. I had an argument with Andrew Wiles in which I claimed that physics will have an impact on his kind of number theory; he thinks this is nonsense, but we had a good argument.

I would also like to make another prediction, namely that fundamental progress on the physics/mathematics front, string theory questions, etc., will emerge from a much more thorough understanding of classical four-dimensional geometry, of

Einstein's equations, etc. The hard part of physics in some sense is the nonlinearity of Einstein's equations. Everything that has been done at the moment is circumventing this problem in lots of ways. They haven't really got to grips with the hardest part. Big progress will come when people by some new techniques or new ideas really settle that. Whether you call that geometry, differential equations, or physics depends on what is going to happen, but it could be one of the big breakthroughs.

These are of course just my speculations.

Singer: I will be speculative in a slightly different way, though I do agree with the number theory comments that Sir Michael mentioned, particularly theta functions entering from physics in new ways. I think other fields of physics will affect mathematics—such as statistical mechanics and condensed matter physics. For example, I predict a new subject of statistical topology. Rather than count the number of holes, Betti numbers, etc., one will be more interested in the distribution of such objects on noncompact manifolds as one goes out to infinity. We already have precursors in the number of zeros and poles for holomorphic functions. The theory that we have for holomorphic functions will be generalized, and insights will come from condensed matter physics as to what, statistically, the topology might look like as one approaches infinity.

Continuity of Mathematics

R & S: *Mathematics has become so specialized, it seems, that one may fear that the subject will break up into separate areas. Is there a core holding things together?*

Atiyah: I like to think there is a core holding things together, and that the core is rather what I look at myself; but we tend to be rather egocentric. The traditional parts of mathematics, that evolved—geometry, calculus and algebra—all center on certain notions. As mathematics develops, there are new ideas, which appear to be far from the center going off in different directions, which I perhaps do not know much about. Sometimes they become rather important for the whole nature of the mathematical enterprise. It is a bit dangerous to restrict the definition to just whatever you happen to understand yourself or think about. For example, there are parts of mathematics that are very combinatorial. Sometimes they are very closely related to the continuous setting, and that is very good: we have interesting links between combinatorics and algebraic geometry and so on. They may also be related to, e.g., statistics. I think that mathematics is very difficult to constrain; there are also all sorts of new applications in different directions.

It is nice to think of mathematics having a unity; however, you do not want it to be a straitjacket. The center of gravity may change with time. It is not necessarily a fixed rigid object in that sense; I think it should develop and grow. I like to think of mathematics having a core, but I do not want it to be rigidly defined so that it excludes things that might be interesting. You do not want to exclude somebody who has made a discovery saying: "You are outside, you are not doing mathematics, you are playing around." You never know! That particular discovery might be the mathematics of the next century; you have got to be careful. Very often, when new ideas come in, they are regarded as being a bit odd, not really central, because they look too abstract.

Singer: Countries differ in their attitudes about the degree of specialization in mathematics and how to treat the problem of too much specialization. In the United States I observe a trend toward early specialization driven by economic considerations. You must show early promise to get good letters of recommendations to get good first jobs. You can't afford to branch out until you have established yourself and have a secure position. The realities of life force a narrowness in perspective that is not inherent to mathematics. We can counter too much specialization with new resources that would give young people more freedom than they presently have, freedom to explore mathematics more broadly, or to explore connections with other subjects, such as biology these days in which there is lots to be discovered.

When I was young the job market was good. It was important to be at a major university, but you could still prosper at a smaller one. I am distressed by the coercive effect of today's job market. Young mathematicians should have the freedom of choice we had when we were young.

R & S: *The next question concerns the continuity of mathematics. Rephrasing slightly a question that you, Professor Atiyah, are the originator of, let us make the following gedanken experiment: if, say, Newton or Gauss or Abel were to reappear in our midst, do you think they would understand the problems being tackled by the present generation of mathematicians—after they had been given a short refresher course? Or is present-day mathematics too far removed from traditional mathematics?*

Atiyah: The point that I was trying to make there was that really important progress in mathematics is somewhat independent of technical jargon. Important ideas can be explained to a really good mathematician, such as Newton or Gauss or Abel, in conceptual terms. They are in fact coordinate-free—more than that, technology-free and in a sense jargon-free. You don't have to talk of ideals, modules or whatever—you can talk in the common language of scientists and mathematicians. The really important progress mathematics has made within two hundred years could easily be understood by

people such as Gauss and Newton and Abel. Only a small refresher course in which they were told a few terms—and then they would immediately understand.

Actually, my pet aversion is that many mathematicians use too many technical terms when they write and talk. They were trained in a way that, if you do not say it 100 percent correctly, like lawyers, you will be taken to court. Every statement has to be fully precise and correct. When talking to other people or scientists, I like to use words that are common to the scientific community, not necessarily just to mathematicians. And that is very often possible. If you explain ideas without a vast amount of technical jargon and formalism, I am sure it would not take Newton, Gauss, and Abel long—they were bright guys, actually!

Singer: One of my teachers at Chicago was André Weil, and I remember his saying: "If Riemann were here, I would put him in the library for a week, and when he came out he would tell us what to do next."

Communication of Mathematics

R & S: *Next topic: communication of mathematics. Hilbert, in his famous speech at the International Congress in 1900, in order to make a point about mathematical communication, cited a French mathematician who said: "A mathematical theory is not to be considered complete until you have made it so clear that you can explain it to the first man whom you meet on the street." In order to pass on to new generations of mathematicians the collective knowledge of the previous generation, how important is it that the results have simple and elegant proofs?*

Atiyah: The passing of mathematics on to subsequent generations is essential for the future, and this is only possible if every generation of mathematicians understands what they are doing and distills it out in such a form that it is easily understood by the next generation. Many complicated things get simple when you have the right point of view. The first proof of something may be very complicated, but when you understand it well, you readdress it, and eventually you can present it in a way that makes it look much more understandable—and that's the way you pass it on to the next generation! Without that, we could never make progress—we would have all this messy stuff. Mathematics does depend on a sufficiently good grasp, on understanding of the fundamentals so that we can pass it on in as simple a way as possible to our successors. That has been done remarkably successfully for centuries. Otherwise, how could we possibly be where we are? In the 19th century, people said: "There is so much mathematics, how could anyone make any progress?" Well, we have—we do it by various devices, we generalize, we put all things together, we unify by new ideas, we simplify lots of the constructions—we are very successful in mathematics and have been so for several hundred years. There is no evidence that this has stopped: in every new generation, there are mathematicians who make enormous progress. How do they learn it all? It must be because we have been successful communicating it.

Singer: I find it disconcerting speaking to some of my young colleagues, because they have absorbed, reorganized, and simplified a great deal of known material into a new language, much of which I don't understand. Often I'll finally say, "Oh; is that all you meant?" Their new conceptual framework allows them to encompass succinctly considerably more than I can express with mine. Though impressed with the progress, I must confess impatience because it takes me so long to understand what is really being said.

R & S: *Has the time passed when deep and important theorems in mathematics can be given short proofs? In the past, there are many such examples—e.g., Abel's one-page proof of the addition theorem of algebraic differentials or Goursat's proof of Cauchy's integral theorem.*

Atiyah: I do not think that at all! Of course, that depends on what foundations you are allowed to start from. If we have to start from the axioms of mathematics, then every proof will be very long. The common framework at any given time is constantly advancing; we are already at a high platform. If we are allowed to start within that framework, then at every stage there are short proofs.

One example from my own life is this famous problem about vector fields on spheres solved by Frank Adams, for which the proof took many hundreds of pages. One day I discovered how to write a proof on a postcard. I sent it over to Frank Adams and we wrote a little paper which then would fit on a bigger postcard. But of course that used some K-theory; not that complicated in itself. You are always building on a higher platform; you have always got more tools at your disposal that are part of the lingua franca which you can use. In the old days you had a smaller base: if you make a simple proof nowadays, then you are allowed to assume that people know what group theory is, you are allowed to talk about Hilbert space. Hilbert space took a long time to develop, so we have got a much bigger vocabulary, and with that we can write more poetry.

Singer: Often enough one can distill the ideas in a complicated proof and make that part of a new language. The new proof becomes simpler and more illuminating. For clarity and logic, parts of the original proof have been set aside and discussed separately.

Atiyah: Take your example of Abel's Paris memoir: his contemporaries did not find it at all easy. It laid the foundation of the theory. Only later on,

in the light of that theory, we can all say: "Ah, what a beautifully simple proof!" At the time, all the ideas had to be developed, and they were hidden, and most people could not read that paper. It was very, very far from appearing easy for his contemporaries.

Individual Work Style

R & S: *I heard you, Professor Atiyah, mention that one reason for your choice of mathematics for your career was that it is not necessary to remember a lot of facts by heart. Nevertheless, a lot of threads have to be woven together when new ideas are developed. Could you tell us how you work best, how do new ideas arrive?*

Atiyah: My fundamental approach to doing research is always to ask questions. You ask "Why is this true?" when there is something mysterious or if a proof seems very complicated. I used to say—as a kind of joke—that the best ideas come to you during a bad lecture. If somebody gives a terrible lecture—it may be a beautiful result but with terrible proofs—you spend your time trying to find better ones; you do not listen to the lecture. It is all about asking questions—you simply have to have an inquisitive mind! Out of ten questions, nine will lead nowhere, and one leads to something productive. You constantly have to be inquisitive and be prepared to go in any direction. If you go in new directions, then you have to learn new material.

Usually, if you ask a question or decide to solve a problem, it has a background. If you understand where a problem comes from, then it makes it easy for you to understand the tools that have to be used on it. You immediately interpret them in terms of your own context. When I was a student, I learned things by going to lectures and reading books—after that I read very few books. I would talk with people; I would learn the essence of analysis by talking to Hörmander or other people. I would be asking questions because I was interested in a particular problem. So you learn new things because you connect them and relate them to old ones, and in that way you can start to spread around.

If you come with a problem, and you need to move to a new area for its solution, then you have an introduction—you have already a point of view. Interacting with other people is of course essential: if you move into a new field, you have to learn the language, you talk with experts; they will distill the essentials out of their experience. I did not learn all the things from the bottom upward; I went to the top and got the insight into how you think about analysis or whatever.

Singer: I seem to have some built-in sense of how things should be in mathematics. At a lecture, or reading a paper, or during a discussion, I frequently think, "that's not the way it is supposed to be." But when I try out my ideas, I'm wrong 99% of the time. I learn from that and from studying the ideas, techniques, and procedures of successful methods. My stubbornness wastes lots of time and energy. But on the rare occasion when my internal sense of mathematics is right, I've done something different.

R & S: *Both of you have passed ordinary retirement age several years ago. But you are still very active mathematicians, and you have even chosen retirement or visiting positions remote from your original work places. What are the driving forces* for *keeping up your work? Is it wrong that mathematics is a "young man's game" as Hardy put it?*

Atiyah: It is no doubt true that mathematics is a young man's game in the sense that you peak in your twenties or thirties in terms of intellectual concentration and in originality. But later you compensate for that by experience and other factors. It is also true that if you haven't done anything significant by the time you are forty, you will not do so suddenly. But it is wrong that you have to decline, you can carry on, and if you manage to diversify in different fields this gives you a broad coverage. The kind of mathematician who has difficulty maintaining the momentum all his life is a person who decides to work in a very narrow field with great depths, who, e.g., spends all his life trying to solve the Poincaré conjecture—whether you succeed or not, after ten to fifteen years in this field you exhaust your mind; and then, it may be too late to diversify. If you are the sort of person that chooses to make restrictions to yourself, to specialize in a field, you will find it harder and harder—because the only things that are left are harder and harder technical problems in your own area, and then the younger people are better than you.

You need a broad base, from which you can evolve. When this area dries out, then you go to that area—or when the field as a whole, internationally, changes gear, you can change too. The length of the time you can go on being active within mathematics very much depends on the width of your coverage. You might have contributions to make in terms of perspective, breadth, interactions. A broad coverage is the secret of a happy and successful long life in mathematical terms. I cannot think of any counterexample.

Singer: I became a graduate student at the University of Chicago after three years in the U.S. Army during World War II. I was older and far behind in mathematics. So I was shocked when my fellow graduate students said, "If you haven't proved the Riemann hypothesis by age thirty, you might as well commit suicide." How infantile! Age means little to me. What keeps me going is the excitement of what I'm doing and its possibilities. I constantly check [and collaborate!] with younger colleagues to be sure that I'm not deluding myself—that what we are doing is interesting. So I'm happily active in

mathematics. Another reason is, in a way, a joke. String theory needs us! String theory needs new ideas. Where will they come from, if not from Sir Michael and me?

Atiyah: Well, we have some students....

Singer: Anyway, I am very excited about the interface of geometry and physics and delighted to be able to work at that frontier.

History of the EMS

R & S: You, Professor Atiyah, have been very much involved in the establishment of the European Mathematical Society (EMS) around 1990. Are you satisfied with its development since then?

Atiyah: Let me just comment a little on my involvement. It started an awful long time ago, probably about thirty years ago. When I started trying to get people interested in forming a European Mathematical Society in the same spirit as the European Physical Society, I thought it would be easy. I got mathematicians from different countries together and it was like a mini-UN: the French and the Germans wouldn't agree; we spent years arguing about differences, and—unlike in the real UN, where eventually at the end of the day you are dealing with real problems of the world and you have to come to an agreement sometime—in mathematics, it was not absolutely essential. We went on for probably fifteen years before we founded the EMS.

On the one hand, mathematicians have much more in common than politicians. We are international in our mathematical life; it is easy to talk to colleagues from other countries. On the other hand, mathematicians are much more argumentative. When it comes to the fine details of a constitution, then they are terrible; they are worse than lawyers. But eventually—in principle—the good will was there for collaboration.

Fortunately, the timing was right. In the meantime, Europe had solved some of its other problems. The Berlin Wall had come down—so suddenly there was a new Europe to be involved in the EMS. This very fact made it possible to get a lot more people interested in it. It gave an opportunity for a broader base of the EMS, with more opportunities and also relations to the European Commission and so on.

Having been involved with the setup, I withdrew and left it to others to carry on. I have not followed in detail what has been happening except that it seems to be active. I get my newsletter, and I see what is going on.

Roughly at the same time as the collapse of the Berlin Wall, mathematicians in general—both in Europe and in the United States—began to be more aware of their need to be socially involved and that mathematics had an important role to play in society. Instead of being shut up in their universities doing just their mathematics, they felt that there was some pressure to get out and get involved in education, etc. The EMS took on this role at a European level, and the EMS congresses—I was involved in the one in Barcelona—definitely made an attempt to interact with the public. I think that these are additional opportunities over and above the old-fashioned role of learned societies. There are a lot of opportunities both in terms of the geography of Europe and in terms of the broader reach.

Europe is getting ever larger: when we started we had discussions about where were the borders of Europe. We met people from Georgia, who told us very clearly that the boundary of Europe is this river on the other side of Georgia; they were very keen to make sure that Georgia is part of Europe. Now, the politicians have to decide where the borders of Europe are.

It is good that the EMS exists; but you should think rather broadly about how it is evolving as Europe evolves, as the world evolves, as mathematics evolves. What should its function be? How should it relate to national societies? How should it relate to the AMS? How should it relate to the governmental bodies? It is an opportunity! It has a role to play!

Apart from Mathematics...

R & S: Could you tell us in a few words about your main interests besides mathematics?

Singer: I love to play tennis, and I try to do so two to three times a week. That refreshes me, and I think that it has helped me work hard in mathematics all these years.

Atiyah: Well, I do not have his energy! I like to walk in the hills, the Scottish hills—I have retired partly to Scotland. In Cambridge, where I was before, the highest hill was about this [gesture] big. Of course you have got even bigger ones in Norway. I spent a lot of my time outdoors, and I like to plant trees, I like nature. I believe that if you do mathematics, you need a good relaxation that is not intellectual—being outside in the open air, climbing a mountain, working in your garden. But you actually do mathematics meanwhile. While you go for a long walk in the hills or you work in your garden, the ideas can still carry on. My wife complains, because when I walk she knows I am thinking of mathematics.

Singer: I can assure you, tennis does not allow that!

R & S: Thank you very much on behalf of the Norwegian, the Danish, and the European Mathematical Societies!

Teachers, Exams, Standards: AMS Committee on Education Examines Issues

"It is almost a disaster." Irwin Kra's blunt words summed up the basic impression that many mathematicians have about the state of K–12 mathematics education. The last several years have seen a growing sense of urgency within the mathematical community about the poor quality of mathematics instruction in the nation's schools, as well as efforts on the part of mathematicians to help address the problems. At the same time, mathematics departments today are taking seriously the need to improve their own teaching. In particular, the role that math departments play in preparing future teachers of mathematics is increasingly being seen as one of the keys to improving mathematics education at all levels.

As attention to education has increased within the mathematical community, the AMS Committee on Education (COE) has become a focal point for discussions and debate. The COE is a policy committee, not an action committee, so its primary role is to stay abreast of developments in education and to provide advice when needed. The annual COE meetings, held each fall in Washington, DC, and arranged by the AMS Washington Office, are one of the main venues for finding out about developments in mathematics education that are pertinent to the interests of mathematicians. The most recent COE meeting, held in October 2004, attracted about fifty representatives from mathematics departments all over the country.

One of the most unusual developments discussed at the COE meeting came in the presentation by Kra, who recently retired from the State University of New York at Stony Brook and is currently the executive director of a new organization called Math for America (MfA). MfA was founded by James Simons, whose name is attached to the Chern-Simons invariants in geometry and who won the AMS Veblen Prize in 1976. Simons, who used to be on the faculty at Stony Brook, made a fortune by establishing a successful financial investment company and in recent years has become a major financial supporter of mathematics research at several major universities and institutes. MfA is his first large-scale venture into mathematics education.

Founded in February 2004, MfA has already committed over $25 million of private funds to improve mathematics education in New York City public high schools over the next five years. With this commitment, MfA will award about forty Newton Fellowships each year to mathematically sophisticated young people and people who want to change careers, to enable them to enroll in MAT programs and become high school mathematics teachers in New York City. The fellowships will pay for graduate mathematics education programs at partner universities, currently Queens College and New York University, and will also provide stipends, in addition to the regular salary paid by the schools, during the fellows' first four years of teaching. In addition, for each of the next five years, the Newton Master Teacher Fellowship Program will award about ten four-year fellowships of $50,000 each to mathematics teachers in New York City public schools to nurture them to become leaders in improving mathematics education.

The initial focus is on New York City simply because the group behind MfA consists mainly of New Yorkers, and they believe they can make progress in their home base. Plans call for expansion of the fellowship programs to other cities, and MfA will eventually seek federal funding for a national program. COE member Paul Sally of the University of Chicago, who has led mathematics education improvement programs in Chicago for many years, commented that it could take MfA a decade to gain enough experience to expand its programs nationally. Kra did not disagree but added: "We think there is a crisis out there. We want to see change as quickly as possible. We are impatient."

Another group that is making a mark in mathematics education is Achieve, a nonprofit organization that helps the states raise standards and improve assessment. Laura McGiffert, director of Achieve's mathematics program, described the results of an Achieve study of high school exit

examinations. Twenty-four states now require that students pass such exams in order to graduate, and today there is a lot of pressure on schools to use this kind of testing to show they are doing a good job. What is the mathematical content of these exit exams? Achieve studied the exams in six states, looking at the exams themselves rather than relying on what the states said was on them. What it found is that the tests focus on material that students in most other countries learn in the 7th or 8th grades rather than in high school. Most of the tests are multiple-choice, are not very demanding, and do not probe very deeply the students' reasoning and problem-solving skills. The study concluded that, while the exams are at a reasonable level, they should not be made any easier and should be strengthened over time.

Another study discussed at the COE meeting is one conducted by the Mathematical Sciences Education Board of the National Academy of Sciences. On the committee preparing the study is Donald Saari of the University of California, Irvine, who made a presentation before the COE. The study explored the question, Is the effectiveness of mathematics curricula being adequately evaluated? There was no attempt to evaluate the curricula themselves; rather, the goal was to evaluate the evaluations of the curricula. The study focused on nineteen curricula, thirteen of which were funded by the National Science Foundation (NSF) and the remainder of which were the products of commercial curriculum developers. The committee began with a collection of seven hundred evaluations of these nineteen curricula. Upon closer inspection, they found that around five hundred of those "evaluations" were really not evaluations at all but were such things as editorials, product descriptions, and progress reports. Of the remaining two hundred evaluations, another fifty were eliminated as not being sufficiently rigorous and quantitative.

The study concluded that these 150 evaluations are not adequate to say with certainty whether the curricula are effective. Furthermore, the committee found that there are no standards for evaluating the effectiveness of mathematics curricula. The report attempts to fill this gap by offering a framework for curricular evaluation. One component of this framework is content analysis, in which the disciplinary content of mathematics curricula is evaluated for clarity, accuracy, mathematical depth, and balance. Content analysis "is a place where we mathematicians can and should have a voice," Saari commented. The report, *On Evaluating Curricular Effectiveness: Judging the Quality of K-12 Mathematics Evaluations*, is now available on the web at `http://www.nap.edu/books/0309092426/html`.

For its meeting the COE organized a panel on the NSF's VIGRE (Vertical Integration of Research and Education) program. VIGRE has helped many mathematics departments energize the teaching of graduate and undergraduate students and the training of postdocs. During the panel, four representatives of mathematics departments spoke about their VIGRE activities: University of Wisconsin at Madison, Texas A&M University, University of California Los Angeles, and University of Arizona. Representatives of the NSF's Division of Mathematical Sciences (DMS) presented the disheartening news that, of the thirteen VIGRE grants that are expiring in 2005, at most five will be renewed. The DMS is well aware of the pain the ending of these grants will cause to the departments affected. However, that pain may be eased by two new programs that have aims similar to VIGRE: Research Training Groups and Mentoring Through Critical Transition Points. DMS officials say that the total amount of funding DMS is now putting into such training programs has actually increased.

During the COE meeting, the president of the American Mathematical Association of Two-Year Colleges (AMATYC), Susan Wood of J. Sargeant Reynolds Community College, described AMATYC's update of the "Crossroads" report, which lays out standards for two-year college mathematics. In addition, former COE chair Roger Howe of Yale University described an effort by a small group of mathematicians who are working on a document that will provide guidance for development of mathematics standards. The meeting ended with a panel in which four speakers representing a range of institutions discussed issues and challenges in undergraduate education in mathematics. What the COE meeting showed above all is that, unlike in years past, it is now taken for granted that mathematicians must pay attention to education. Future students, future teachers, and the future of the field itself all depend on it.

—Allyn Jackson

Committee on Education

Arthur Benjamin, Harvey Mudd College
Sylvia T. Bozeman, Spelman College
John B. Conway, National Science Foundation
Robert Daverman, University of Tennessee (ex officio)
David Eisenbud, Mathematical Sciences Research Institute (ex officio)
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2004 Annual Survey of the Mathematical Sciences

(First Report)

Report on the 2003–2004 New Doctoral Recipients Faculty Salary Survey

Ellen E. Kirkman, James W. Maxwell, and Colleen Rose

The First Report of the 2004 Annual Survey gives a broad picture of 2003-04 new doctoral recipients from U.S. departments in the mathematical sciences, including their employment status in fall 2004. The First Report also presents salary data for faculty members in U.S. departments of mathematical sciences in four-year colleges and universities. This report is based on information collected from two questionnaires distributed to departments in May 2004. A follow-up questionnaire was distributed to the individual new doctoral recipients in October 2004. 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 2004 Annual Survey in the August 2005 issue of the *Notices of the AMS*. Another questionnaire concerned with data on fall 2004 course enrollments, majors, graduate students, and departmental faculty was distributed to departments in September 2004. Results from this questionnaire will appear in the Third Report of the 2004 Annual Survey in the September 2005 issue of the *Notices of the AMS*.

The 2004 Annual Survey represents the forty-eighth in an annual series begun in 1957 by the American Mathematical Society. The 2004 Survey is conducted by staff at the American Mathematical Society with guidance from the Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Institute of Mathematical Statistics, and the Mathematical Association of America. The current members of this committee are Amy Cohen-Corwin, Donald M. Davis, Nicholas M. Ercolani, J. Douglas Faires, Alexander Hahn, Naresh Jain, Stephen F. Kennedy, Ellen E. Kirkman (chair), David J. Lutzer, James W. Maxwell (ex officio), and Polly Phipps. The committee is assisted by AMS survey analyst Colleen Rose. Comments or suggestions regarding this Survey Report may be directed to the members of the Data Committee.

Report on the 2003–2004 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, 2003, through June 30, 2004. It includes a preliminary analysis of the fall 2004 employment plans of 2003–04 doctoral recipients and a demographic profile summarizing characteristics of citizenship status, sex, and racial/ethnic group. All information came from the departments that gave the degrees.

Table 1: Doctorates Granted Response Rates

Group I (Pu)	24 of 25 including	0 with 0 degrees
Group I (Pr)	22 of 23 including	0 with 0 degrees
Group II	52 of 56 including	4 with 0 degrees
Group III	70 of 73 including	21 with 0 degrees
Group IV	65 of 87 including	7 with 0 degrees
Group Va	20 of 23 including	1 with 0 degrees

See "Definitions of the Groups" on page 251.

Table 1 provides the departmental response rates for the 2004 Survey of New Doctoral Recipients. See page 251 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 2004 Annual Survey using information gathered from the new doctoral recipients. The Second Report will appear in the August 2005 issue of the *Notices of the AMS*.

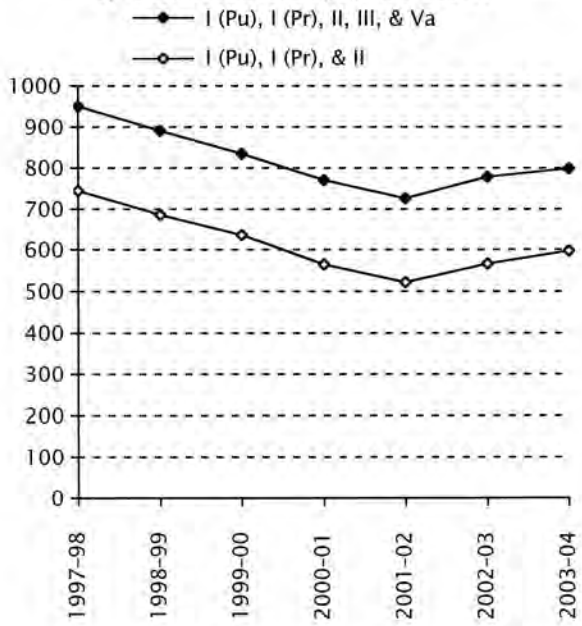
Changes in the Annual Survey occur over time, and these changes need to be considered when comparing results in this report to those in prior years. Information about changes that occurred in 1997 or later can be found in the First Report for the 2000 Annual Survey in the February 2001 issue of the *Notices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

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**

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



Ellen E. Kirkman is professor of mathematics at the Wake Forest University. James W. Maxwell is AMS associate executive director for Membership, Meetings, and Programs. Colleen Rose is AMS survey analyst.

Highlights

- There were 1,041 new doctoral recipients reported for 2003-04 by departments responding in time for the 2004 First Report.
- Group I (Pu) reported the smallest number of new doctoral recipients in the last 10 years (down 40% from 1995-96 figure). The number of new doctoral recipients from Groups I (Pu), I (Pr), and II combined has increased from 566 in 2002-03 to 597 this year, an increase of 31 (5%).
- Only 441 (42%) of the new doctoral recipients for 2003-04 are U.S. citizens, a decrease of 48 (10%) from 2002-03 and down 145 (25%) from 586 in 1997-98. The percentage of new doctoral recipients who are U.S. citizens is the lowest percentage observed in the past nine years.
- Based on responses from departments alone, the fall 2004 unemployment rate for the 914 new doctoral recipients whose employment status is known is 5.7%, up from 5.1% for fall 2003.
- Fifty-eight new doctoral recipients hold positions at the institution that granted their degree, although not necessarily in the same department. This is 7% of the new doctoral recipients who are currently known to have jobs and 9% of those who have academic positions in the U.S. Nineteen new doctoral recipients have part-time positions.
- The number of new doctoral recipients employed in the U.S. is 739, up 76 from last year. The number of new doctoral recipients employed in academic positions in the U.S. increased to 614 (a nine-year high) from 534 last year (a 15% increase); there were increases in the categories of the doctoral-employing institutions (combined), but the Master's and Bachelor's institutions hired 2 fewer new doctoral recipients than last year.
- Of the 739 new doctoral recipients taking positions in the U.S., 99 (13%) have jobs in business and industry; the number of new doctoral recipients taking jobs in business and industry, after oscillating in the late 1990s, declined three consecutive years by 38 in fall 2001, 45 in fall 2002, and 26 in fall 2003 before showing a slight increase of 2 in fall 2004. The number of new doctoral recipients taking jobs in government is down 6 (19%) over fall 2003.
- Among the 739 new doctoral recipients having employment in the U.S., 338 (46%) are U.S. citizens (down from 376 (57%) last year). The number of non-U.S. citizens having employment in the U.S. is 401, up 40% from 287 last year.
- Among the 302 new doctoral recipients hired by U.S. doctoral-granting departments, 38% are U.S. citizens (down from 52% last year). Among the 312 having other academic positions in the U.S., 53% are U.S. citizens.
- Of the 1,041 new doctoral recipients, 315 (30%) are females, up just 11 from fall 2003. Of the 441 U.S. citizen new doctoral recipients, 145 (33%) are females, down 12 from fall 2003. The all-time high was 187 in fall 1998.
- Among the 441 U.S. citizen new doctoral recipients, 5 are American Indian or Alaska Native, 23 are Asian, 12 are Black or African American, 13 are Hispanic or Latino, 386 are White, and 2 are Native Hawaiian or Other Pacific Islander.
- Group IV produced 243 new doctorates, of which 97 (40%) are females, compared to all other groups combined, where 218 (27%) are females. In Group IV, 81 (31%) of the new doctoral recipients are U.S. citizens (while in the other groups 45% are U.S. citizens).
- Three hundred eighteen new doctorates had a dissertation in statistics/ biostatistics (289) and probability (29). The next highest number was in algebra and number theory with 144. Those with dissertations in statistics/biostatistics and probability accounted for 31% of the new doctorates in 2003-04.

Table 3: Full-Time Graduate Students in Groups I, II, III, & Va, Fall 1994 to Fall 2003

GRADUATE STUDENTS	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total full-time	10185	9761	9476	9003	8791	8838	9637	9361	9972	9731
First-year full-time	2668	2601	2443	2386	2458	2664	2839	2875	2996	3612
U.S. citizen full-time	5945	5623	5445	4947	4831	4668	5085	4631	5055	5168
First-year U.S. citizen full-time	1664	1551	1465	1316	1349	1401	1527	1517	1630	1426

(Data Reprinted from Table 6B in Third Report, 2003 Annual Survey)

recipients themselves as well as additional new 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 2003–04

Table 2 shows the number of new doctoral degrees granted by the different doctoral groups surveyed in the Annual Survey for the past seven years. The 1,041 new doctorates granted by these departments in 2003–04 is an increase of 24 from the fall count for 2002–03. Figure 1 presents the trends in doctorates granted for Groups I (Pu), I (Pr), II, III, and Va combined and Groups I (Pu), I (Pr), and II combined.

The response rates were above 90% for all groups except Groups IV and Va. Group IV historically has had slightly lower response rates than the other groups. Overall, twelve fewer Group IV departments responded in time for the First Report this year than responded by this time last year.

The 1,041 new doctoral recipients is a preliminary count. A final count will appear in the Second Report in the August 2005 issue of the *Notices of the AMS*. Efforts are under way to obtain data from as many of the nonresponding departments as possible. A careful look at the past history of the nonresponding departments makes it unlikely that the final count of new doctoral recipients will increase by more than 35.

From Table 2 we see that Group I (Pr) showed the largest increase (49) in the number of doctoral recipients from the previous year, while Groups II and IV also had an increase. Groups I (Pu), III, and Va showed decreases of 63, 10, and 1 respectively. The total number in doctoral recipients in Group I (Pu) is the lowest number reported by this group in ten years (down 40% from the 1995–96 number of 325). Group III continues to decline slowly, down 25 from its high in 1998–99, and Group Va dropped slightly this year after reaching its highest level last year. In addition, we see that Group I (Pr) reported its highest number of doctoral recipients since 1997–98 with an increase of 49 over last year, Group II increased by 45 but is still down 49 from its high in 1997–98, and Group IV for the second consecutive year shows an increase but is still down 41 from its high in 1999–2000.

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 2003 Departmental Profile survey, are reprinted from Table 6B of the Third Report of the 2003 Annual Survey (*Notices of the AMS*, September 2004). It sheds some light on the downward trend in number of new doctorates as shown in Table 2 and Figure 1. Since 2000 the total number of full-time students has fluctuated in the 9,000s, with the fall 2003 count at 9,731. The number of first-year full-time graduate students fell from 2,668 in 1994 to 2,386 in 1997 before starting to increase in 1998, reaching a high of 3,612 for fall 2003. Full-time first-year U.S. citizen graduate students fell from 1,664 in 1994 to 1,316 in 1997, then climbed to a high of 1,630 for 2002 before declining to 1,426 for fall 2003. The increase in new doctoral recipients reported for 2003–04 continues what appears to be a moderate trend upward.

The 2003–04 numbers in Table 2 will be broken down in various ways, such as by

Figure 2: Percentage of New Doctoral Recipients Unemployed (as reported in the respective Annual Survey Reports 1992–2003)

Report	Fall	Final
1992–93	12.0	8.9
1993–94	14.0	11.0
1994–95	15.0	11.0
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	*

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

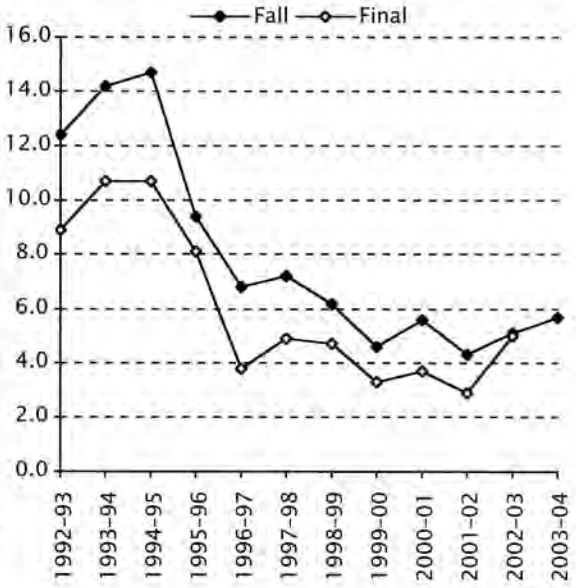


Table 4A: Employment Status of 2003-04 U.S. New Doctoral Recipients in the Mathematical Sciences by Field of Thesis

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	5	8	6	3	2	11	7	1	8	0	0	**69**
Group I (Private)		10	8	19	3	2	0	7	0	0	8	0	0	**57**
Group II		15	7	12	6	2	4	5	3	0	7	0	0	**61**
Group III		4	2	5	4	2	10	4	0	0	1	3	0	**35**
Group IV		0	0	0	0	0	62	1	0	0	0	0	0	**63**
Group Va		1	0	0	3	0	1	4	5	0	3	0	0	**17**
Master's		10	7	4	7	2	14	3	7	3	3	2	0	**62**
Bachelor's		16	14	11	8	2	12	5	7	3	11	3	0	**92**
Two-Year College		3	3	4	0	0	1	0	1	0	2	0	0	**14**
Other Academic Dept.		4	4	5	6	2	56	19	8	3	3	5	0	**115**
Research Institute/ Other Nonprofit		2	2	4	3	2	8	3	2	0	3	0	0	**29**
Government		2	2	1	3	0	8	5	2	2	1	0	0	**26**
Business and Industry		6	1	5	7	3	55	13	5	1	3	0	0	**99**
Non-U.S. Academic		18	10	13	12	3	9	11	6	5	15	0	1	**103**
Non-U.S. Nonacademic		1	0	0	1	0	3	2	0	0	1	0	0	**8**
Not Seeking Employment		1	0	0	1	1	5	2	1	0	1	0	0	**12**
Still Seeking Employment		10	2	6	9	1	10	8	2	2	2	0	0	**52**
Unknown (U.S.)		12	7	4	6	2	18	6	7	2	4	2	0	**70**
Unknown (non-U.S.)*		11	7	5	9	2	11	5	3	0	3	1	0	**57**
TOTAL		**144**	**81**	**106**	**94**	**29**	**289**	**114**	**66**	**22**	**79**	**16**	**1**	**1041**
Column Subtotals	Male	107	58	78	71	23	176	84	50	18	53	7	1	**726**
	Female	37	23	28	23	6	113	30	16	4	26	9	0	**315**

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

Table 4B: Employment Status of 2003-04 U.S. 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)		29	25	9	0	1	5	**69**	53	16
Group I (Private)		15	32	6	0	0	4	**57**	46	11
Group II		20	17	16	2	4	2	**61**	41	20
Group III		5	9	5	10	6	0	**35**	22	13
Group IV		1	1	0	2	59	0	**63**	48	15
Group Va		0	3	1	0	0	13	**17**	13	4
Master's		8	1	25	18	9	1	**62**	42	20
Bachelor's		14	8	46	16	5	3	**92**	61	31
Two-Year College		4	0	2	7	1	0	**14**	9	5
Other Academic Dept.		6	10	16	15	48	20	**115**	69	46
Research Institute/ Other Nonprofit		8	7	4	0	9	1	**29**	17	12
Government		3	4	6	2	8	3	**26**	15	11
Business and Industry		9	13	9	9	50	9	**99**	69	30
Non-U.S. Academic		31	22	24	9	7	10	**103**	78	25
Non-U.S. Nonacademic		0	4	0	0	3	1	**8**	6	2
Not Seeking Employment		0	1	6	2	3	0	**12**	4	8
Still Seeking Employment		8	11	15	6	7	5	**52**	40	12
Unknown (U.S.)		16	10	19	6	13	6	**70**	49	21
Unknown (non-U.S.)*		18	9	6	7	10	7	**57**	44	13
TOTAL		**195**	**187**	**215**	**111**	**243**	**90**	**1041**	**726**	**315**
Column Subtotals	Male	151	137	152	72	146	68	**726**		
	Female	44	50	63	39	97	22	**315**		

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

Table 4C: Field of Thesis of 2003-04 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)	52	28	32	21	8	3	20	10	1	20	0	0	**195**
Group I (Private)	43	15	36	23	9	5	31	4	1	19	0	1	**187**
Group II	34	30	29	25	3	11	23	27	12	17	4	0	**215**
Group III	15	8	9	17	2	19	8	10	2	9	12	0	**111**
Group IV	0	0	0	0	2	239	2	0	0	0	0	0	**243**
Group Va	0	0	0	8	5	12	30	15	6	14	0	0	**90**
Column Total	**144**	**81**	**106**	**94**	**29**	**289**	**114**	**66**	**22**	**79**	**16**	**1**	**1041**

Table 5A: U.S. Employed 2003-04 New Doctoral Recipients by Type of Degree-Granting Department

U.S. EMPLOYER	I (Pu)	I (Pr)	II	III	IV	Va	TOTAL
Groups I, II, III, IV, and Va	70	87	37	14	70	24	**302**
Master's, Bachelor's, and 2-Year Colleges	26	9	73	41	15	4	**168**
Other Academic and Research Institutes	14	17	20	15	57	21	**144**
Government	3	4	6	2	8	3	**26**
Business and Industry	9	13	9	9	50	9	**99**
TOTAL	**122**	**130**	**145**	**81**	**200**	**61**	**739**

sex, in later sections of this report. The names of the 1,041 new doctoral recipients are found on pages 264-82 of this issue of the *Notices*.

Employment Status of 2003-04 New Doctoral Recipients

Tables 4A, 4B, and 4C each provide a different cross-tabulation of the 1,041 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 revised using information from the doctoral recipients themselves and will appear in the 2004 Second Report in the August 2005 issue of the *Notices of the AMS*.

Table 5B: Number of New Doctoral Recipients Taking Positions in Business and Industry in the U.S. by Type of Degree-Granting Department, Fall 2000 to Fall 2004

Group	I (Pu)	I (Pr)	II	III	IV	Va	TOTAL
Fall 2000	31	23	34	25	79	14	**206**
Fall 2001	24	15	25	21	59	24	**168**
Fall 2002	15	12	19	6	56	15	**123**
Fall 2003	19	13	5	8	45	7	**97**
Fall 2004	9	13	9	9	50	9	**99**

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 "Unknowns" are removed. The overall unemployment rate for these data is 5.7%. This figure will be updated later with information gathered from the individual new doctoral recipients. The figure for fall 2003 was 5.1%. 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 7.9% for Group II and lows of 3.2% and 5.0% for Groups IV and I (Pu) respectively.

Table 5C: Number of New Doctoral Recipients Taking U.S. Academic Positions by Type of Degree-Granting Department, Fall 2000 to Fall 2004

Group	I (Pu)	I (Pr)	II	III	IV	Va	TOTAL
Fall 2000	133	78	112	75	126	27	**551**
Fall 2001	146	70	109	74	84	27	**510**
Fall 2002	120	83	91	86	92	31	**503**
Fall 2003	123	76	117	60	118	40	**534**
Fall 2004	110	113	130	70	142	49	**614**

There are 739 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 739 new doctoral recipients. Of these, 614 (83%) hold academic positions, 26 (4%) are employed by government, and 99 (13%) hold positions in business and industry.

In the First Report for 2002-03, there were 663 new doctoral recipients employed in the U.S., of which

Table 5D: U.S. Academic Positions Filled by New Doctoral Recipients by Type of Hiring Department, Fall 2000 to Fall 2004

Group	I-III	IV	Va	M&B	Other	TOTAL
Fall 2000	209	46	13	158	125	**551**
Fall 2001	199	41	12	161	97	**510**
Fall 2002	213	46	7	138	99	**503**
Fall 2003	203	39	9	156	127	**534**
Fall 2004	222	63	17	154	158	**614**

534 (81%) held academic positions, 32 (5%) were in government, and 97 (15%) were in business and industry. The number of new doctoral recipients employed in the U.S. increased in all categories of Table 5A except "Government".

Table 5E: Females as a Percentage of 2003-04 New Doctoral Recipients Produced by and Hired by Doctoral-Granting Groups

Percent	I (Pu)	I (Pr)	II	III	IV	Va	TOTAL
Produced	23	27	29	35	40	24	**30**
Hired	23	19	33	37	24	24	**26**

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 2000 to fall 2004. The number of new doctoral recipients taking jobs in business and industry, after oscillating in the late 1990s, declined three consecutive years (by 38 in fall 2001, 45 in fall 2002, and 26 in fall 2003) before showing a slight increase of 2 in fall 2004. The fall 2004 number is down 52% from the fall 2000 number.

Among the 739 new doctoral recipients known to have employment in the U.S. in fall 2004, Group II has the smallest percentage taking jobs in business and industry at 6% and Group IV the highest at 25%.

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 2000 to fall 2004. It shows a moderate rebound in the total number of new doctoral recipients taking academic employment in fall 2004, compared with the previous nine years. This year's number is up 15% over last year. Among the 739 new doctoral recipients employed in the U.S. in fall 2004, 83% have academic positions. This percentage is highest for Groups I (Pu) and II at 90% and lowest for Groups IV at 71%.

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 M & B.

In fall 2004, 58 new doctoral recipients held positions in the institution that granted their degree, although not necessarily in the same department.

Table 5G: 2003-04 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, Groups I-Va	116	186	**302**
Academic, Other	164	148	**312**
Nonacademic	58	67	**125**
TOTAL	**338**	**401**	**739**

Table 5F: Employment Status of 2003-04 U.S. 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	338	50	326	25	**739**
U.S. Academic	280	36	278	20	**614**
Groups I, II, III, and Va	96	16	119	8	**239**
Group IV	20	5	34	4	**63**
Non-Ph.D. Department	155	15	106	7	**283**
Research Institute/Other Nonprofit	9	0	19	1	**29**
U.S. Nonacademic	58	14	48	5	**125**
Non-U.S. Employer	23	2	84	2	**111**
Non-U.S. Academic	21	2	78	2	**103**
Non-U.S. Nonacademic	2	0	6	0	**8**
Not Seeking Employment	9	0	3	0	**12**
Still Seeking Employment	24	7	21	0	**52**
SUBTOTAL	394	59	434	27	**914**
Unknown (U.S.)	44	5	19	2	**70**
Unknown (non-U.S.)*	3	0	46	8	**57**
TOTAL	**441**	**64**	**499**	**37**	**1041**

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

Table 6: Sex, Race/Ethnicity, and Citizenship of 2003-04 U.S. 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	3	0	0	0	3	2	0	0	0	2	5
Asian	13	17	187	13	230	10	11	86	0	107	337
Black or African American	7	5	10	0	22	5	1	3	1	10	32
Hispanic or Latino	11	1	25	1	38	2	1	4	1	8	46
Native Hawaiian or Other Pacific Islander	2	0	1	0	3	0	0	0	0	0	3
White	260	14	137	8	419	126	11	46	1	184	603
Unknown	0	1	5	3	9	0	1	0	5	6	15
TOTAL	296	38	365	25	724	145	25	139	8	317	1041

This represents 7% of new doctoral recipients who are currently employed and 9% of the U.S. academic positions held by new doctoral recipients. In fall 2003 there were 60 such individuals making up 8% of the new doctoral recipients who were employed at the time of the First Report. Nineteen new doctoral recipients have taken part-time positions in fall 2004 compared with 10 in fall 2003.

Information about 2003-04 Female New Doctoral Recipients

Tables 4A and 4B give male and female breakdowns of the new doctoral recipients in 2003-04 by Field of Thesis, by Type of Degree-Granting Department, and by Type of Employer.

Overall, 315 (30%) of the 1,041 new doctoral recipients in 2003-04 are female. In 2002-03, 304 (30%) 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 for Group IV at 40%, while last year it was highest in Group III. While the lowest percentage last year was for Group I (Pr) at 19%, this year it is for Group I (Pu) at 23%.

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, 32% of the new doctoral recipients hired in Group M, master's departments, are female; 34% of the new doctoral recipients hired in Group B, bachelor's departments, are female; and 30% of new doctoral recipients hired in business and industry are female.

The unemployment rate for female new doctoral recipients is 4% compared to 6% for males and 5.7% overall.

The percentage of female new doctoral recipients within fields of thesis ranged from 18% in optimization/control to 39% in statistics and 56% 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 2003-04 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 441 U.S. citizens is 6.1% compared to 5.1% in fall 2003. The unemployment rate for non-U.S. citizens is 5.4%. This varies by type of visa. The unemployment rate for non-U.S. citizens with a permanent visa is 11.9%, while that for non-U.S. citizens with a temporary visa is 4.8%. Among U.S. citizens whose employment status is known, 86% are employed in the U.S. Among non-U.S. citizens with a permanent visa whose employment status is known, 85% have jobs in the U.S. (last year the percentage was 81%), while the percentage for non-U.S. citizens with a temporary visa is 75% (last year the percentage was 68%). The number of non-U.S. citizens having employment in the U.S. is 401, up 40% from 287 last year.

Table 5G is a cross-tabulation of the 739 new doctoral recipients who have employment in the U.S. by citizenship and broad employment categories, using numbers from Table 5F. Of the 739 new doctoral recipients having jobs in the U.S., 46% are U.S. citizens. Of the 302 new doctoral recipients who took jobs in U.S. doctoral-granting departments, 38% are U.S. citizens (down from 52% last year). Of the 312 who took other academic positions, 53% are U.S. citizens. Of the 125 who took nonacademic positions, 46% are U.S. citizens. Of the 338 U.S. citizens employed in the U.S., 34% have jobs in a doctoral-granting department, 49% are in other academic positions, and 17% are in nonacademic positions. For the 401 non-U.S. citizens employed

Table 7: U.S. Citizen Doctoral Recipients

Year	Total Doctorates Granted by U.S. Institutions	Total U.S. Citizen Doctoral Recipients	%
1980-81	839	567	68
1985-86	755	386	51
1990-91	1061	461	43
1996-97	1158	516	45
1997-98	1216	586	48
1998-99*	1133	554	49
1999-00	1119	537	48
2000-01	1008	494	49
2001-02	948	418	44
2002-03	1017	489	48
2003-04	1041	441	42

*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.

in the U.S., the analogous percentages are 46%, 37%, and 17% respectively.

Sex, Race/Ethnicity, and Citizenship Status of 2003-04 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 this table was obtained in summary form from the departments granting the degrees.

There were 441 (42%) U.S. citizens among the 1,041 new doctoral recipients in 2003-04. Among U.S. citizens, 5 are American Indian or Alaska Native (3 males and 2 females), 23 are Asian (13 males and 10 females), 12 are Black or African American (7 males and 5 females), 13 are Hispanic or Latino (11 males and 2 females), 2 are Native Hawaiian or Other Pacific Islander (males), and 386 are White (260 males and 126 females). Among non-U.S. citizens, there are 314 Asians, 20 Blacks or African Americans, 33 Hispanics or Latinos, 1 Native Hawaiian or Other Pacific Islander (male), 217 Whites, and 15 other.

Table 8: U.S. Citizen Doctoral Recipients by Sex

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
1996-97	516	368	148	29
1997-98	586	423	163	28
1998-99*	554	367	187	34
1999-00	537	379	158	29
2000-01	494	343	151	31
2001-02	418	291	127	30
2002-03	489	332	157	32
2003-04	441	297	144	33

*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

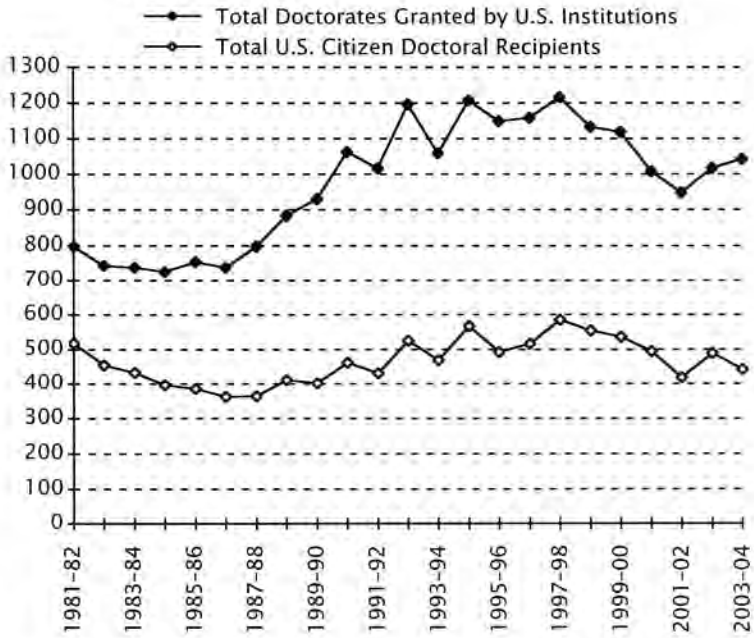


Table 7 (and Figure 3) gives the number of new U.S. doctoral recipients and the number of U.S. citizens back to 1980-81. The 441 U.S. citizen new doctoral recipients is down by 145 (25%) since 1997-98. The percentage of U.S. citizens is the lowest percentage (42%) reported since 1995-96 (43%).

Females make up 33% of the 441 U.S. citizens receiving doctoral degrees in the mathematical

Figure 4: Females as a Percentage of U.S. Citizen New Doctoral Recipients

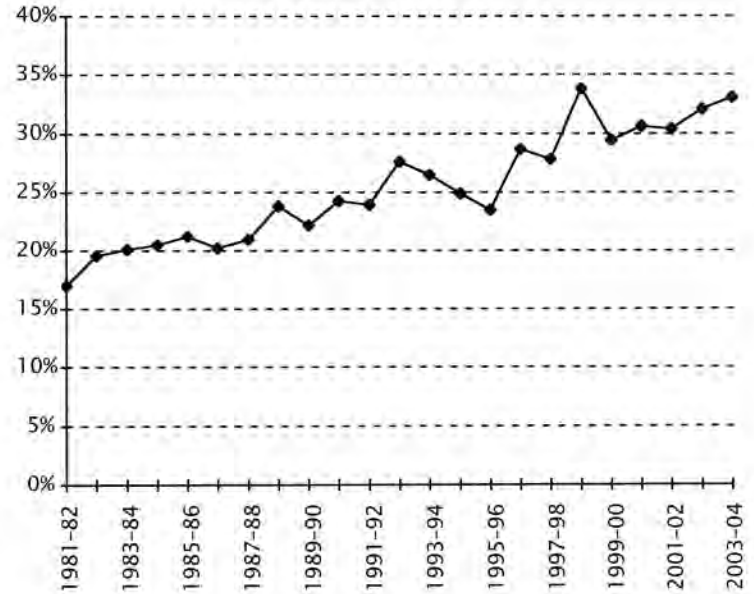


Table 9: Sex and Citizenship of 2003-04 New Doctoral Recipients by Granting Department

	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.	67	22	55	23	76	33	29	20	43	38	27	8	**297**	**144**
Non-U.S.	84	22	82	27	76	30	43	19	103	59	41	14	**429**	**171**
TOTAL	**151**	**44**	**137**	**50**	**152**	**63**	**72**	**39**	**146**	**97**	**68**	**22**	**726**	**315**

sciences in 2003-04. This is the second highest percentage of females among U.S. citizen new doctoral recipients reported since 1985-86, when it was 34%, the highest ever reported by the Annual Survey. Last year this percentage was 32%. Among the 600 non-U.S. citizen new doctoral recipients, 29% (172) are female, up from last year's 28%.

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 43 (23%) from an all-time high of 187 in 1998-99.

Table 9 gives a sex and citizenship breakdown of the new doctorates within each of the six groups of doctoral-granting departments. Among all 1,041 new doctoral recipients, 41% of the males and 46% 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 33% and highest in Group II at 50%. Groups II is the only group to have more U.S. citizen than non-U.S. citizen new doctoral recipients in 2003-04.

2003-04 New Doctoral Recipients with Dissertations in Statistics/Biostatistics and Probability

Group IV contains U.S. departments (or programs) of statistics, biostatistics, and biometrics 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 and probability. The other groups produced 77 new doctoral recipients with dissertations in statistics/biostatistics and probability in 2003-04 and have averaged 75 per year over the past seven years. Information about these 77 new doctoral recipients and the 243 new doctoral recipients in Group IV is found in this section of the report.

For nine years substantial effort has gone into making Group IV an appropriate set of departments for the Annual Survey and increasing the number of Group IV departments that respond to the Annual Survey. 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 the past seven years. The last two rows of Table 10 give a split of the 2003-04 results between the 56 statistics departments and the 31 biostatistics and biometrics departments in Group IV. Quite a bit of the variation in numbers from year to year in this table is due to the changes made in the departments in Group IV over the nine years and to the relatively low response rate for this group. At the time of the Second Report last year, 77 of 86 (90%) of Group IV departments had responded, which is the largest percentage ever.

Group IV has 87 departments for 2003-04, 14 more than the next largest doctoral group. It contains 30% of all doctoral departments surveyed, and the 65 Group IV departments responding to the Annual Survey reported 243 new doctoral recipients,

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

			New Doctoral Recipients in Group IV				New Doctoral Recipients in Statistics/Biostatistics and Probability				New Doctoral Recipients Hired by Group IV	
Year	Depts Surveyed	Depts Responding (percent)	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
Statistics	56	44 (79)	180	63 (35)	38	3.0					28	10
Biostatistics	31	21 (68)	63	34 (54)	12	3.0					20	5

* Of 241, there were 239 in statistics/biostatistics and 2 in probability. For complete details, see Table 4C.
** Of 77, there were 50 in statistics/biostatistics and 27 in probability. For complete details, see Table 4C.

23% of all new doctoral recipients in 2003–04. The number of new doctoral recipients in Group IV is up four from the number reported at this time last year, while the number of departments responding is down nine 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.

Table 9 shows that for the Group IV new doctoral recipients, 97 of 243 (40%) are female, while 218 of 798 (27%) are female in the other doctoral groups. Among U.S. citizens, females accounted for 38 of the 81 (47%) Group IV new doctoral recipients, while for the other groups 106 of 360 (29%) were female. Overall, 144 of 441 (33%) U.S. citizen new doctoral recipients were female.

In Group IV, 81 of 243 (33%) new doctoral recipients are U.S. citizens, while in other groups 360 of 798 (45%) are U.S. citizens.

Of the 200 new doctoral recipients from Group IV who found employment in the U.S., 50 (25%) took jobs in business or industry. From the other groups, 539 new doctoral recipients found employment in the U.S., of which 49 (9%) took jobs in business or industry.

The employment status for 220 Group IV new doctoral recipients is known, and 7 (3.2%) are unemployed. For the other groups, the employment status of 694 is known, and 45 (6.5%) are unemployed. Fifteen of 63 (24%) new doctoral recipients hired by Group IV departments were female, down from last year's 49%, the lowest percentage of female hires reported since 1999–2000. The other doctoral groups reported that 64 of 239 (27%) new doctoral recipients hired were female, the same percentage as reported last year, significantly more than the 16% reported in 1999–2000.

Group IV had 241 new doctoral recipients with fields of thesis in statistics/biostatistics (239) and probability (2), and the other doctoral departments had 77 with field of thesis in statistics/biostatistics (50) and probability (27). The distribution of these 77 degrees among the various groups can be found in Table 4C. The number of new doctoral recipients with theses in statistics/biostatistics and probability (318) is substantially larger than any other field, with algebra and number theory next with 144.

Faculty Salary Survey

The charts on the following pages display faculty salary data for Groups I (Pu), I (Pr), II, III, IV (Statistics), IV (Biostatistics), Va, M, and B: faculty salary distribution by rank, mean salaries by rank, information on quartiles by rank, and the number of returns for the group. Results reported here are summaries based on the departments who responded to this portion of the Annual Survey. This is the third year that salary information has been reported separately for statistics departments and biostatistics and biometrics departments in Group IV.

Table 11 provides the departmental response rates for the 2004 Faculty Salary Survey. Departments were asked to report for each rank the number of tenured and tenure-track faculty whose 2004–05 academic-year salaries fell within given salary intervals. Reporting salary data in this fashion eliminates some of the concerns about confidentiality but does not permit determination of actual quartiles. Although the actual quartiles cannot be determined from the data gathered, these quartiles have been estimated assuming that the density over each interval is uniform.

Since departments in Groups I, II, and III were changed in 1995–96 (see definitions of the groups on page 251), comparisons are possible only to the last eight years' data. In addition, prior to the 1998 survey Groups Va and Vb were reported together as Group V. When comparing current and prior year figures, one should keep in mind that differences in the set of responding departments may be a significant factor in the change in the reported mean salaries.

Table 11: Faculty Salary Response Rates

Department	Number	Percent
Group I (Public)	21 of 25	84
Group I (Private)	17 of 23	74
Group II	48 of 56	86
Group III	62 of 73	85
Group IV (Statistics)	39 of 56	70
Group IV (Biostatistics)	20 of 31	65
Group Va	8 of 18*	44
Group M	104 of 192	54
Group B	350 of 1020	34

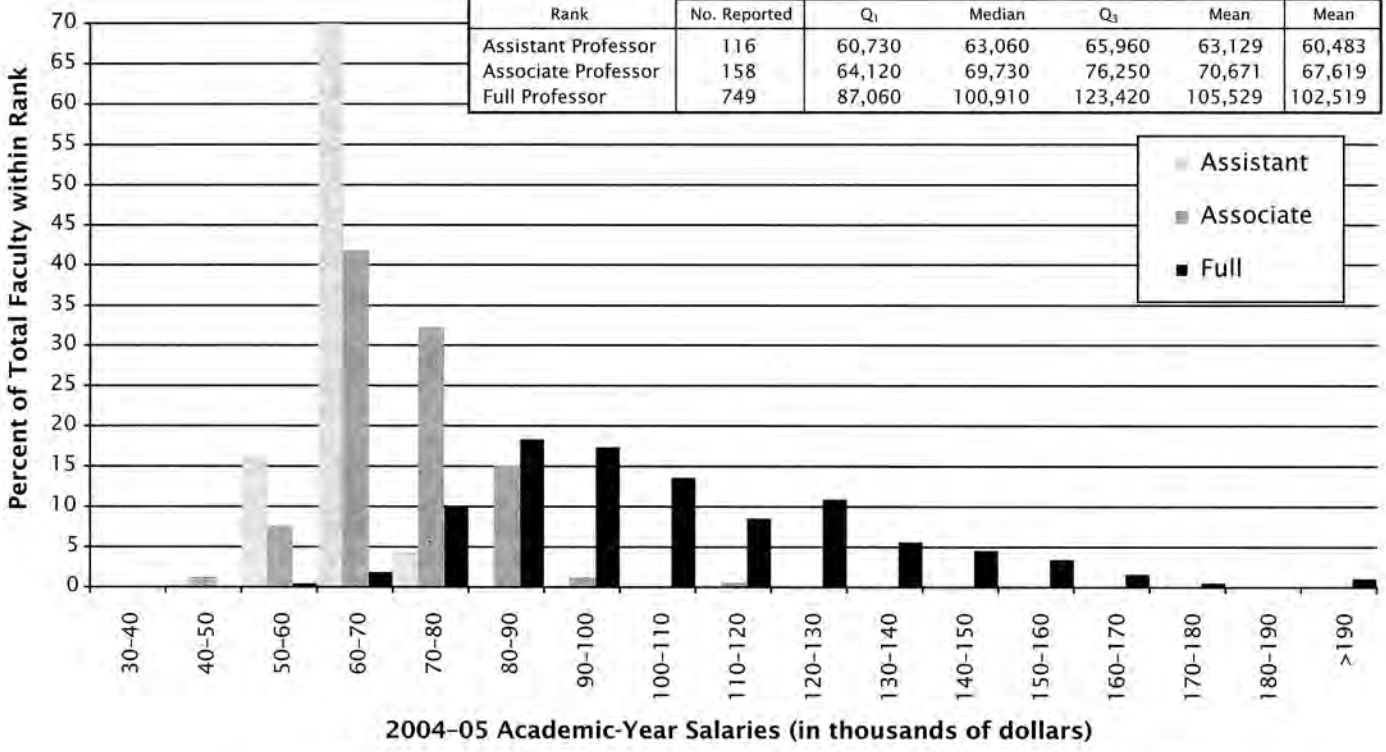
* The population for Group Va is slightly less than for the Doctorates Granted Survey, because some departments grant degrees but do not formally "house" faculty and their salaries.

Group I (Public) Faculty Salaries

Doctoral degree-granting departments of mathematics (25)

21 responses (84%)

Rank	2004-05 No. Reported	Q_1	Median	Q_3	Mean	2003-04 Mean
Assistant Professor	116	60,730	63,060	65,960	63,129	60,483
Associate Professor	158	64,120	69,730	76,250	70,671	67,619
Full Professor	749	87,060	100,910	123,420	105,529	102,519

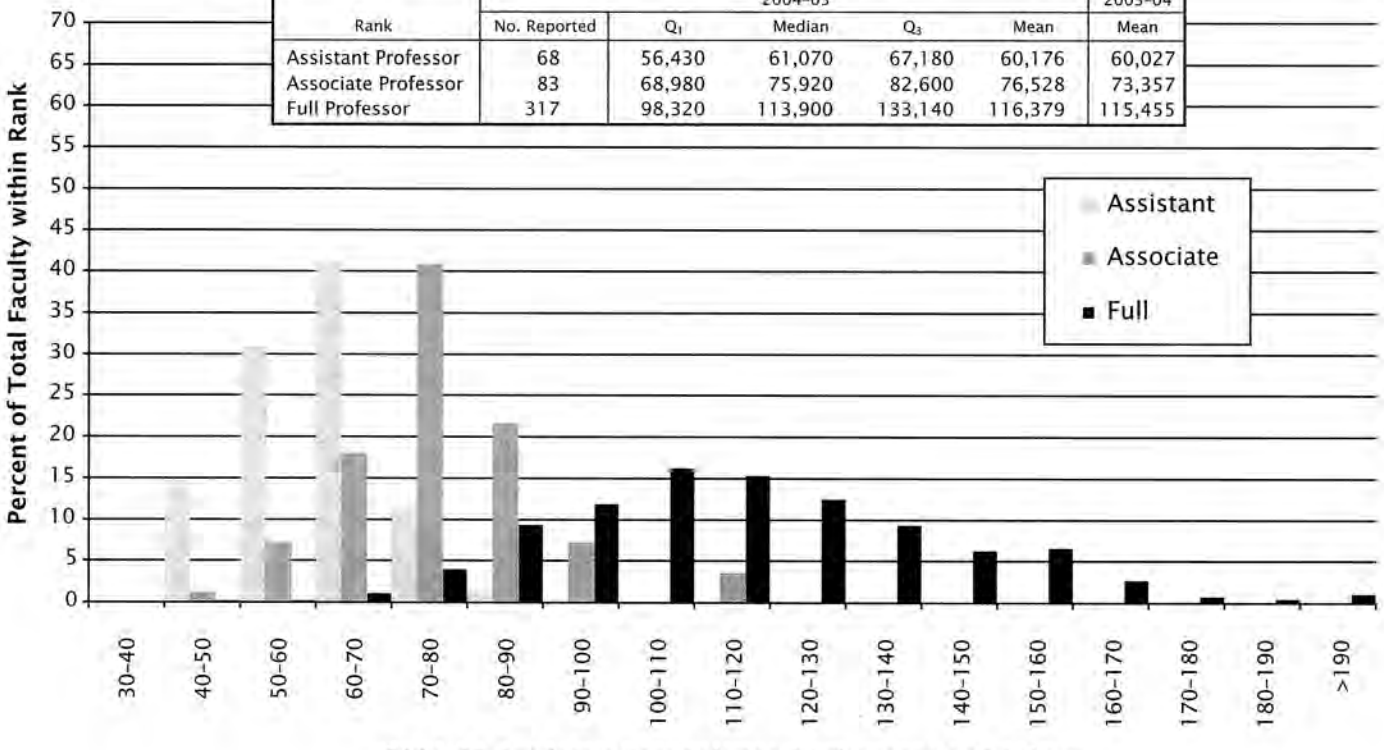


Group I (Private) Faculty Salaries

Doctoral degree-granting departments of mathematics (23)

17 responses (74%)

Rank	2004-05 No. Reported	Q_1	Median	Q_3	Mean	2003-04 Mean
Assistant Professor	68	56,430	61,070	67,180	60,176	60,027
Associate Professor	83	68,980	75,920	82,600	76,528	73,357
Full Professor	317	98,320	113,900	133,140	116,379	115,455

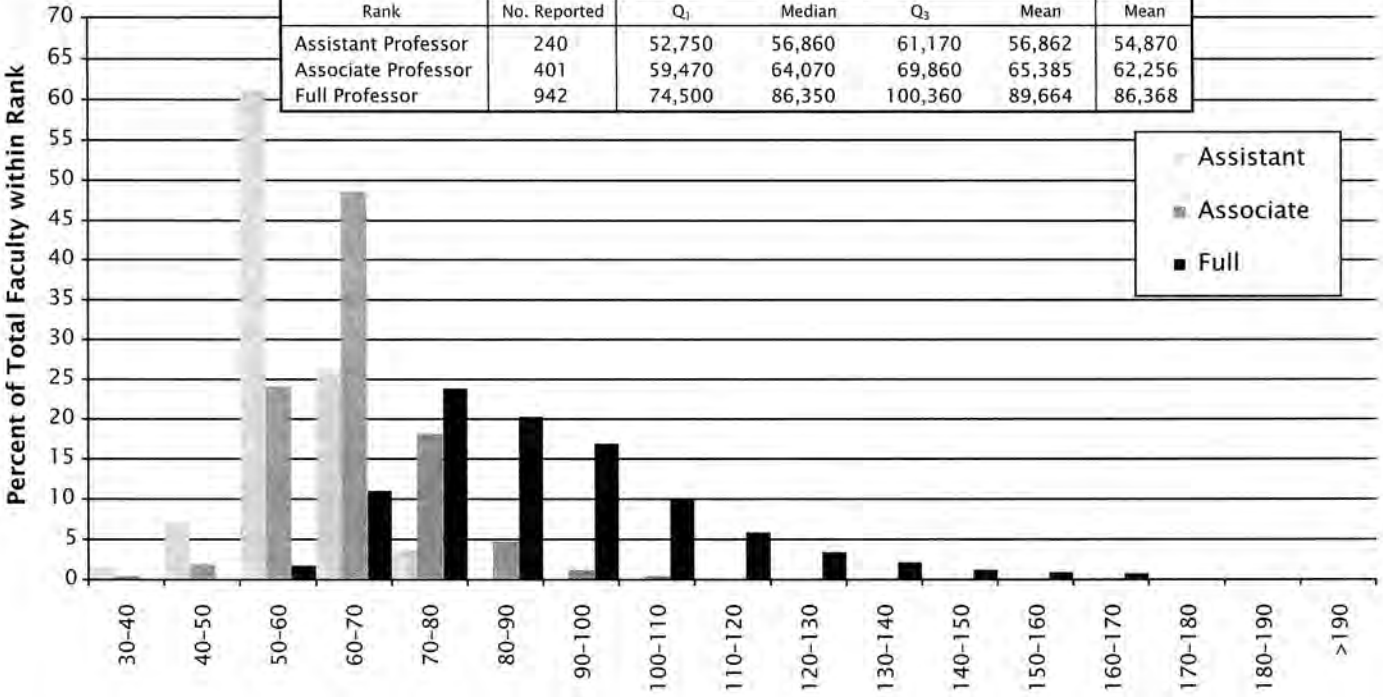


Group II Faculty Salaries

Doctoral degree-granting departments of mathematics (56)

48 responses (86%)

Rank	2004-05 No. Reported	Q_1	Median	Q_3	Mean	2003-04 Mean
Assistant Professor	240	52,750	56,860	61,170	56,862	54,870
Associate Professor	401	59,470	64,070	69,860	65,385	62,256
Full Professor	942	74,500	86,350	100,360	89,664	86,368

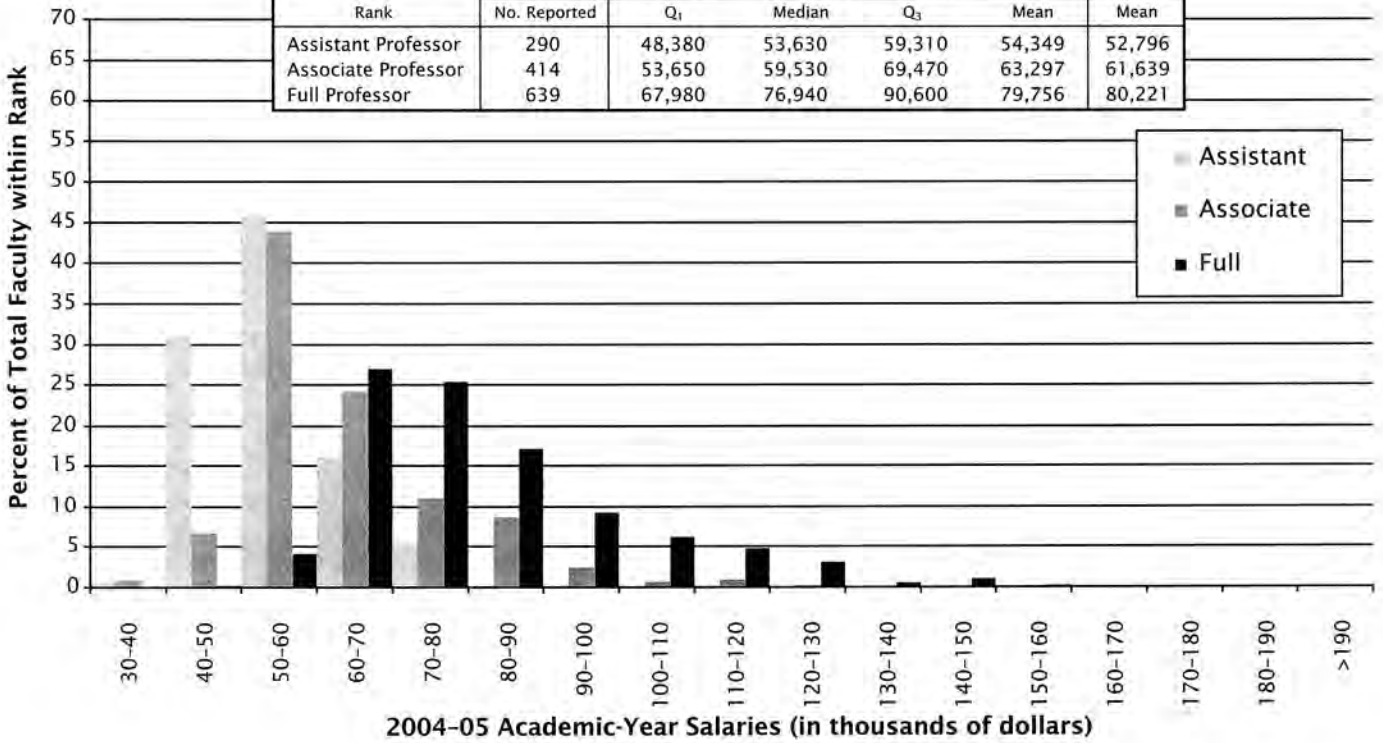


Group III Faculty Salaries

Doctoral degree-granting departments of mathematics (73)

62 responses (85%)

Rank	2004-05 No. Reported	Q_1	Median	Q_3	Mean	2003-04 Mean
Assistant Professor	290	48,380	53,630	59,310	54,349	52,796
Associate Professor	414	53,650	59,530	69,470	63,297	61,639
Full Professor	639	67,980	76,940	90,600	79,756	80,221

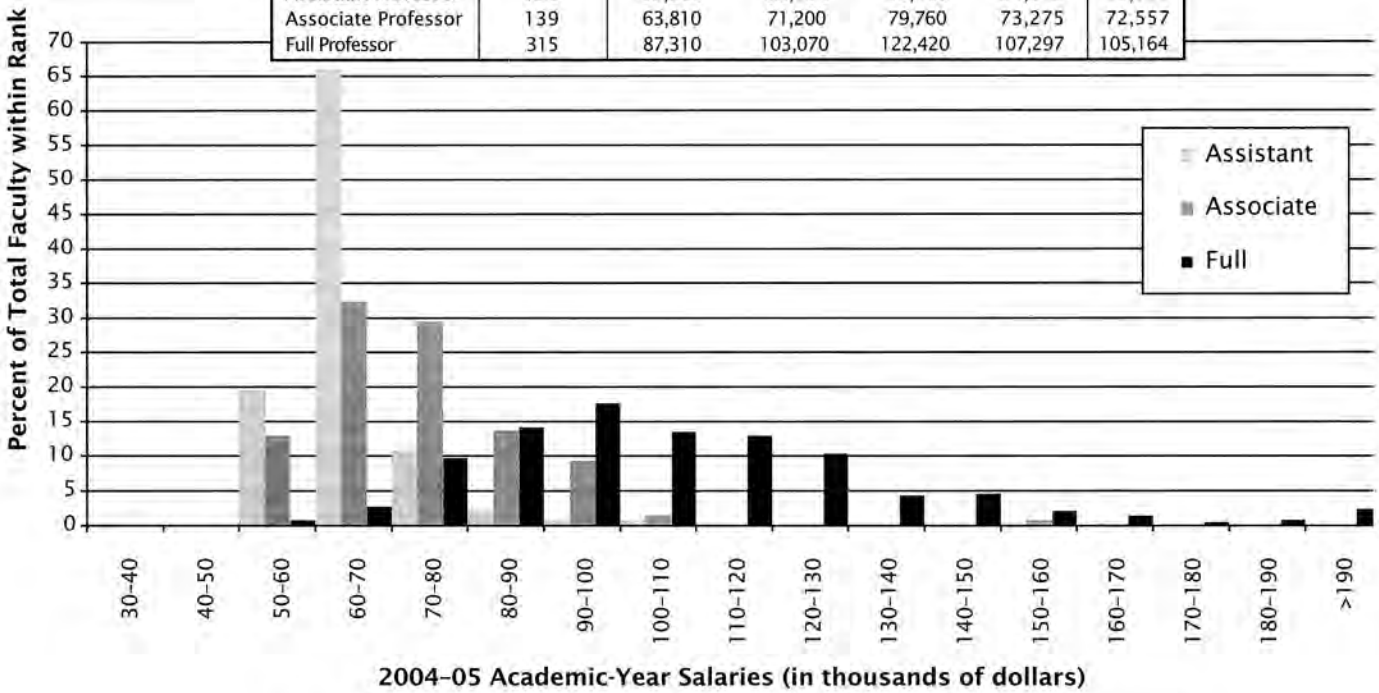


Group IV (Statistics) Faculty Salaries

Doctoral degree-granting departments of statistics (56)

39 responses (68%)

Rank	2004–05 No. Reported	Q_1	Median	Q_3	Mean	2003–04 Mean
Assistant Professor	138	60,900	65,100	68,480	64,975	65,656
Associate Professor	139	63,810	71,200	79,760	73,275	72,557
Full Professor	315	87,310	103,070	122,420	107,297	105,164

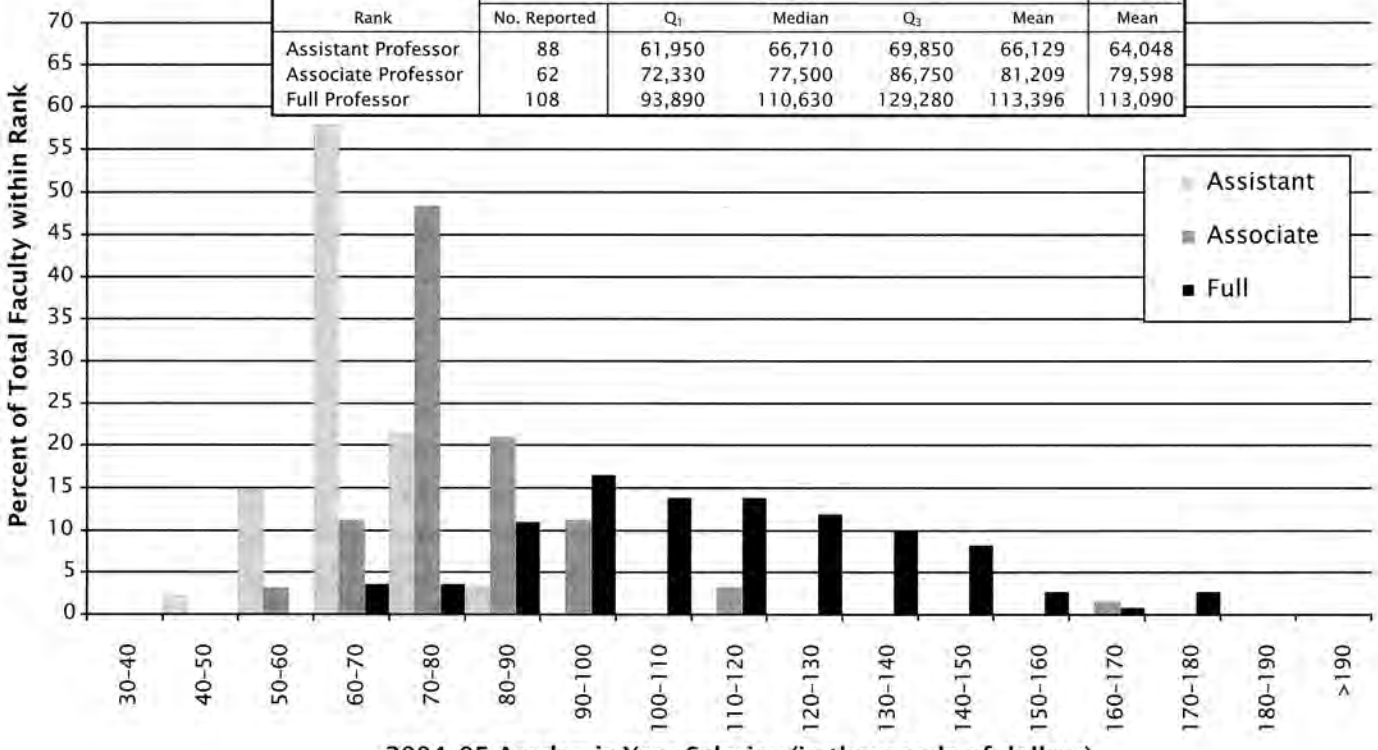


Group IV (Biostatistics) Faculty Salaries

Doctoral degree-granting departments of biostatistics and biometrics (31)

20 responses (65%)

Rank	2004–05 No. Reported	Q_1	Median	Q_3	Mean	2003–04 Mean
Assistant Professor	88	61,950	66,710	69,850	66,129	64,048
Associate Professor	62	72,330	77,500	86,750	81,209	79,598
Full Professor	108	93,890	110,630	129,280	113,396	113,090

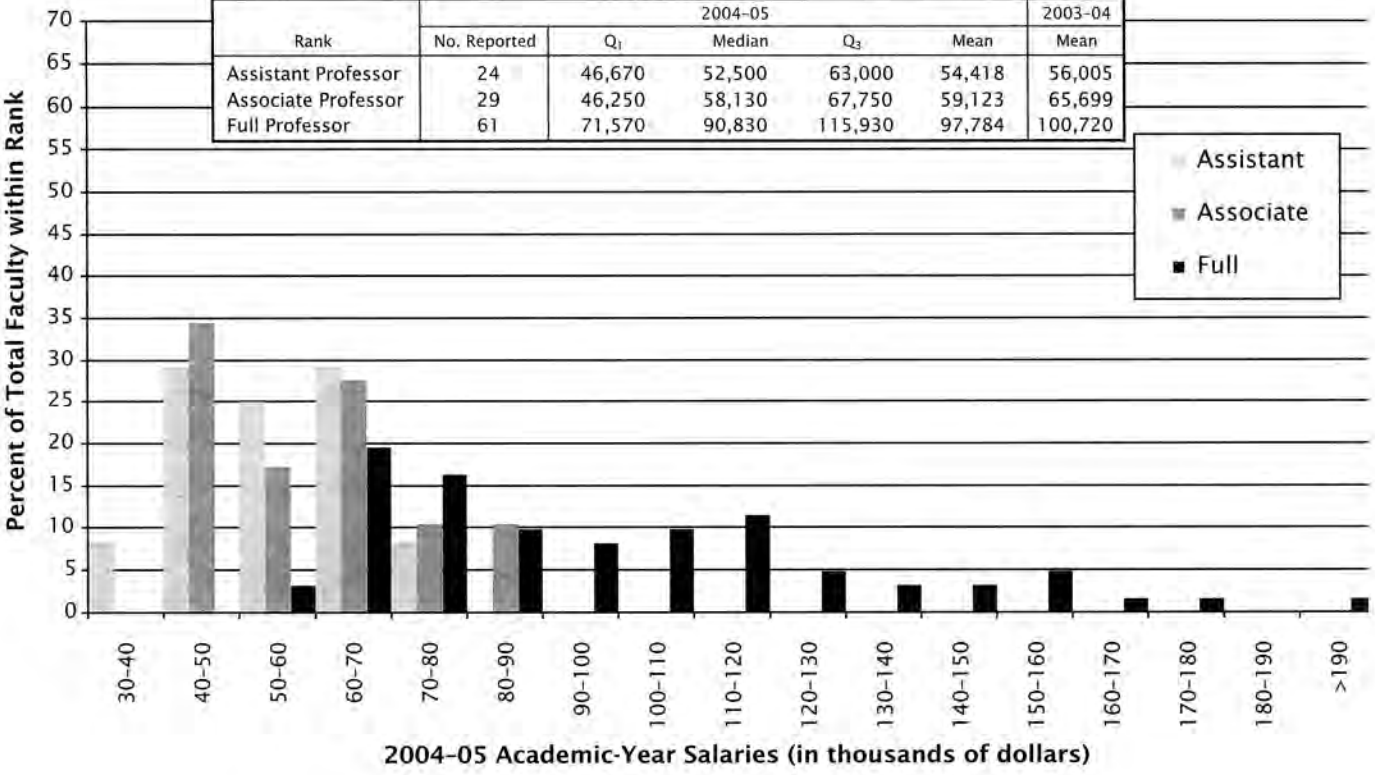


Group Va Faculty Salaries

Doctoral degree-granting departments of applied mathematics (18)

8 responses (44%)

Rank	2004-05 No. Reported	Q_1	Median	Q_3	Mean	2003-04 Mean
Assistant Professor	24	46,670	52,500	63,000	54,418	56,005
Associate Professor	29	46,250	58,130	67,750	59,123	65,699
Full Professor	61	71,570	90,830	115,930	97,784	100,720

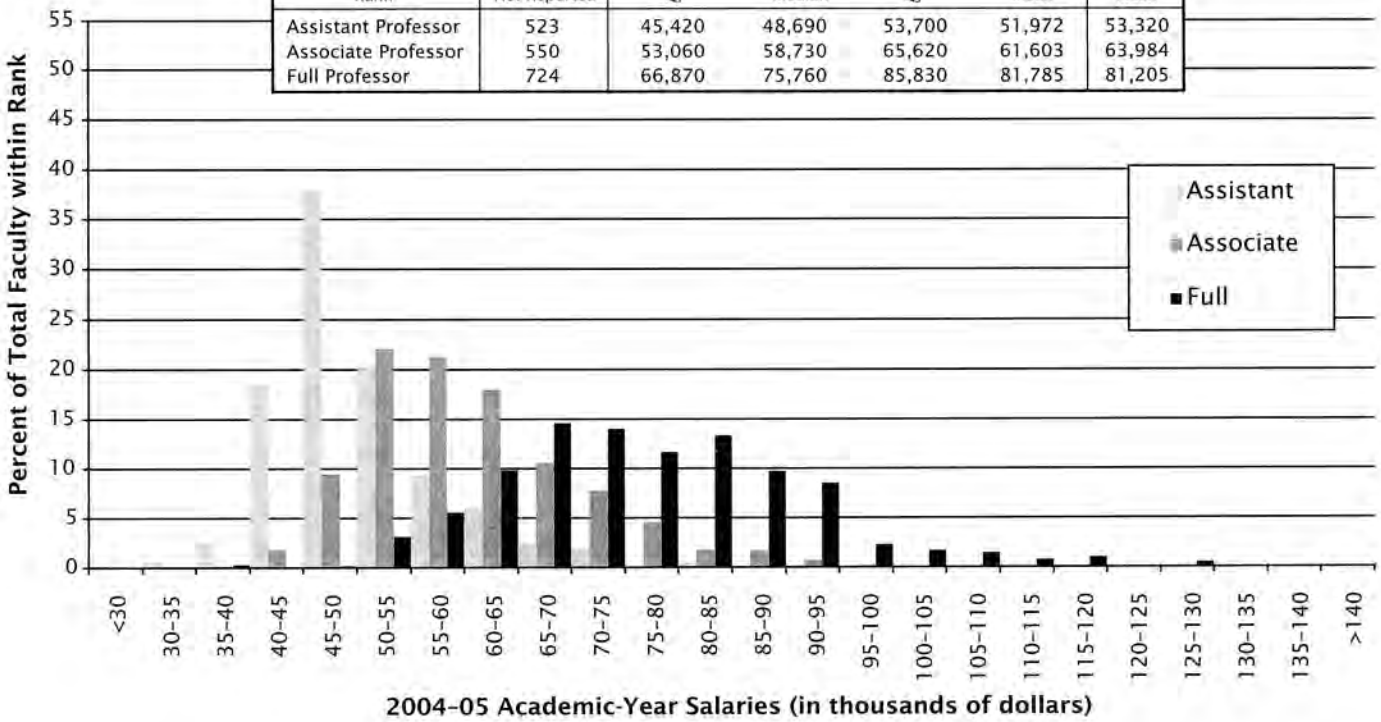


Group M Faculty Salaries

Master's degree-granting departments of mathematics (192)

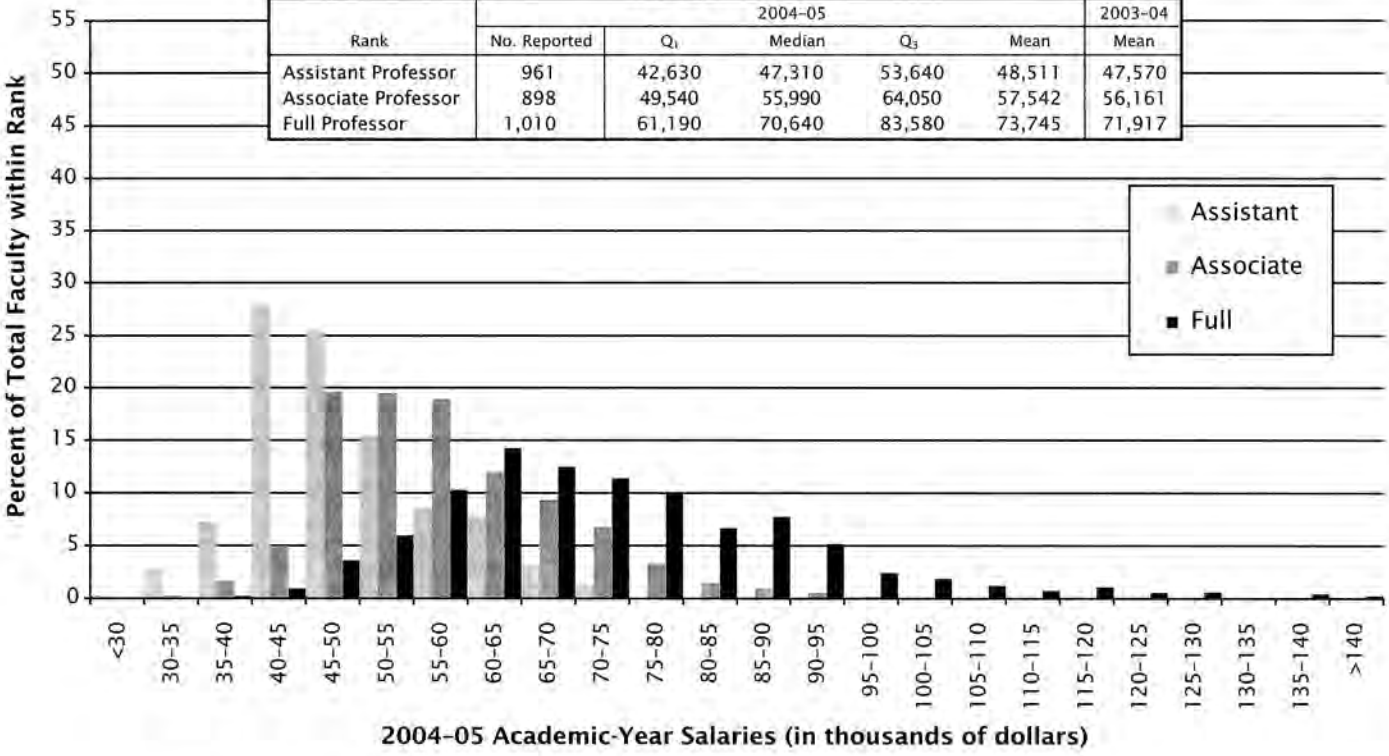
104 responses (54%)

Rank	2004-05 No. Reported	Q_1	Median	Q_3	Mean	2003-04 Mean
Assistant Professor	523	45,420	48,690	53,700	51,972	53,320
Associate Professor	550	53,060	58,730	65,620	61,603	63,984
Full Professor	724	66,870	75,760	85,830	81,785	81,205



Group B Faculty Salaries
Bachelor's degree-granting departments of mathematics (1020)
350 responses (34%)

Rank	2004–05					2003–04
	No. Reported	Q_1	Median	Q_3	Mean	Mean
Assistant Professor	961	42,630	47,310	53,640	48,511	47,570
Associate Professor	898	49,540	55,990	64,050	57,542	56,161
Full Professor	1,010	61,190	70,640	83,580	73,745	71,917



Previous Annual Survey Reports

The 2003 First, Second, and Third Annual Survey Reports were published in the *Notices of the AMS* in the February, August, and September 2004 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

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Commission on Professionals in Science and Technology, *Professional Women and Minorities*, 15th ed., CPST, Washington, DC, 2004.

———, *Salaries of Scientists, Engineers, and Technicians: A Summary of Salary Surveys*, 20th ed., CPST, Washington, DC, 2003.

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Conference Board of the Mathematical Sciences, *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 2000 CBMS Survey*, American Mathematical Society, Providence, RI, 2002.

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National Science Board, *Science and Engineering Indicators—2004* (NSB 04-01), National Science Foundation, Arlington, VA, 2004.

National Science Foundation, *Characteristics of Doctoral Scientists and Engineers in the United States: 2001* (NSF 03-310), Detailed Statistical Tables, Arlington, VA, 2003.

———, *Emigration of U.S.-Born S&E Doctorate Recipients* (NSF 04-327), Arlington, VA, June 2004.

———, *Graduate Students and Postdoctorates in Science and Engineering: Fall 2001* (NSF 03-320), Arlington, VA, 2003.

———, *Gender Differences in the Careers of Academic Scientist and Engineers* (NSF 04-323), Arlington, VA, 2004.

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

———, *Science and Engineering Degrees: 1966–2000* (NSF 02-327), Detailed Statistical Tables, Arlington, VA, 2002.

———, *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: 2002* (NSF 04-303), Detailed Statistical Tables, Arlington, VA, 2003.

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

———, *Statistical Profiles of Foreign Doctoral Recipients in Science and Engineering: Plans to Stay in the United States* (NSF 99-304), Arlington, VA, 1998.

———, *Who Is Unemployed? Factors Affecting Unemployment among Individuals with Degrees in Science and Engineering*, Higher Education Surveys Report (NSF 97-336), Arlington, VA, 1997.

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 compo se 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

Bañuelos Awarded Blackwell-Tapia Prize

Rodrigo Bañuelos of Purdue University has been awarded the 2004 Blackwell-Tapia Prize. His research focuses on probability and its connections to harmonic analysis, partial differential equations, spectral theory, and geometry.

The prize, which honors David Blackwell and Richard A. Tapia, is presented every two years to a mathematical scientist who has contributed significantly to his or her field of expertise and who has served as a role model for mathematical scientists and students from underrepresented minority groups or has contributed in other significant ways to addressing the problem of the underrepresentation of minorities in mathematics. The prize amount, contributed this year by Cornell University, is $3,000. The prize is cosponsored by the Mathematical Sciences Research Institute (MSRI), the Institute for Pure and Applied Mathematics (IPAM), and Cornell University, with additional support from Arizona State University.

The organizing committee for the 2004 prize consisted of Carlos Castillo-Chavez (Arizona State University and Cornell University), Mark Green (IPAM), William Massey (Princeton University), Robert Megginson (MSRI), and Richard Tapia (Rice University).

—Mark Green, Institute for Pure and Applied Mathematics

Clay Research Award Winners Announced

The Clay Mathematics Institute (CMI) has announced the recipients of the 2004 Clay Research Awards. The awards, which recognize major research breakthroughs, were presented to Ben Green of Trinity College, Cambridge, and to Gérard Laumon and Bao-Chau Ngo, both of the Université Paris-Sud and the Centre Nationale de Recherche Scientifique (CNRS).

Green was recognized for his joint work with Terence Tao on arithmetic progressions of prime numbers. These are equally spaced sequences of primes such as 31, 37, 43 or 13, 43, 73, 103. Results in the area go back to the work of Lagrange and Waring in the 1770s. A breakthrough came in 1939 when the Dutch mathematician Johannes van der Corput showed that there are an infinite number of three-term arithmetic progressions of primes. Green and Tao showed that for any n there are infinitely many n-term progressions of primes. Their proof, which relies on results of Szemerédi (1975) and of Goldston and Yildirim (2003), uses ideas from combinatorics, ergodic theory, and the theory of pseudorandom numbers. The Green-Tao result is a major advance in our understanding of the primes.

Laumon and Ngô were recognized for their proof of the fundamental lemma for unitary groups. The lemma is a conjectured identity between orbital integrals for two groups, for example, the unitary groups $U(n)$ and $U(p) \times U(q)$, where $p + q = n$. Combined with the Arthur-Selberg trace formula, it enables one to prove relations between automorphic forms on different groups and is a key step toward proving links between certain automorphic forms and Galois representations. This is one of the aims of the Langlands program, which seeks a far-reaching unification of ideas in number theory and representation theory. The result of Laumon and Ngô uses the equivariant cohomology approach introduced by Goresky, Kottwitz, and MacPherson, who proved the lemma in the split and equal valuation case. The proof for the unitary case, which is significant for applications, requires many new ideas, including Laumon's deformation strategy and Ngô's purity result, which is based on a geometric interpretation of the endoscopy theory of Langlands and Kottwitz in terms of the Hitchin fibration.

Green was named a Clay Research Fellow for a term of two years. Laumon and Ngô were named Clay Research Scholars for a period of one year. Each awardee received a bronze replica of the CMI icon by sculptor Helaman Ferguson. Former recipients of the Clay Research Award are Andrew Wiles, Laurent Lafforgue, Alain Connes,

Stanislav Smirnov, Edward Witten, Oded Schramm, Manindra Agrawal, Richard Hamilton, and Terence Tao.

Ben Green was born in 1977 in Bristol, England. He was educated at Trinity College, Cambridge, first as an undergraduate and later as a research student of Fields Medalist Timothy Gowers. Since 2001 he has been a Fellow of Trinity College, and in that time he has made extended research visits to Princeton University, the Rényi Institute in Budapest, the University of British Columbia, and the Pacific Institute of Mathematics (PIMS), where he was a postdoctoral fellow. In January 2005 he will take up a chair in pure mathematics at the University of Bristol.

Gérard Laumon, born in 1952, received his *Thèse d'État* from the Université de Paris-Sud, Orsay, in 1983 under the direction of Luc Illusie. In 1987 Laumon was awarded the Silver Medal of CNRS. In 1992 he was awarded the E. Dechelle Prize of the French Academy of Sciences.

Bao-Châu Ngô, born in 1972 in Hanoi, Vietnam, received his Ph.D. at the Université de Paris-Sud, Orsay, in 1997 under the direction of Gérard Laumon. He has held visiting positions at the Max Planck Institute in Bonn, the Universities of Toronto, Sydney, and Chicago, and the Institut des Hautes Études Scientifiques. He has held a CNRS position at the Université de Paris 13 since 1998, and he assumed a professorship at the Université de Paris-Sud in the fall of 2004.

—From a CMI announcement

Friedrich Hirzebruch

Hirzebruch Awarded Cantor Medal

The Deutsche Mathematiker Vereinigung (DMV, German Mathematical Society) has awarded the 2004 Georg Cantor Medal to FRIEDRICH HIRZEBRUCH. The medal was presented during the DMV meeting in Heidelberg in September 2004.

The citation reads: "In recognition of his remarkable achievements the Deutsche Mathematiker Vereinigung bestows the Georg Cantor Medal on Prof. Dr. Friedrich Hirzebruch. With this distinction the DMV honors a mathematician of worldwide reputation whose path-breaking works have substantially furthered mathematics. His ideas and discoveries—particularly in connection with Riemann Roch theorems, characteristic classes, and K-theory—have contributed to the instigation of one of the most important developments in mathematics in the second half of the 20th century. He has contributed more than anyone else to the international integration of German mathematics and to the absorption of east and west German mathematicians into a common organization."

Friedrich Hirzebruch was born in Hamm, Westphalia, on October 17, 1927. He received his Ph.D. from the Universität Münster under the direction of H. Behnke and also studied with Heinz Hopf at the Eidgenössische Technische Hochschule in Zürich. After serving as an assistant at the Universität Erlangen, Hirzebruch spent two years (1952–54) at the Institute for Advanced Study in Princeton. After a year in Münster he went to Princeton University for a year. In 1956 he became a professor at the Universität Bonn. Hirzebruch is perhaps most famous for proving what is now known as the Hirzebruch-Riemann-Roch Theorem and for developing the theory of characteristic classes around it. Together with M. F. Atiyah and A. Grothendieck, Hirzebruch was one of the main architects of K-theory. In later years he made significant contributions to the theory of algebraic surfaces and 3-folds. Hirzebruch also had an important influence on the mathematical life in Germany by organizing the famous Arbeitstagung meetings since 1957 and by founding the Max-Planck-Institut für Mathematik in Bonn in 1981. He served as director of that institute until 1995.

—Allyn Jackson

Izumi Awarded Operator Algebra Prize

MASAKI IZUMI of Kyoto University has been awarded the second Operator Algebra Prize for his outstanding contributions to the theory of subfactors and the classification of automorphisms of C^*-algebras, and thus to the advancement of operator algebra theory. The prize consists of a cash award of about US$3,000, a prize certificate, and a medal.

The Operator Algebra Prize was established in 1999 by initiatives and contributions from some senior Japanese researchers in operator algebra theory and related fields to encourage young researchers in these fields. The prize is awarded every four years to a person under forty years of age either of Japanese nationality or principally based in a Japanese institution for outstanding contributions to operator algebra theory and related areas.

—Huzihiro Araki, Kyoto University

NRC-Ford Foundation Minority Fellowships Awarded

SCOTT IZU of New Mexico State University has been awarded an NRC-Ford Foundation Predoctoral Fellowship for 2004. He is a student in the field of analytical mathematics.

The NRC-Ford Foundation Minority Fellowships programs are administered by the National Research Council for the purpose of increasing the presence of underrepresented groups among faculty members in colleges and universities. The recipients were selected on the basis of merit and promise of future achievement.

—From an NRC announcement

Papikian Awarded Emil Artin Junior Prize

The 2005 Emil Artin Junior Prize in Mathematics has been awarded to MIHRAN PAPIKIAN of Stanford University. Papikian was chosen for his paper "On the degree of modular parametrizations over function fields", which appeared in the *Journal of Number Theory* **97** (2002), 317–349.

Established in 2001, the Emil Artin Junior Prize in Mathematics carries a cash award of US$500 and is presented usually every year to a student or former student of an Armenian university who is under the age of thirty-five, for outstanding contributions to algebra, geometry, topology, and number theory—the fields in which Emil Artin made major contributions. Previous awardees were Vahagn Mikaelian (2001), Artur Barkhudaryan (2002), and Gurgen Asatryan (2004).

The prize committee consisted of A. Basmajian, Y. Movsisyan, and V. Pambuccian.

—Artin Prize Committee announcement

DMV Awards Media and Journalism Prizes

In October 2004 in Berlin, the Deutsche Mathematiker Vereinigung (DMV, German Mathematical Society) awarded two prizes recognizing outstanding contributions to raising public awareness of mathematics. The DMV Media Prize was awarded to CHRISTOPH PÖPPE, a writer and editor for the magazine *Spektrum der Wissenschaft*. The DMV Journalist Prize went to HUBERTUS BREUER for his article "Der mit den Falten rechnet" ("He who computes with the folds"), which appeared in the newspaper *Die Zeit*.

The DMV Media Prize of 5,000 euros (approximately US$6,500 is presented every two years to recognize outstanding activities to popularize mathematics within the general public. The first recipient of the prize was Gero von Randow (2002)

—Allyn Jackson

Math in Moscow Scholarships Awarded

The AMS has made awards to four undergraduate students to attend the Math in Moscow program in spring 2005. The names of the students and their institutions are: CHRISTOPHER E. BIERMANN, Dartmouth College; BRENDAN MATTHEW CREUTZ, California Polytechnic State University, San Luis Obispo; VICTOR KOSTYUK, Rochester Institute of Technology; JOEL LOUWSMA, University of Michigan; and ADRIENNE RAU, Barnard College/Columbia University.

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. The fifteen-week program is similar to the Research Experiences for Undergraduates programs that are held each summer across the United States. Math in Moscow draws on the Russian tradition of teaching mathematics, which emphasizes creative approaches to problem solving and in-depth understanding. All instruction is in English.

Each semester since 2001 the AMS has awarded several scholarships of approximately $5,000 each for U.S. students to attend the Math in Moscow program. The scholarships are made possible through a grant from the National Science Foundation (NSF). Information about how to apply may be found in the August 2004 issue of the *Notices*, page 805, or on the webpage `http://www.ams.org/careers-edu/mimoscow.html`. 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 1250–54.

—Allyn Jackson

Mathematics Opportunities

NSF Integrative Graduate Education and Research Training

The Integrative Graduate Education and Research Training (IGERT) program was initiated by the National Science Foundation (NSF) to meet the challenges of educating Ph.D. scientists and engineers with the interdisciplinary backgrounds and the technical, professional, and personal skills needed for the career demands of the future. The program is intended to catalyze a cultural change in graduate education for students, faculty, and universities by establishing innovative models for graduate education in a fertile environment for collaborative research that transcends traditional disciplinary boundaries. It is also intended to facilitate greater diversity in student participation and to contribute to the development of a diverse, globally aware science and engineering workforce. Supported projects must be based on a multidisciplinary research theme and administered by a diverse group of investigators from U.S. Ph.D.-granting institutions with appropriate research and teaching interests and expertise.

The preproposal deadline for the 2005 IGERT competition is **February 4, 2005**. Further information may be found at the website `http://www.nsf.gov/pubs/2005/nsf05517/nsf05517.htm`.

—From an NSF announcement

Call for Proposals for 2006 NSF-CBMS Regional Conferences

To stimulate interest and activity in mathematical research, the National Science Foundation (NSF) intends to support up to seven NSF-CBMS Regional Research Conferences in 2006. A panel chosen by the Conference Board of the Mathematical Sciences will make the selections from among the submitted proposals.

Each five-day conference features a distinguished lecturer who delivers ten lectures on a topic of important current research in one sharply focused area of the mathematical sciences. The lecturer subsequently prepares an expository monograph based on these lectures, which is normally published as a part of a regional conference series. Depending on the conference topic, the monograph will be published by the American Mathematical Society, by the Society for Industrial and Applied Mathematics, or jointly by the American Statistical Association and the Institute of Mathematical Statistics.

Support is provided for about thirty participants at each conference, and the conference organizer invites both established researchers and interested newcomers, including postdoctoral fellows and graduate students, to attend.

The proposal due date is **April 8, 2005**. For further information on submitting a proposal, consult the CBMS website, `http://www.cbms.org`, or contact: Conference Board of the Mathematical Sciences, 1529 Eighteenth Street, NW, Washington, DC 20036; telephone: 202-293-1170; fax: 202-293-3412; email: `kolbe@math.georgetown.edu` or `rosier@math.georgetown.edu`.

—From a CBMS announcement

National Academies Research Associateship Programs

The Policy and Global Affairs Division of the National Academies is sponsoring the 2005 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.

Awards are made for one or two years, renewable for a maximum of three years. Annual stipends for recent Ph.D. recipients range from $30,000 to $50,000, depending on the sponsoring laboratory; the awards for senior recipients will be higher. 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 2005 review is **February 1, 2005**.

For further information and application materials, see the National Academies website at http://www4.nas.edu/pga/rap.nsf/WebDocuments/Home+Page, or contact Research Associateship Programs, Keck Center of the National Academies, 500 Fifth Street, NW, GR322A, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.

—From an NRC announcement

National Academies Graduate Fellowship Program

The Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies is designed to engage graduate science, engineering, medical, veterinary, business, and law students in the analysis and creation of science and technology policy and to familiarize them with the interactions of science, technology, and government. As a result, students develop essential skills different from those attained in academia and make the transition from graduate student to professional. In 2005 programs will be held in the summer from June 6 through August 12, and in the fall from September 12 through November 18.

Applications for the fellowships are invited from scholars from graduate through postdoctoral levels in any physical, biological, or social science field or any field of engineering, medicine and health, or veterinary medicine, as well as business, law, education, and other graduate and professional programs. Postdoctoral scholars should have received their Ph.D.'s within the past five years.

The stipend for both 10-week programs is $4,800. The fellowship stipend is intended to cover all living expenses for the period. In addition, a travel stipend of up to $500 will be provided.

Deadlines for receipt of materials for the summer program is **March 1, 2005**, and for the fall program, **June 1, 2005**. More information and application forms and instructions can be found on the website http://www7.nationalacademies.org/policyfellows or by contacting National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 5th Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667.

—From a National Academies announcement

Clay Mathematics Institute 2005 Summer School

The Clay Mathematics Institute (CMI) Summer School on Ricci Flow, 3-Manifolds, and Geometry will be held at the Mathematical Sciences Research Institute (MSRI) in Berkeley, California, June 20–July 15, 2005.

Designed for graduate students and mathematicians within five years of receipt of the Ph.D., the program is organized around Ricci flow and the geometrization of 3-manifolds, particularly the recent work of Grisha Perelman. Topics covered will include an introduction to geometrization, Ricci flow (both geometric and analytic aspects), minimal surfaces, and various fundamental results in topology and differential geometry. Courses will be dedicated to Perelman's work on general Ricci flow, as well as some results and applications in 3 dimensions. There will be three weeks of foundational courses and one week of minicourses focusing on more advanced topics. Lecturers include Jeff Cheeger, Bennett Chow, Tobias Colding, Richard Hamilton, Bruce Kleiner, John Lott, John Morgan, Gang Tian, and others. The organizing committee for the summer school consists of Gang Tian, John Lott, John Morgan, Bennett Chow, Tobias Colding, Jim Carlson, David Ellwood, and Hugo Rossi.

Funding is available to graduate students and postdoctoral fellows who are within five years of receipt of the Ph.D. Standard support amounts will include funds for local expenses and accommodations plus economy travel.

The deadline for application is **February 28, 2005**. Application forms are available at http://www.claymath.org/summerschool. For more information, see the website http://www.claymath.org/summerschool; telephone: 617-995-2600; email: summerschool@claymath.org.

—From a CMI announcement

NSF-CBMS Regional Conferences, 2005

With funding from the National Science Foundation (NSF), the Conference Board of the Mathematical Sciences (CBMS) will hold three NSF-CBMS Regional Research Conferences during the spring and summer of 2005.

These conferences are intended to stimulate interest and activity in mathematical research. Each five-day conference features a distinguished lecturer who will deliver ten lectures on a topic of important current research in one sharply focused area of the mathematical sciences. The lecturer subsequently prepares an expository monograph based on these lectures. Depending on the conference topic, the monograph will be published by the American Mathematical Society, by the Society for Industrial and Applied Mathematics, or jointly by the American Statistical Association and the Institute of Mathematical Statistics.

Support for about thirty participants will be provided for each conference. Established researchers and interested newcomers, including postdoctoral fellows and graduate students, are invited to attend.

Information about an individual conference may be obtained by contacting the conference organizer. The three conferences to be held in 2005 are listed below.

New Perspectives for Boundary Value Problems and Their Asymptotics, Athanassios Fokas, lecturer. May 16–20, University of Texas-Pan American. Organizers: Lokenath Debnath, telephone 956-381-3459, email: debnathl@utpa.edu; and Andras Balogh, telephone 956-381-2119, email: abalogh@utpa.edu; website: http://www.math.panam.edu/cbms2005.htm.

Nonlinear Dispersive and Wave Equations, Terence Tao, lecturer. June 13–18, New Mexico State University. Organizers: Joseph Lakey, telephone 505-646-2417, email: jlakey@nmsu.edu; Tiziana Giorgi, telephone 505-646-2323, email: tgiorgi@nmsu.edu; Cristina Pereyra, telephone 505-277-4147, email: crisp@math.unm.edu; Adam Sikora, telephone 505-646-6269, email: asikora@nmsu.edu; and Robert Smits, telephone 505-646-2884, email: rsmits@nmsu.edu; website: http://www.math.nmsu.edu/~jlakey.cbms.html.

Algebraic and Topological Combinatorics of Ordered Sets, Anders Björner, lecturer. August 8–12, San Francisco State University. Organizers: Joseph Gubeladze, telephone 415-338-7722, email: soso@math.sfsu.edu; and Serkan Hosten, telephone 415-338-7723, email: serkan@math.sfsu.edu; website http://www.sfsu.edu/gubeladze/cbms.html.

—From a CBMS announcement

News from SAMSI

The Statistical and Applied Mathematical Sciences Institute (SAMSI) has entered its third year of operation. SAMSI is a national NSF institute in the mathematical sciences whose mission is to forge a new synthesis of the statistical sciences with the applied mathematical sciences and disciplinary science to confront the very hardest and most important data- and model-driven scientific challenges. SAMSI is housed in the NISS building in Research Triangle Park, North Carolina.

After a very successful second year, with well over 700 participants in SAMSI activities, the current year has an exciting slate of programs, on *Computational Biology of Infectious Diseases*, *Latent Variable Models in the Social Sciences*, and *Data Assimilation for Geophysical Systems*. Some opportunities for participation in these programs still remain, especially in the latter program, which begins January 2005. See the SAMSI website (http://www.samsi.info) for further information about these programs.

Plans are well under way for SAMSI's 2006–07 programs (discussed below), and numerous opportunities exist for participation by AMS members. Visiting young and senior researchers will be resident at SAMSI for periods of one month to one year. Several postdoctoral positions will be funded for each SAMSI program. Special programs exist for graduate and upper-level undergraduate students to initiate their involvement in cross-disciplinary and team research. New researchers will have special opportunities, from both the SAMSI environment and from financial support. Senior researchers will have the chance for serious broadening of their interests and skill sets.

Workshops will enable many others to join in the effort. Every SAMSI program will have at least an opening and a closing workshop, allowing for broad participation of individuals who cannot spend part of the year at SAMSI. New researchers and members of underrepresented groups are especially encouraged to participate in SAMSI workshops and programs.

SAMSI is very interested in obtaining proposals for future research programs. Anyone with an idea for a future program should contact Jim Berger (berger@samsi.info). Such ideas can also be communicated to the other members of the SAMSI directorate—Tom Banks (htbanks@eos.ncsu.edu), Alan Karr (karr@niss.org), and Young Truong (truong@bios.unc.edu)—or to the SAMSI National Advisory Committee, chaired by Peter Bickel and Margaret Wright.

Brief descriptions of the upcoming Fourth Year SAMSI programs follow. A program on **Financial Mathematics, Statistics and Econometrics** will run from September 2005 through December 2005. This program, being led by Jean-Pierre Fouque and Eric Ghysels, has the goal of bringing together the three disciplines of mathematics, statistics, and econometrics to focus on the major challenges in the three essential tasks: modeling, data analysis, and computation in applications ranging from financial and energy derivatives to real options and defaultable securities.

A program on **National Defense and Homeland Security** will run from September 2005 through May 2006. This program, being led by Lawrence Cox and Nell Sedransk, will emphasize *biointelligence*, which intersects the planned development of a CDC Biointelligence Center; *real time inference*, involving data streams; *anomaly detection*, with particular attention to high-dimensional data, extremely rare events, and false positives; *data integration*, including integration of new forms of data such as images or biometric identification; and *dynamics of massive databases*, which is in part a fundamental issue of data quality.

The third program is **Astrostatistics**, to be conducted from January to June 2006. This program, being led by Jogesh Babu, will address a range of statistical and mathematical problems that arise in modern astronomical and space sciences research, particularly due to the flood of data produced by space-based astronomical surveys at many wave-bands. The program will especially emphasize collaborations involving astronomers, mathematicians, and statisticians on novel problems facing upcoming astronomy missions.

In addition to these three major programs, SAMSI will conduct planning or hot topics workshops, undergraduate and graduate outreach workshops, summer schools (as part of programs), and several interdisciplinary courses associated with ongoing programs. For more information about any of the SAMSI activities and the possibilities for participating in them, go to the SAMSI website, http://www.samsi.info.

—James Berger, SAMSI director

For Your Information

Return of the CBMS Survey

The Conference Board of the Mathematical Sciences (CBMS) is an umbrella organization whose members are the presidents of sixteen professional associations in the mathematical and statistical sciences (these associations are listed at `http://www.cbmsweb.org/Members/member_societies.htm`). Every five years since 1965 the CBMS has sponsored a national survey of undergraduate mathematical and statistical sciences in the nation's universities and colleges, both four-year and two-year. With National Science Foundation support, there will be a new CBMS survey in 2005, called CBMS2005.

The CBMS2005 project is supervised by a steering committee with members representing the AMATYC (American Mathematical Association of Two-Year Colleges), the AMS, the ASA (American Statistical Association), and the MAA (Mathematical Association of America). CBMS2005 will use carefully designed random sampling to study curriculum, pedagogy, enrollment levels, number of bachelor's graduates, and faculty in the nation's undergraduate mathematical and statistical sciences departments and programs. In addition to continuing numerous long-term studies, CBMS2005 will investigate certain "topics of opportunity", i.e., issues identified as being of timely interest to the national mathematical and statistical community. The final survey report will follow the general pattern of the CBMS2000 report (available for free download at the website `http://www.ams.org/cbms/`).

The CBMS2005 steering committee will finalize the list of topics of opportunity early in 2005. Professional society committees and officers have suggested several topics as deserving of further study, including: the growing dichotomy (detected in CBMS2000) between doctoral and bachelor's-only mathematics departments in the availability of advanced undergraduate courses, growth and quality control issues associated with dual-enrollment courses, changes in calculus pedagogy, the mathematical education of preservice K–8 teachers, the statistical background of faculty who teach statistics in mathematics departments, the apparent shift away from tenure-stream appointments in mathematical sciences departments and toward faculty appointments outside of the tenure stream, and self-assessment methods used by mathematical science departments. The steering committee welcomes further suggestions from the mathematics and statistics community about important issues that might become part of the 2005 survey. Please send suggestions to David Lutzer at `Lutzer@math.wm.edu`.

Increased coordination with the Joint Data Committee of the AMS/ASA/IMS/MAA will allow considerable simplification of the questionnaires used in CBMS2005 compared to previous years. Survey questionnaires will be mailed to selected departments and programs in September 2005. There will be an intense follow-up effort in the fall of 2005 in the hope of matching the roughly 65 percent response rate for the CBMS2000 project. Responses will be analyzed in the spring and summer of 2006, and the final CBMS2005 report will be published by the AMS in the spring of 2007.

—David Lutzer, College of William and Mary

Mathematics Awareness Month 2005

The AMS, the American Statistical Association (ASA), the Mathematical Association of America (MAA), and the Society for Industrial and Applied Mathematics (SIAM) announce that the theme for Mathematics Awareness Month 2005 is **Mathematics and the Cosmos**.

Mathematics is at the core of our attempts to understand the universe at every level, from the most theoretical to the most mundane. Modern cosmology is based on the ideas of Riemann regarding the nature of space, along with the notion of curved spaces of three and more dimensions, adapted by Einstein to four-dimensional space time, and encapsulated in Einstein's fundamental insight that gravity is geometry. From this and his justly famous field equations, Einstein deduced on theoretical grounds the bending of light as it passes a massive object, the precise amount of precession of Mercury's perihelion, the expansion of the universe, the existence of black holes, the behavior of binary stars, and the existence of gravitational waves, all of which led to experiments to confirm their validity.

In cases not subject to direct experimentation, other mathematical methods are vital for carrying out simulations of the motions within galaxies and star clusters, the

collision of galaxies and black holes, and other large-scale gravitational interactions. At the level of the solar system, the mathematical methods initiated by Newton and continually elaborated over the ensuing centuries have explained or predicted the action of the tides; the bulge of the Earth around the equator; the existence of previously unknown planets; the orbits and return times of comets; and, just in the past decade, the existence of planets orbiting other stars.

In the realm of practical space exploration, mathematical techniques allow the planning of efficient trajectories to reach the Moon, Mars, and the outer planets and the means to communicate with those satellites, both for navigation and to encode, compress, and transmit images across many hundreds of millions of miles of space, as in the recent spectacular photographs from the Cassini mission to Saturn.

Mathematics departments may find on the Mathematics Awareness Month website, `http://www.mathaware.org`, a sample press release that can be adapted for public awareness activities.

Each year in April the Joint Policy Board for Mathematics sponsors Mathematics Awareness Month to recognize the importance of mathematics through written materials and an accompanying poster that highlight mathematical developments and applications in one particular area.

The Mathematics Awareness Month 2005 advisory committee members are: Robert Osserman (chair), Mathematical Sciences Research Institute; Douglas N. Arnold, Institute for Mathematics and Its Applications; Jonathan Borwein, Dalhousie University; Tony Chan, University of California, Los Angeles; Charles Elachi, Jet Propulsion Laboratory, California Institute of Technology; and Sarah J. Greenwald, Appalachian State University.

—AMS announcement

TV Program Featuring Mathematician

A new television series called *NUMB3RS* will feature a mathematician as a main character. According to the webpage for the series (`http://kidk.cbsnow.com/primetime/numb3rs/`), the story revolves around an FBI agent who recruits his "mathematical genius brother" to help solve a wide range of crimes in Los Angeles. "From two very different perspectives, the brothers take on the most confounding criminal cases," the webpage states. "Inspired by actual events, the series will depict how the confluence of police work and mathematics provides unexpected revelations and answers to the most perplexing criminal questions."

The premiere episode of *NUMB3RS* will be broadcast on CBS on Friday, January 21, 2005, at 10:00 p.m. EST.

—Allyn Jackson

Universität Ulm

The **Faculty of Mathematics and Economics** at the University of Ulm invites applications for a

Professorship in Algebra/ Discrete Mathematics (W3)

to commence in October 2005.

Candidates should have an excellent research record in Algebra/Discrete Mathematics and be able to both contribute to the research activities within the mathematics group and to strengthen the interdisciplinary research activities within the University. The applicants work should be well connected with an applied area of algorithmic mathematics such as e.g. Information and Coding Theory, Cryptography or Complexity Theory. We expect that the applicant participates actively in our interidisciplinary graduate college Mathematical Evolution, Information and Complexity.

Successful candidates will be teaching at all levels both for students of our faculty as well as other faculties of the University of Ulm.

Applicants are expected to have a doctorate in mathematics and a Habilitation or must otherwise present evidence of excellence in research and teaching.

The position is an established (permanent) Professorship. However, in the case of a first appointment the employment is initially temporary. Exceptions may be made for applications form abroad or from outside academia. No new application process is required if it is decided to continue the employment permanently after the initial appointment.

The University of Ulm is committed to increase the percentage of women in research and teaching. We therefore affirmatively encourage female scientists to apply.

Applications with the usual documents (including reprints of the three most important publications) are due four weeks after publication of the advertisement to the Dean of the Faculty of Mathematics an Economics, University of Ulm, D-89069 Ulm (Phone ++49-731-50235 00, Telefax ++49-731-50236 10). For further information about the Faculty consult our homepage: www.mathematik.uni-ulm.de

Equally qualified individuals with disabilities will be considered with priority.

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

January 13, 2005: Proposals for ONR Young Investigator Program. See http://www.onr.navy.mil/sci_tech/industrial/363/yip.asp.

January 31, 2005: Applications for postdoctoral fellowships at the Mittag-Leffler Institute. See http://www.ml.kva.se/grants.

February 1, 2005: Applications for February review for National Academies Postdoctoral and Senior Research Associateship Programs. See "Mathematics Opportunities" in this issue.

February 1, 2005: Applications for AWM Collaborative Research Grants for Women. See http://www.awm-math.org/travelgrants.html#collaborative; telephone 301-405-7892; email: awm@math.umd.edu.

February 1, 2005: Applications for AWM Travel Grants and AWM Mentoring Travel Grants. See the AWM website, http://www.awm-math.

Where to Find It

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

AMS Bylaws—*November 2003, p. 1283*

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

AMS Ethical Guidelines—*June/July 2004, p. 675*

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

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

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

Information for *Notices* Authors—*June/July 2004, p. 670*

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

National Science Board—*January 2005, p. 76*

New Journals for 2003—*June/July 2004, p. 672*

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

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

NSF Mathematical and Physical Sciences Advisory Committee—*February 2005, p. 261*

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

org/travelgrants.html; telephone: 301-405-7892; email: awm@math.umd.edu.

February 4, 2005: Preproposals for NSF IGERT competition. See "Mathematics Opportunities" in this issue.

February 15, 2005: Nominations for Clay Mathematics Institute Liftoff Program. See the website http://claymath.org/fas/liftoff_fellows/.

February 28, 2005: Applications for Clay Mathematics Institute 2005 Summer School. See "Mathematics Opportunities" in this issue.

March 1, 2005: Applications for summer program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies. See "Mathematics Opportunities" in this issue.

March 1, 2005: Applications for Summer Program for Undergraduate Women in Mathematics at George Washington University. See http://www.gwu.edu/~math/spwm.html.

March 1, 2005: Applications for EDGE Summer Program. See website at http://www.edgeforwomen.org/index.html.

March 1, 2005: Applications for IMA New Directions visiting professorships at IMA. See http://www.ima.umn.edu/docs/membership.html.

April 1, 2005: Applications for IMA New Directions Short Course. See http://www.ima.umn.edu/new-directions/2005NDshort-course/NDcourse-app.php.

April 8, 2005: Proposals for 2005 NSF-CBMS Regional Conferences. See "Mathematics Opportunities" in this issue.

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

June 1, 2005: Applications for fall program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies. See "Mathematics Opportunities" in this issue.

June 2, 2005: Applications for NSF University-Industry Cooperative Research Programs in the Mathematical Sciences (UICRP). See http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf05504.

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

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

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.

Shenda Baker (10/05)
Department of Chemistry
Harvey Mudd College

Lars Bildsten (10/07)
KITP
University of California, Santa Barbara

Janet M. Conrad (10/06)
Department of Physics
Columbia University

Susan Coppersmith (10/07)
Department of Physics
University of Wisconsin

Luis Echegoyen (10/06)
Department of Chemistry
Clemson University

Mostafa El-Sayed (10/06)
School of Chemistry and Biochemistry
Georgia Institute of Technology

Lucy Fortson (10/06)
Department of Astronomy
Adler Planetarium

Jean H. Futrell (10/05)
Director
Pacific Northwest National Laboratory

Peter F. Green (10/05)
Department of Chemical Engineering
University of Texas, Austin

Sol M. Gruner (10/07)
Department of Physics
Cornell University

Frances Hellman (10/06)
Department of Physics
University of California, Berkeley

John Huchra (10/06)
Harvard-Smithsonian Center for Astrophysics
Harvard University

Raymond L. Johnson (10/06)
Department of Mathematics
University of Maryland, College Park

Jon R. Kettenring (10/06)
Charles A. Dana Research Institute
Drew University

Robert V. Kohn (10/07)
Courant Institute
New York University

Steven E. Koonin (10/07)
Chief Scientist
BP, plc

W. Carl Lineberger (chair) (10/06)
Department of Chemistry and Biochemistry
Joint Institute for Laboratory Astrophysics
University of Colorado at Boulder

David R. Morrison (10/05)
Department of Mathematics
Duke University

Venkatesh Narayanamurti (10/06)
Division of Engineering and Applied Sciences
Harvard University

Claudia Neuhauser (10/05)
Professor and Director of Graduate Studies
Ecology, Evolution and Behavior
University of Minnesota

Eve Ostriker (10/07)
Department of Astronomy
University of Maryland

David W. Oxtoby (10/07)
Office of President
Pomona College

Marcia J. Rieke (10/07)
Steward Observatory 262
University of Arizona

Gary Sanders (10/05)
Thirty Meter Telescope Project
California Institute of Technology

Elizabeth H. Simmons (10/07)
Department of Physics
and Astronomy
Michigan State University

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.

1089 and All That. A Journey into Mathematics, by David Acheson. Oxford University Press, July 2002. ISBN 0-19-851623-1. (Reviewed in this issue.)

* *13: The Story of the World's Most Popular Superstition*, by Nathaniel Lachenmeyer. Thunder's Mouth Press, October 2004. ISBN 1-568-58306-0.

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

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

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

Alan Turing: Life and Legacy of a Great Thinker, edited by Christof Teuscher. Springer, 2004. ISBN 3-540-20020-7.

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

Alpha and Omega: The Search for the Beginning and End of the Universe, by Charles Seife. Viking, July 2003. ISBN 0-670-03179-8.

Automated Reasoning and the Discovery of Missing and Elegant Proofs, by Larry Wos and Gail Pieper. Rinton Press, December 2003. ISBN 1-58949-023-1.

Beyond Coincidence, by Martin Plimmer and Brian King. Icon Books, March 2004. ISBN 1-840-46534-4.

The Changing Shape of Geometry: Celebrating a Century of Geometry and Geometry Teaching, edited by Chris Pritchard. Cambridge University Press, January 2003. ISBN 0-521-53162-4.

Cogwheels of the Mind: The Story of Venn Diagrams, by A. W. F. Edwards. Johns Hopkins University Press, April 2004. ISBN 0-801-87434-3.

Constantin Carathéodory: Mathematics and Politics in Turbulent Times, by M. Georgiadou. Springer, September 2004. ISBN 3-540-44258-8.

The Constants of Nature: From Alpha to Omega—The Numbers That Encode the Deepest Secrets of the Universe, by John D. Barrow. Jonathan Cape, September 2002. Pantheon Books, January 2003. ISBN 0-375-42221-8. (Reviewed November 2004.)

Count Down: Six Kids Vie for Glory at the World's Toughest Math Competition, by Steve Olson. Houghton Mifflin, April 2004. ISBN 0-618-25141-3. (Reviewed August 2004.)

The Curious Life of Robert Hooke, the Man Who Measured London, by Lisa Jardine. HarperCollins, February 2004. ISBN 0-060-53897-X.

Everything and More: A Compact History of Infinity, by David Foster Wallace. W. W. Norton, October 2003. ISBN 0-393-00338-8. (Reviewed June/July 2004.)

The Fabric of the Cosmos, by Brian Greene. Knopf, February 2004. ISBN 0-375-41288-3.

Fields Medalists' Lectures, edited by Sir Michael Atiyah and Daniel Iagolnitzer. World Scientific, 2nd edition, December 2003. ISBN 9-812-38259-3.

* *From Eudoxus to Einstein: A History of Mathematical Astronomy*, by C. M. Linton. Cambridge University Press, August 2004. ISBN 0-521-82750-7.

From Newton to Hawking: A History of Cambridge University's Lucasian Professors of Mathematics, edited by Kevin C. Knox and Richard Noakes. Cambridge University Press, November 2003. ISBN 0-521-66310-5.

Gamma: Exploring Euler's Constant, by Julian Havil. Princeton University Press, May 2003. ISBN 0-691-09983-9. (Reviewed August 2004.)

Geometry: Our Cultural Heritage, by Audun Holme. Springer, April 2002. ISBN 3-540-41949-7. (Reviewed May 2004.)

Gödel's Proof, by Ernest Nagel and James R. Newman. New York University Press, revised edition, February 2002. ISBN 0-8147-5816-9. (Reviewed March 2004.)

The Golden Ratio: The Story of Phi, the World's Most Astonishing Number, by Mario Livio. Broadway Books, October 2002. ISBN 0-767-90815-5.

A Handbook of Mathematical Discourse, by Charles Wells. Infinity Publishing Company, 2003. ISBN 0-7414-1685-9. (Reviewed September 2004.)

* *The Heart of Mathematics: An Invitation to Effective Thinking*, by Edward B. Burger and Michael Starbird. Key College Publishing (Springer-Verlag), April 2000. ISBN 0-555953-407-9. (Reviewed in this issue.)

Karl Pearson: The Scientific Life in a Statistical Age, by Theodore M. Porter. Princeton University Press, February 2004. ISBN 0-691-11445-5.

Kepler's Conjecture: How Some of the Greatest Minds in History Helped Solve One of the Oldest Math Problems in the World, by George G. Szpiro.

Wiley, January 2003. ISBN 0-471-08601-0. (Reviewed January 2005.)

* *The Knot Book: An Elementary Introduction to the Mathematical Theory of Knots*, Colin C. Adams. AMS, September 2004. ISBN 0-8218-3678-1.

* *The Liar Paradox and the Towers of Hanoi: The Ten Greatest Math Puzzles of All Time*, by Marcel Danesi. Wiley, August 2004. ISBN 0-471-64816-7.

Masters of Theory: Cambridge and the Rise of Mathematical Physics, by Andrew Warwick. University of Chicago Press, July 2003. ISBN 0-226-87375-7.

* *Math Magic: How to Master Everyday Math Problems*, by Scott Flansburg. Perennial Currents, revised edition, August 2004. ISBN 0-060-72635-0.

Math through the Ages: A Gentle History for Teachers and Others, by William P. Berlinghoff and Fernando Q. Gouvêa. Oxton House, 2002. ISBN 1-881929-21-3. (Reviewed October 2004.)

The Mathematical Century: The 30 Greatest Problems of the Last 100 Years, by Piergiorgio Odifreddi, translated by Arturo Sangalli. Princeton University Press, May 2004. ISBN 0-691-09294-X.

Mathematical Journeys, by Peter D. Schumer. Wiley-Interscience, February 2004. ISBN 0-471-22066-3.

A Mathematician's Survival Guide: Graduate School and Early Career Development, by Steven G. Krantz. AMS, August 2003. ISBN 0-8218-3455-X. (Reviewed April 2004.)

Mathematicians as Enquirers: Learning about Learning Mathematics, edited by Leone Burton. Kluwer, April 2004. Hardbound, ISBN 1-4020-7853-6; paperback, ISBN 1-4020-7859-5; eBook, ISBN 1-4020-7908-7.

Mathematicians under the Nazis, by Sanford L. Segal. Princeton University Press, July 2003. ISBN 0-691-00451-X.

Mathematics: A Very Short Introduction, by Timothy Gowers. Oxford University Press, October 2002. ISBN 0-192-85361-9. (Reviewed in this issue.)

Mathematics and Culture I, edited by Michele Emmer. Springer, January 2004. ISBN 3-540-01770-4.

Mathematics and War, edited by Bernhelm Booss-Bavnbek and Jens Høyrup. Birkhäuser, December 2003. ISBN 3-764-31634-9.

Mathematics, Art, Technology, and Cinema, edited by Michele Emmer and Mirella Manaresi. Springer, 2003. ISBN 3-540-00601-X.

Mathematics in Nature: Modeling Patterns in the Natural World, by John Adam. Princeton University Press, November 2003. ISBN 0-691-11429-3.

Meta Math! The Quest for Omega, by Gregory J. Chaitin. April 2004. Available at `http://www.cs.umaine.edu/~chaitin/omega.html`.

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

The Music of the Primes: Searching to Solve the Greatest Mystery in Mathematics, by Marcus Du Sautoy. HarperCollins, April 2003. ISBN 0-066-21070-4.

Newton's Apple: Isaac Newton and the English Scientific Renaissance, by Peter Aughton. Weidenfeld & Nicolson, October 2003. ISBN 0-297-84321-4.

The Number π, by Pierre Eymard and Jean-Pierre Lafon. AMS, 2004. ISBN 0-8218-3246-8.

Number Theory from an Analytic Point of View, by Badih Ghusayni. Komati, December 2003. ISBN 9953-0-0282-7.

Phase Change: The Computer Revolution in Science and Mathematics, by Douglas S. Robertson. Oxford University Press, March 2003. ISBN 0-195-15748-6.

Portraits of the Earth: A Mathematician Looks at Maps, by Timothy G. Feeman. AMS, September 2002. ISBN 0-8218-3255-7.

Prime Obsession: Bernhard Riemann and the Greatest Unsolved Problem, by John Derbyshire. Joseph Henry Press, March 2003. ISBN 0-309-08549-7.

Probability Theory: The Logic of Science, by E. T. Jaynes, edited by G. Larry Bretthorst. Cambridge University Press, April 2003. ISBN 0-521-59271-2.

The Reader of Gentlemen's Mail: Herbert O. Yardley and the Birth of American Codebreaking, by David Kahn. Yale University Press, March 2004. ISBN 0-300-09846-4.

The Riemann Hypothesis: The Greatest Unsolved Problem in Mathematics, by Karl Sabbagh. Farrar Straus & Giroux, April 2003. ISBN 0-374-25007-3.

The Saga of Mathematics: A Brief History, by Marty Lewinter and William Widulski. Prentice Hall, January 2002. ISBN 0-130-34079-0.

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

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

Strange Curves, Counting Rabbits, and Other Mathematical Explorations, by Keith Ball. Princeton University Press, November 2003. ISBN 0-691-11321-1. (Reviewed in December 2004.)

Sync: The Emerging Science of Spontaneous Order, by Steven Strogatz. Hyperion, February 2003. ISBN 0-786-86844-9. (Reviewed March 2004.)

Towards a Philosophy of Real Mathematics, by David Corfield. Oxford University Press, April 2003. ISBN 0-521-81722-6.

* *The Universal Book of Mathematics: From Abracadabra to Zeno's Paradoxes*, by David Darling. Wiley, July 2004. ISBN 0-471-27047-4.

* *You Can Do the Math: Overcome Your Math Phobia and Make Better Financial Decisions*, by Ron Lipsman. Praeger Publishers, November 2004. ISBN 0-275-98341-2.

Doctoral Degrees Conferred

2003–2004

ALABAMA

University of Alabama, Birmingham (4)

BIOSTATISTICS

Li, Yufeng, Parameter estimation for a proposed joint distribution of multivariate Bernoulli trials.

Zhang, Yuting, A pattern mixture model for censored binary longitudinal data.

MATHEMATICS

Malaugh, James M., Rotational sets of the circle under Z^d.

Yan, Aimin, An inverse goundwater model.

University of Alabama, Tuscaloosa (4)

INFORMATION SYSTEMS, STATISTICS, AND MANAGEMENT SCIENCE

Flynn, Timothy, Sequencing mixed-model assembly lines in a lean environment.

MATHEMATICS

Bunnag, Dhiranuch, Stochastic algorithms for global optimization.

Cheng, Kang-Ping, Three numerical schemes for solving nonlinear partial differential equations.

Sukantamala, Nattakorn, Area operator on Hardy spaces.

ARIZONA

Arizona State University (12)

MATHEMATICS AND STATISTICS

Boerner, Rochus, Wavelets with integer dilation factors larger than two.

Burke, John, Mathematical models of metabolic cascades and gene regulation.

Chidambaram, Rama, Modeling and decision making in a semiconductor supply chain.

Do, Younghae, Chaotic transient behavior of dynamical systems under random perturbations.

Ephrem, Menassie, Characterizing liminal and type I graph C^*-algebras and C^*-algebra of the Z^2-tree.

Hirman, Joseph, The role of variance: an extension of small area estimation.

Kim, Bong-Sik, Alpha models for rotating Navier-Stokes equations in geophysics with nonlinear dispersive regularization.

Larsem, Sean, Supporting the guided reinvention of the concepts of group and isomorphism: a developmental research project.

Negoita, Cristina, Global kinetic imaging using dynamic positron emission tomography data.

Smith, Shelly, A discrete homotopy theory for graphs, with application to order complexes of lattices.

Yang, Daqing, Extension of the game coloring number and some results on the choosability of complete multipartite graphs.

Ybarra, Lynn, Small area estimation using data from multiple surveys.

University of Arizona (11)

APPLIED MATHEMATICS

Hoppin, John, Ranking estimation methods in medical imaging without the use of a gold standard.

Kuecken, Michael, On the formation of fingerprints.

Lane, Emily, Wave-current interactions in coastal waters and their application to shore-connected bars.

Lo, Arthur, Theoretical simulation of metabolic mechanisms for regulating capillary perfusion in working skeletal muscle.

Parra, Mario, Filter-bank transforms with exact inverses.

MATHEMATICS

Hoffman, Thomas, Constructing basic algebras for the principal block of sporadic simple groups.

Piatek-Jimenez, Katrina, Undergraduate mathematics students' understanding of mathematical statements and proofs.

Pierce, Virgil, The asymptotic expansion of the partition function of random matrices.

Rasmussen, Christopher, Jacobians of etale covers of the projective line minus three points.

Selden, Jeffrey, The density of states in a quasi-gap.

Wootton, Aaron, Defining algebraic polynomials for cyclic prime covers of the Riemann sphere.

ARKANSAS

University of Arkansas (3)

MATHEMATICAL SCIENCES

Hughes, Kimberly, Variations on generalized logit models: alternative links and stepwise selection.

Reed, Michael, Symbolic blow-ups and generation in degree four.

Wu, Hsing-Yen, Tight congruences on semigroups.

CALIFORNIA

California Institute of Technology (15)

APPLIED MATHEMATICS

Camp, Charles David, Temporal and spatial patterns of the interannual variability of stratospheric ozone and dynamics.

Chaubell, Mario Julian, Low-coherence interferometric imaging: solution of the one-dimensional inverse scattering problem.

CONTROL AND DYNAMICAL SYSTEMS

Dunbar, William, Distributed receding horizon control of multiagent systems.

Leok, Melvin, Foundations of computational geometric mechanics.

The above list contains the names and thesis titles of recipients of doctoral degrees in the mathematical sciences (July 1, 2003, to June 30, 2004) reported in the 2004 Annual Survey of the Mathematical Sciences by 221 departments in 152 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 2005 issue of the *Notices*.

Ross, Shane, Cylindrical manifolds and tube dynamics in the restricted three-body problem.

West, Matthew, Variational integrators.

MATHEMATICS

Bartroff, Jay, Asymptotically optimal multistage hypothesis tests.

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Claremont Graduate University (3)

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Leng, Xiaoyan, Functional linear discrimination analysis.

Senturk, Damla, Covariate adjusted regression and correlation.

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Yuan, Shin-Sheg, Some contributions in computational biology.

University of California, Riverside (5)

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Lindborg, Suzanne, Representations of affine Lie algebras of level zero.

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Miller, Diane, Can we ask better questions? An examination of the respondent generated interval protocol.

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University of Southern California (2)

MATHEMATICS

Kim, Dong-Jin, Efficient methods for nonlinear parabolic PDEs.

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COLORADO

Colorado School of Mines (1)

MATHEMATICAL AND COMPUTER SCIENCES

Yang, Yongjun, A new discontinuous finite element method based on a least-squares stabilization for elliptic and convection-diffusion problems.

Colorado State University (4)

STATISTICS

Andrews, Margaret, Parameter estimation for all-pass time series.

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Mahabir, Sean, Evaluation of the method R procedure for one way random effects models.

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Baker, Allison Hoat, On improving the performance of the linear solver restarted GMRES.

McNamara, Richard, Applications of spanning trees to continuous-time Markov processes, with emphasis on loss systems.

Olson, Luke Nathan, Multilevel least-squares finite element methods for hyperbolic PDEs.

Sandberg, Kristian Hans, Forward and inverse wave propagation using bandlimited functions and a fast reconstruction algorithm for electron microscopy.

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Gomez, Andriana, Conservative maps: Reversibility, invariants and approximation.

Kirwin, William, Coherent states and geometric quantization.

Seaton, Christopher, Two Gauss-Bonnet and Poincaré-Hopf theorems for orbifolds with boundary.

University of Colorado, Denver (3)

MATHEMATICS

Argentati, Merico, Principal angles between subspaces as related to Rayleigh quotient and Raleigh Ritz inequalities with applications to eigenvalue accuracy and an eigenvalue solver.

Brown, David, Variations on interval graphs.

Uiyyasathian, Chariya, Maximal-clique partitions.

CONNECTICUT

University of Connecticut (8)

MATHEMATICS

Bulancea, Gabriela, Sequence algebras of continuous functions.

Jones, Molli, Group gradings of incidence algebras.

Keiter, Jonathan, One-vertex triangulations and Heegaard splittings.

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Xu, Jianhong, Parallel computation for Markov chains via Perron complementation.

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Bhaumik, Amitabha, Dynamical hierarchical models with applications.

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Akhmedov, Azer, Quasi-isometric rigidity in group varieties.

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DELAWARE

University of Delaware (5)

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Chandler, David, The Smith normal forms of design with classical parameters.

Dmytrenko, Vasyl, Classes of polynomial graphs.

Fiedler, Frank, Maximal arcs in $PG(2, 2, m)$.

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Williford, Jason, Constructions in finite geometry with application to graphs.

DISTRICT OF COLUMBIA

American University (3)

MATHEMATICS AND STATISTICS

Dickens, James, An analysis of the impact and focus of preparation efforts to improve performance on the Stanford nine mathematics test.

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George Washington University (4)

MATHEMATICS

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Christophi, Costas, Distances in random tries via analytic probability: The oscillatory distribution.

El-Baz, Abeer, Some contributions to statistical prediction theory.

Fan, Jiaquan, Short-term cancer incidence prediction.

Howard University (1)

MATHEMATICS

Diatta, Bassirou, Quivers, representation theory, non-commutative symplectic geometry, stratification and singular symplectic quotients.

FLORIDA

Florida Institute of Technology (2)

MATHEMATICAL SCIENCES

Dontha, Satyanarayana, Variational Lyapunov method for differential equations.

Martinez-Garza, Cesar, Impulsive hybrid differential systems with invisible solutions.

Florida State University (8)

MATHEMATICS

Jones, Deborah, Intersection numbers of divisors in graph varieties.

Lengfield, Marc, Envelopes, duality, and multipliers for certain non-locally convex Hardy-Lorentz spaces.

Montin, Benoit, A stock market agent-based model using evolutionary game theory and quantum mechanical formalism.

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STATISTICS

Kitsanta, Panagiota, Assessing adverse birth outcomes via classification trees.

Liu, Dacheng, Mixed-effects state space models for longitudinal data analysis.

Pu, Wenji, Selecting mixed-effects models based on a generalized information criterion.

Smith, Michael, A framework for using multi-modal sensors to estimate target locations and identities in a battlefield scene.

University of Central Florida (5)

MATHEMATICS

Boncek, John, Studies in tight frames and polar derivatives.

Korotkova, Olga, A model for a partially coherent Gaussian beam in atmospheric turbulence with applications for Lasercom and Lidar systems.

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Zamyatin, Alexander, Mathematics of cone-beam transform in computer tomography.

University of Florida (1)

MATHEMATICS

Griffiths, William, On integer solutions to systems of linear equations.

University of Miami (2)

MATHEMATICS

Cañas, Carlos, Multiserver cyclic queueing networks with discrete time: Exact results and approximations.

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University of South Florida (2)

MATHEMATICS

Abdallah, Ahmed, Global dynamics of damped Boussinesq equations.

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GEORGIA

Emory University (7)

BIOSTATISTICS

Davis, Xiaohong, Estimating vaccine efficacy from household data.

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Georgia Institute of Technology (7)

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Curran, Sean, Independent trees in 4-connected graphs.

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Figueroa-Lopez, José Enrique, Nonparametric estimation of Levy processes with a view towards mathematical finance.

Kreslavskiy, Dmitry, Lorentz lattice gases on graphs.

Ohoudjou, Kasso, Characterization of function spaces and boundedness of bilinear operators through Gabor frames.

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Awanou, Gerard, Energy methods in 3D spline approximations of the Navier Stokes equations.

Beck, Michael, Square dependence in random integers.

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Lee, Jaechoul, Linear trends, periodicities, and extremes.

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Xiao, YuanHui, Shot noise processes.

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HAWAII

University of Hawaii (1)

MATHEMATICS

Wills, Luis, Finite group graded Lie algebraic extensions and trefoil symmetric relativity, standard model, Yang Mills and gravity theories.

IDAHO

Idaho State University (1)

MATHEMATICS

Potter, Russell, Further results on the Siler cones and related cone theory.

University of Idaho (1)

MATHEMATICS

Zhang, Danhong, Disjoint cycles in graphs and directed graphs.

ILLINOIS

Illinois Institute of Technology (1)

APPLIED MATHEMATICS

Miranda, Jesus, Incorporating R-functions into the theory of positive definite functions to solve elliptic partial differential equations.

Illinois State University (7)

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Bower, Michelle (Wallace), Characterization of high school mathematics and physics language genres.

Foster, Halcyon, Already left behind: What can be done for low achieving high school mathematics students.

Johnson, Yolanda, Come home, then: An exploration of the past and present experiences of two 8th grade black females in one mathematics classroom.

Nugent, Patricia, Using a webboard as an asynchronistic community to facilitate first year secondary mathematics teachers as they move from apprenticeship status to effective teacher status.

Olson, Jo, Teachers' acceptance of new leadership roles and changes in classroom practices.

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Cui, Changrong, Hydrodynamic and differential-diffusion effects on premixed flame propagation.

Devadoss, Divya E., Mathematical modeling of polymerization waves.

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Moroz, Vadim, Rotating non-Boussinesq Rayleigh-Benard convection.

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Southern Illinois University, Carbondale (5)

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Hjouj, Fawaz, Identification of reflected, dilated, translated and rotated objects from their Radon projections.

Ibrahim, Haslinda, A family of designs for triads and related factorizations.

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Staples, George, Clifford algebras, combinatorics, and stochastic processes.

University of Chicago (26)

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Barnhill, Angela, Fixed point theorems for actions of Coxeter groups on non-positively curved singular spaces.

Belkin, Mikhail, Problems of learning on manifolds.

Calta, Kariane, Veech surfaces and complete periodicity in genus two.

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Sigurdsson, Johann, The homotopy theory of ex-spaces.

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Bouman, Peter, Statistical and computational methods for complex multicenter data analysis.

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Budur, Nero, Multiplier ideals and Hodge theory.

Dominici, Diego, Asymptotic analysis of a data handling system and its generalization.

Egorin, Vladimir, Characteristic varieties of algebraic curves.

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University of Illinois, Urbana-Champaign (20)

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INDIANA

Indiana University, Bloomington (4)

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Chung, Min, Local sine and cosine bases of Coifman and Meyer type and the construction of smooth wavelets.

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Indiana University-Purdue University, Indianapolis (1)

MATHEMATICAL SCIENCES

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Purdue University (12)

MATHEMATICS

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Janakiraman, Prabhu, Weak-type estimates for singular integral and maximal operators.

Joo, Sookyung, The phase transition between chiral nematic and smectic C^* liquid crystals.

Merenkov, Sergiy, Determining biholomorphic type of a manifold using combinatorial and algebraic structures.

Yu, Xiaoxiang, Finiteness of orbits and poles of intertwining operators.

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Annis, David H., A new statistical model combining strength and binary choice with applications to paired comparison problems.

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Gorla, Elisa, Lifting properties from the general hyperplane section of a projective scheme.

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Kiskowski, Maria, Discrete stochastic models of morphological pattern formation in biology.

Weber, Rebecca, A definable relation between c. e. sets and ideals.

IOWA

Iowa State University (13)

MATHEMATICS

Calhoun-Lopez, Marcus, Numerical solutions of hyperbolic conservation laws: Incorporating multi-resolution viscosity methods into the finite element framework.

Kwon, Hee-Dae, Analysis and approximation of terminal-state tracking optimal control problems and controllability problems constrained by linear and nonlinear parabolic partial differential equations.

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Fridley, Brooke, Data augmentation for the handling of censored spatial data.

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Kim, Ji-Yeon, Nonparametric regression estimation under complex sampling designs.

Lee, Eun-Kyung, Projection pursuit methods for exploratory supervised classification.

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University of Iowa (18)

APPLIED MATHEMATICAL AND COMPUTATIONAL SCIENCES

Jiang, Hong, Exploring algorithms for network capacity dimensioning and traffic modeling.

Kim, Changki, Modeling surrender/lapse rates and valuing surrender options in Korean interest indexed annuities.

Leem, Koung-Hee, Solving linear systems for meshfree discretizations.

BIOSTATISTICS

Wang, Deli, Robust estimation of a two-way semilinear model with applications to microdata normalization and analysis.

Wang, Wenquan, Estimating and testing treatment effects on two binary endpoints and association between endpoints in clinical trials.

MATHEMATICS

Ahn, Jeongho, Dynamic frictionless contact problems with linearly elastic bodies.

Ahn, Myung-sook, Weekly clean rings and almost clean rings.

Clarke, Sharon, Star-operations induced by overrings.

Hidayat, Dylmoon, Continuously translated framelets and wavelets.

Oshima, Chihiro, Characterization theorems in infinitary languages.

Robeson, John, Irredundant generating sets for modalities.

Svidersky, Ilona, Lifting schemes for wavelets.

Ugalde, William, Conformal invariants and the Wodzicki residue.

Waters, Gavin, $W^{2,p}$ estimates for parabolic equations.

Yoon, Jasang, Structure and spectral theory of multivariable weighted shifts of hyponormal operators.

Youn, Eun-Jung, Essential laminations and Dehn surgery on Montesinos knots.

STATISTICS AND ACTUARIAL SCIENCE

Christ, Aaron, An animal movement model incorporating resource selection and home range.

Lin, Yu-Jau, The Bayesian analysis of threshold autoregressive models.

KANSAS

Kansas State University (5)

MATHEMATICS

Onofrei, Silvia, A characterization of two classes of locally truncated diagram geometries.

STATISTICS

Lee, Eun-Joo, Statistical analysis software for multiplicative interaction models.

Shanga, Gilbert, Analysis of crossover designs when treatments have unequal variances.

Su, Zhaohui, Inference on some linear mixed-effect models and testing for lack-of-fit for experiments without replication.

Taylor, Veronica, Use of three partial areas for establishing bioequivalence and estimation of sample size for equivalence studies.

University of Kansas (3)

MATHEMATICS

Arana, Luis, The C^*-algebra of Lie semidirect products of the form $R^n \times_a R$.

Bach, Kelly, A cancellation problem for quantum spheres.

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Wichita State University (1)

MATHEMATICS AND STATISTICS

Benchama, Noureddine, A simplified Fornberg-like method for the conformal mapping of multiply connected regions.

KENTUCKY

University of Kentucky (7)

MATHEMATICS

Bendall, Gareth, Domination analysis beyond the traveling salesman problem.

Goodloe, Mary, Hadamard products of convex harmonic mappings.

Ishizuka, Wataru, The weak compactness and regularity of weakly harmonic maps on Riemannian manifolds with bounded measurable metrics.

Kovacs, Steve, Invertibility preserving maps of C^*-algebras.

Menzel, Matthew, Generalized sewing constructions for polytopes.

Mueller, Stacey, Harmonic mappings and solutions of a differential equation related to the de la Vallée Poussin means.

Riehemann, Robert, Subset takeaway on graphs.

LOUISIANA

Louisiana State University, Baton Rouge (5)

MATHEMATICS

Blankenship, Robin, Book embeddings of graphs.

Harris, John, The Kauffman bracket skein module of the quaternionic manifold.

Holcomb, Michael, On the geometry and topology of moduli spaces of multi-polygonal linkages.

Kanno, Jinko, Splitter theorems for 3- and 4-regular graphs.

Wang, Hao-Hao, Equations of parametric surfaces with base points via syzygies.

Louisiana Technical University (4)

MATHEMATICS AND STATISTICS PROGRAM

Hu, Jing, Mathematical and empirical modeling of chemical reactions in a microreactor.

Kaba, Ibrahima, A numerical method to solve the two-step parabolic heat transfer equations in a microsphere subjected to an ultrafast laser pulse.

Shen, Lixin, A three-level finite difference scheme for solving a dual-phase-lagging heat transport equation in spherical coordinates.

Zhen, Peng, Modeling of the inverse heat-conduction problem with application to laser chemical vapor deposition and bioheat transfer.

University of Louisiana at Lafayette (3)

MATHEMATICS

Guo, Huizhen, Inference on quantiles of some parametric models.

Lu, Yong, Inferences on the common mean of normal populations: The correlated and uncorrelated cases.

Sonnier, William Joshua, Mathematical modeling of coupled nonlinear Schroedinger systems using conservation schemes.

MARYLAND

Johns Hopkins University (9)

APPLIED MATHEMATICS AND STATISTICS

Cope, Leslie, Some asymptotic properties of smooth quantile ratio estimation.

Yuan, Weishi, Asymptotic properties and inferences for varying coefficient regression with longitudinal variables.

BIOSTATISTICS

Chen, Weimin, Robust quantitative trait linkage analysis in extended human pedigrees.

Eddings, Wesley, Topics in the philosophy of statistics: Methods, data, and theory.

Gupte, Nikhil, Statistical models and methods for mother to infant HIV transmission studies.

MATHEMATICS

Dean, Brian, Some results on stable compact embedded minimal surfaces in 3-manifolds.

Lee, Seok-Min, On certain cohomological invariants of quadratic number field.

Xu, Xiangjin, Eigenfunction estimates on compact manifolds with boundary and Hörmander multiplier theorem.

Zhang, Sirong, Curvature estimates for constant mean curvature surfaces in three manifolds.

University of Maryland, Baltimore (2)

MATHEMATICS AND STATISTICS

Webster, Samuel, Stability and convergence of a spectral Galerkin method for the linear Boltzmann equation.

Zhao, Qing, Correlation machines and their applications.

University of Maryland, College Park (13)

MATHEMATICS

Calcut, Jack, Torelli actions and smooth structures on 4-manifolds.

Eikenberg, Edward, Rational points on some families of elliptic curves.

Jones, Catherine, Pyramids of properness: Proving the properness conjecture.

Kolesar, Joseph, Sigma delta modulation and correlation criteria for the construction of finite frames arising in communication theory.

Kollar, Richard, Existence and stability of vortex solutions of certain nonlinear Schrödinger equations.

Ott, William, Infinite-dimensional dynamical systems and projections.

Perlitz, Michael, Explaining the emergence of cooperation: An axiomic theory of accumulation.

Ridley, Ahmad, Performance analysis of multiclass preemptive-resume priority call center with time-varying arrivals.

Snitz, Kobi, Theta correspondence of automorphic characters.

Tang, Zhihui, Fast transforms based on structured matrices with applications to the fast multiple method.

Wu, Chin-Tien, On implementation of an accurate and efficient solver for convection-diffusion equations.

Zheng, Shijun, Besov spaces for the Schrödinger operator with barrier potential.

MEASUREMENT, STATISTICS AND EVALUATION

Koenig, Judith, Comparison of characteristic curve methods for linking parameters estimated with the generalized graded unfolding model.

MASSACHUSETTS

Boston University (7)

BIOSTATISTICS

Govindarajulu, Usha, The selection of frailty models and the development of a frailty model for unexplained heterogeneity in the Framingham heart study.

Guo, Chao-Yu, Extensions of family-based genetic tests of linkage and/or association for a dichotomous trait.

MATHEMATICS AND STATISTICS

Andonova Jaeger, Savina, Theoretical and experimental analysis of the generalization ability of some statistical learning algorithms.

Chazaro, Irmarie, A comparison of family-based association test for quantitative traits.

Macabea, Joyce, Dynamics of Shepherd moon ring systems.

Vierling, Angela, Linear systems on ruled surfaces and moduli of vector bundles over curves.

Zompatori, Marina, Curves of high genus in projective space.

Brandeis University (5)

MATHEMATICS

Bone, Eric, A generalization of Pohlig-Hellman simplification in elliptic curve cryptography.

Bourgoin, Mario, Immersed curves and links in oriented thickenings.

Kim, Hee-Jung, Modifying surfaces in 4-manifolds by twist spinning.

Varvak, Anna, Encoding properties of lattice paths.

Xin, Gouce, The ring of Malcev-Neumann series and the residue theorem.

Harvard University (28)

BIOSTATISTICS

Arroyo, Cassandra, High dimensional data analysis with applications to diabetes prevention and physical activity data.

Ding, Beiying, Analysis of high dimensional data: Classification, measurement error model and graph based association measures, with application to microarray data.

O'Brien, Liam, Methods for the analysis longitudinal multiple source data and multiple predictor data.

Park, Yuhyun, Semiparametric statistical inference in survival analysis.

Retina Rabbee, Nusrat, Power studies: I. Power and sample size for ordered categorical data. II. Power calculations for familial aggregation studies. III. Power calculations for selective genotyping in QTL mapping in backcrosses.

Roberts, Kevin, Latent predictor models with applications to asthma.

Scholtens, Denise, Studies in multidimensional data: Estimation of the bivariate survival curve, analysis of factorial designed microarray experiments, identification of protein complex membership.

Wilkins, Kenneth, Marginally-specified conditional models for longitudinal outcomes with possibly non-ignorable nonresponse.

Zhao, Yihua (Mary), General design Bayesian generalized linear mixed models with applications to spatial statistics.

ENGINEERING AND APPLIED SCIENCES

Ashmore, Jacqueline, Free-surface and coating flows.

Cettei, Kim, Code cache management in dynamic optimization systems.

Ellard, Daniel, Trace-based analyses and optimizations for network storage servers.

Fischer, Robert, Web applications with client-side storage.

Mansouri, Abdol, Sub-elliptic diffusions, geometry, and control.

Rauenbusch, Timothy, Measuring information transmission for team decision making.

Schechter, Stuart, Computer security strength and risk: A quantitative approach.

Sullivan, David, Using probabilistic reasoning to automatic software tuning.

Valente, Andre, Symmetries and geometrical ansätze in dynamical systems: Hybrid dynamics, control with moving averages, microflows, and network robustness problem.

MATHEMATICS

Coskun, Izzet, Degenerations of scrolls and Del Pezzo surfaces and applications to enumerative geometry.

Dumas, David, Complex projective structures, grafting, and Teichmuller theory.

Manolescu, Ciprian, A spectrum valued TQFT from the Seiberg-Witten equations.

Marian, Alina, Intersection theory on the moduli space of stable bundles via morphism spaces.

Mirzakhani, Maryam, Simple geodesics on hyperbolic surfaces and volume of the moduli space of curves.

Plamenevskaya, Olga, Contact structures and Floer homology.

Ramsey, Nicholas, Geometric and p-adic modular forms of half-integral weight.

Rauch, Daniel, Perturbations of the d-bar operator.

Rogers, Nicholas, Elliptic curves $x^3+y^3=k$ with high rank.

Yang, Stephanie, Special linear series in p^2.

Massachusetts Institute of Technology (24)

MATHEMATICS

Blanchette, François, Sedimentation in a stratified ambient.

Bozin, Vladimir, Geometry of Ricci flat Kähler manifolds and some counterexamples.

Clifford, Peter, Algebraic and combinatorial properties of minimal border strip tableaux.

Costeanu, Viorel, On the 2-typical deRham-Witt complex.

Early, Edward, Chain and antichain enumeration in posets, and b-ary partitions.

Elizalde, Sergi, Statistics on pattern-avoiding permutations.

Ganter, Nora, Orbifold genera, product formulas and power operations.

Hou, Zuoliang, Local complex singularity exponents for isolated singularities.

Korn, Michael, Geometric and algebraic properties of polyomino tilings.

Latour, Frédéric, Representations of Cherednik algebras in positive characteristic.

Lieblich, Max, Moduli of twisted sheaves and generalized Azumaya algebras.

Luo, Wei, On contact homology of the unit cotangent bundle of a Riemann surface with genus greater than one.

Lurie, Jacob, Derived algebraic geometry.

Mahdian, Mohammad, Facility location and analysis of algorithms through factor-revealing programs.

Osserman, Brian, Limit linear series in positive characteristic and Frobenius-unstable vector bundles on curves.

Popescu, Ionel, Morse inequalities, a probabilistic approach.

Radoicic, Rados, Extremal problems in combinatorial geometry and Ramsey theory.

Ragharsson, Kári, Frobenius transfers and p-local finite groups.

Rassart, Etienne, Geometric approaches to computing Kostka numbers and Littlewood-Richardson coefficients.

Sankar, Arvind, Smoothed analysis of Gaussian elimination.

Šešum, Nataša, Limiting behaviour of Ricci flows.

Usher, Michael, Relative Hilbert scheme methods in pseudoholomorphic geometry.

Wang, Lijing, Bergman kernel and stability of holomorphic vector bundles with sections.

Yee, Wai Ling, On the signature of the Shapovalov form.

Northeastern University (6)

MATHEMATICS

Dubrovskiy, Stanislav, Differential invariants of geometric structures.

Keng, Shengli, The geometry of G_2 manifolds.

Kreiman, Victor, Monomial bases and applications for Richardson and Schubert varieties in ordinary and affine Grassmannians.

Scott, Joshua, Grassmannians and cluster algebras.

Silantyev, Valentin, Kirchhoff and Riabouchinsky models with semipermeable obstacles.

Wang, Erxiao, Submanifold geometries and integrable systems.

Tufts University (2)

MATHEMATICS

Cowan, John David, A billiard model of a gas of rigid particles.

Pedroza, Andres, Cohomology and localisation formulas.

University of Massachusetts, Amherst (2)

MATHEMATICS AND STATISTICS

Garibotti, Gilda, Estimation of the stationary distribution of Markov chains.

Otto, Peter, Study of equilibrium macrostates for two models in statistical mechanics.

MICHIGAN

Central Michigan University (2)

MATHEMATICS

Maynard, Jacinth, A class of beta-exponential distributions: Properties, estimation and applications.

Sadir, Dawn, Circular symmetry of spectra of composition operators.

Michigan State University (10)

MATHEMATICS

Cheng, Szu-En, Generating function proofs of identities and congruences.

Cheng, Wen-Chiao, Relations among conditional entropy, topological entropy and pointwise preimage entropy.

Furaidan, Monther Rashed, Imprimitive distance-transitive graphs.

Kwon, Seongchun, Real aspects of the moduli space of stable maps of genus zero curves.

Morgan, Charles, Decay of correlations for piecewise smooth mappings with unbounded distortion.

Redett, David, Invariant vector subspaces of L^p with applications.

Saldivia, Luis, Topological transitivity of bounded linear operators.

Sword, Sarah, Intermediate domains between a local ring and its completion: Conditions for normality and factoriality.

STATISTICS AND PROBABILITY

Li, Fang, Testing for the equality of two autoregressive and regression functions.

Stepanov, Alexey G., Optimal control of dynamical systems with jump Markov perturbations.

Michigan Technological University (2)

MATHEMATICAL SCIENCES

Nickolov, Radoslav, Association tests for candidate genes based on Gibbs random field models.

Sarami, Chekad, Topics in coding theory and combinatorial structures.

Oakland University (2)

MATHEMATICS AND STATISTICS

Ghosh, Pulak, A Bayesian approach to bioequivalence trials.

Kikas, Lazaros, Interconnection networks and the k-disjoint paths problem.

University of Michigan, Ann Arbor (31)

BIOSTATISTICS

Carlson, Nichole, A bivariate model of two pulsatile hormones: A Bayesian approach.

Feng, Shibao, Relative risk model analysis of multivariate survival data.

Hayasaka, Satoru, Validating and improving cluster size influence in brain image analysis.

Hsu, Chiu-Hsieh, Survival analysis via nonparametric multiple imputation.

Huang, Chiang-Ching, Markov model for defining genomic changes using gene expression profiling.

Isaman, Deanna, Use of indirect transition estimates in discrete-state multiple-stage models.

Li, Yisheng, Bayesian inference in generalized additive mixed models.

Liu, Fang, Bayesian methods for statistical disclosure control in microdata.

Patil, Sujata, Latent trajectory models for longitudinal data: A Bayesian approach.

Wang, Yue, Statistical methods utilizing biomarkers in clinical trials and screening studies.

Yu, Jian, Prosper function analysis for organ allocation, a counting process and Martingale approach.

Yu, Menggang, Joint longitudinal-survival-cure model with application in prostate cancer studies.

MATHEMATICS

Aubrey, Jason, Pseudo-dominating families of functions.

Elitzur, Haggai, Tight closure in Artinian modules.

Hitchman, Theron J., Rigidity theorems for large dynamical systems with hyperbolic behavior.

Johnson, Amanda, Multiplier ideals of detrimental ideals.

Jupiter, Daniel, Envelopes of holomorphy and approximation theorems.

Klodginski, Elizabeth, Essential surfaces in fibered 3-manifolds.

Kravitz, Scott, The homology of a filtered Boolean algebra.

Lawes, Elliot, Motivic integration and the regular Shalika germ.

Papikian, Mihran, Optimal elliptic curves, discriminants, and the degree conjecture over function fields.

Slapar, Marko, Real surfaces in complex surfaces.

Storm, Peter, The barycenter method on singular spaces.

Walker, Ronald, Concerning characterizations of boundaries of holomorphic i-chains within complex surfaces.

Westerland, Craig, Stable splittings of configuration spaces of surfaces and related mapping spaces.

Yong, Alexander, On combinatorics or degeneracy loci and $H(G/B)$.

STATISTICS

Choe, Jee-Weon, Bayesian optimality criteria for supersaturated designs.

Gopikrishnan, Ajita, Reliability inference based on time-to-failure and degradation data: Some models, methods and efficiency comparisons.

Kim, Dong-Yun, Sequential test and change point problems with staggered entry.

Mease, David, Contributions to engineering statistics: X-testing for reliability and optimal partitioning strategies.

Shin, Yong-Yun, Inference and applications in hierarchical linear models with missing data.

Wayne State University (4)

MATHEMATICS

Crachiola, Anthony, On the AK invariant of certain domains.

Naga, Ahmed, On recovery type a posteriori error estimators in adaptive C^0 Galerkin finite element methods.

Shvartsman, Ilya, Discrete approximations and minimax synthesis in dynamic optimization.

Wang, Lianwen, Optimal control of hereditary differential inclusions.

Western Michigan University (1)

MATHEMATICS

Weinhold, Marcia, How secondary school mathematics teachers construct an understanding of "appropriate use" of graphing calculators in the context of collegial inquiry.

MINNESOTA

University of Minnesota, Twin Cities (10)

BIOSTATISTICS

Guo, Xu, On Kay and Little's approach to logistic regression model and some new results.

Short, Margaret, Topics in hierarchical spatial models: Covariate-adjusted spatial and spatio-temporal CDF modelling.

Zhao, Yanli, Interim monitoring of randomized clinical trials with multiple endpoints.

MATHEMATICS

Kim, Kyeong-Hun, On stochastic partial differential equations with variable coefficients in C^1 domains.

Lee, Jae-Hyouk, Geometrics motivated from normed algebras.

Lee, Kijung, L_p theory of stochastic partial differential systems.

Rademacher, Jens, A mechanism for periodic secondary wave bifurcation of pulses in reaction-diffusion systems.

STATISTICS

Barnes, Katherine, Bayesian inference in spatial clustering models of crime data.

Sung, Yun Ju, Likelihood inference for mutation accumulation experiments.

Zamba, Kokou (Gideon), Some issues in SPC: Change-point problems.

MISSISSIPPI

Mississippi State University (1)

MATHEMATICS AND STATISTICS

Liao, Wenyuan, Efficient higher order algorithms for solving reaction-diffusion equations.

University of Mississippi (1)

MATHEMATICS

Welch, Amy, Tychonoff's theorem and the metric topology of path spaces.

MISSOURI

University of Missouri, Columbia (4)

MATHEMATICS

Duda, Jakub, Aspects of delta-convexivity.

Portal, Pierre, Harmonic analysis of Banach space valued functions in the study of parabolic evolution equations.

STATISTICS

Lee, Suhwon, Nonparametric Bayesian density estimation and smoothing splines.

Xu, Ke (Bill), Efficient parameterization and estimation of spatio-temporal dynamic models.

University of Missouri, Rolla (1)

MATHEMATICS AND STATISTICS

Lathrom, Grant, Automorphism groups of resolvable incidence structures.

Washington University (9)

MATHEMATICS

Apfel, Lynn, Localization properties and boundary behavior of the Bergman kernel.

Draghici, Cristina, Polarization and rearrangement inequalities for multiple integrals.

Liu, Ningping, Statistical properties of maximum likelihood estimators for complete and censored data from mixed exponential and Weibull distributions.

Zhang, Jing, Threefolds with vanishing Hodge cohomology.

SYSTEMS SCIENCE AND MATHEMATICS

Albright, Brian, An embedded optimization-simulation approach to dynamic pickup and delivery problems.

Celani, Fabio, Omega-limit sets of nonlinear systems that are semiglobally practically stabilizable.

Lan, Chun Hua, Controllability of time dependent quantum control systems.

Liu, Ping, Appearance methods of solving recognition and estimation problems in robotics.

Polpitiya, Ashoka, Geometry and control of human eye movements.

MONTANA

Montana State University (1)

MATHEMATICAL SCIENCES

Griffiths, Roger, Return map characterization of singular solutions for a model of bursting with two slow variables.

University of Montana (2)

MATHEMATICAL SCIENCES

Bedros, Varoujan, An exploratory study of students' understanding of indirect proof.

Clouse, Chris, Greedoid invariant theory and the greedoid Tutte polynomial.

NEBRASKA

University of Nebraska, Lincoln (2)

MATHEMATICS

Hinrichs, Paul, Consumer expenditure estimation incorporating generalized variance functions in hierarchical Bayes models.

Lindblad, Steven, Inverse monoids presented by a single sparse relator.

NEW HAMPSHIRE

Dartmouth College (2)

MATHEMATICS

Clark, Lisa, Classifying the type of groupoid C^*-algebras.

Dryden, Emily, Geometric and spectral properties of compact Riemann orbisurfaces.

NEW JERSEY

New Jersey Institute of Technology (3)

MATHEMATICAL SCIENCES

Goullet, Arnaud, Mixing enhancement by dual speed rotating stirrer.

Picarelli, Michele, A Gibbs sampling approach to maximum a posteriori time delay and amplitude estimation.

Segin, Tetyana, Nonlinear long-wave interfacial stability of two-layer gas-liquid flow.

Princeton University (15)

APPLIED AND COMPUTATIONAL MATHEMATICS

Brown, Eric, Neural oscillators and integrators in the dynamics of decision tasks.

Liu, Di, Topics in the analysis and computation of stochastic differential equations.

Rickard, Scott, Time-frequency and time-scale representations of doubly spread channels.

Rudin, Cynthia, Boosting, margin and dynamics.

Worden, Lee, Evolution, constraint, cooperation, and community structure in simple models.

MATHEMATICS

Araujo, Carolina, The variety of tangents to rational curves.

Berger, Eli, Topological methods in matching theory.

Coskunuzer, Baris, Minimal surfaces and genuine lamination.

Eftekhary, Eaman, Holomorphic curves in topology and geometry.

Gonzalez, Maria Del Mar, Singular sets of a class of fully nonlinear equations in conformal geometry.

Keevash, Peter, The rôle of approximate structure in extremal combinatorics.

Ng, Ting Fai, Geometry of algebraic varieties.

Prasanna, Kartik, On a certain ratio of Petersson norms and level-lowering congruences.

Rodrigo, Jose Luis, On the evolution of sharp fronts for the surface quasi-geostrophic equation.

Rojas-Leon, Antonio, General estimates for exponential sums.

Rutgers University, New Brunswick (12)

MATHEMATICS

Biezuner, Rodney Josue, Best constants, optimal Sobolev inequalities on Riemannian manifolds and applications.

James, Taylor, Connections with Bohmian mechanics.

Kruczek, Klay, Tic-tac-toe and tumbleweeds.

Li, Aobing, On some conformally invariant fully nonlinear equations.

Li, Xiaoyong, Pinned constrained Brownian motion with application to bond pricing.

Mazza, Carlo, Schur functors and motives.

Radnell, David, Schiffer variation in Teichmuller space, determinant line bundles and modular functors.

Rosenthal, Malka, Extremal hypergraphs for certain forbidden traces.

Schutzer, Waldeck, On some combinatorial aspects of representation theory.

Taylor, Yuka, Quantum $6j$ symbols and a semiclassical invariant of three-manifolds.

Young, Matthew, Random matrix theory and families of elliptic curves.

Zhang, Lin, Vertex operator algebras and Kazhdan-Lusztig's tensor category.

NEW MEXICO

New Mexico State University (3)

MATHEMATICAL SCIENCES

Feng, Ding, Choquet weak convergence of capacity functionals and statistical inference with random sets.

Mehta, Parag, Actions of the complex additive group on affine spaces.

Oh, Hyunju, The universal Vassiliev invariant for the Lie superalgebra osp(1|2).

University of New Mexico (5)

MATHEMATICS AND STATISTICS

Brock, Guy, Analysis of gene regulatory networks using fuzzy logic and probabilistic models.

Kehowski, Walter, Hypernormal manifolds.

Liang, Hwa Ching, Diagnostic methods for accelerated failure time models.

Malloy, Elizabeth, Diagnostics for the scale of functional predictors.

Martinez, Derek, Greenberg transforms of singular varieties and maps.

NEW YORK

City University of New York, Graduate Center (9)

MATHEMATICS

Abbaspour, Hossein, On string topology of 3-manifold.

Brock, Martin, Conjugate reducibility of families of block-diagonal matrices over an extension field of a perfect field, and applications to matrix subalgebras and subgroups.

Khan, Bilal, The structure of automorphic conjugacy in the free group of rank two.

Kvaschuk, Alexei, One-variable equations in torsion-free hyperbolic groups.

Majewicz, Stephen, Nilpotent $\mathbb{Q}[x]$-powered groups and $\mathbb{Z}[x]$-groups.

Prado, Lucio, p-potential theory on graphs p-parabolicity and p-hyperbolicity.

Serbin, Denis, Infinite words and length functions.

Suzuki, Cristina, Rough isometries between non-compact Riemannian manifolds.

Wan, Aaron, The local theory of root numbers.

Clarkson University (1)

MATHEMATICS AND COMPUTER SCIENCE

Morawska, Barbara, Goal-directed E-unification-completeness, decidability and complexity.

Columbia University (13)

BIOSTATISTICS

Xie, Hui, An index of sensitivity to nonignorability: Extensions and applications.

Zawadzki, Rosita, A study of the performance of the truncated Levin Robbins sequential elimination procedure for choosing the best of three binomial populations.

MATHEMATICS

Cadman, Charles, Quantum cohomology of stacks and enumerative applications.

Casalaina-Martin, Sebastian, Singularities of the Prym theta divisor.

Sadykov, Marat, Two results in the arithmetic of Shimura curves.

Sampsa, Samila, Models of decision making in a social context.

Song, Jian, The Szegö kernel of an orbifold circle bundle and its application.

Thillainatesan, Meera, A kernel for automorphic L-functions on $GL(n, R)$.

Weinkove, Benjamin, The J-flow, the Mabuchi energy, the Yang-Mills flow and multiplier ideal sheaves.

STATISTICS

Feng, Xin, Functioning in computerized adaptive testing.

Huang, Zaiying, Bayesian computation for multilevel models: Some new methods with applications.

Liu, Mongling, Semiparametric analysis on longitudinal data in the presence of information censoring.

Pasarica, Cristian, Topics in statistics and probability.

Cornell University (18)

APPLIED MATHEMATICS

Casey, Richard, Periodic orbits in neural models: Sensitivity analysis and algorithms for parameter estimates.

Cetin, Umut, Default risk and liquidity risk modeling.

Diaz, Aaron, Topics in hybrid systems.

Mehta, Prashant, Nonbifurcating solutions for parallel flows.

Patron, Maria-Cristina, Risk measures and optimal strategies for discrete hedging.

Tomita, Tiberiu, Applications of stochastic calculus and partial differential equations in financial economics.

BIOMETRICS

Briggs, William Matthew, Assessing the value of yes/no forecasts.

Crainiceanu, Ciprian, Nonparametric likelihood testing.

El Sheneity, Sahar, Alternative methods to the maximum likelihood in the logistic discrimination model.

Joo, Yongsung, Evaluation of model selection criteria in log spline models.

Madsen, Lisa, Regression with spatially misaligned data.

Zhang, Dabao, Bayesian inference for differential gene expression data.

MATHEMATICS

Best, Janet, The mathematics of ecological competition.

Horak, Matthew, Mapping class subgroups of outer automorphism groups.

Hsiao, Samuel, Quasisymmetric functions and combinatorial enumerations in spheres.

Marques, Fernando, Existence and compactness theorems on conformal deformation of metrics.

Schuller, Rebecca, A theory of multitask learning for learning from disparate data sources.

Walker, Shawn, Shift techniques and multicover inequalities on colored complexes.

Courant Institute, New York University (22)

MATHEMATICAL SCIENCES

Atzberger, Paul, Stochastic modeling of the kinesin motor protein.

Cherepinsky, Vera, On mathematical aspects of genomic analysis.

de Aranjo, Thelmo, Effects of upward propagating gravity waves or the mean state of the atmosphere.

Demers, Mark, Markov extensions and natural conditionally invariant measures for dynamical systems with holes.

Forger, Daniel, Deterministic and stochastic mathematical modeling and computer simulation of the mammalian intracellular circadian clock.

Friz, Peter, Rough path theory and applications to stochastic analysis.

Goldfeld, Paulo, Balancing Neumann-Neumann preconditions for the mixed formulation of almost-incompressible linear elasticity.

Herbert, Robert, Codimension two piecewise linear immersion of complex projection space.

Iwasawa, Kazuhiro, Fast relevant simulation in finance.

Jiang, Huiqiang, Free boundary problems with volume constraints: Zero set of Sobolev functions.

Judice, Pedro, Dynamic asset pricing via conic duality.

Kim, Yongsam, The penalty immersed boundary method and its application to aerodynamics.

Lim, Ju Young, Pricing and hedging index options.

Loubet, Enrique, Genesis and extinction of solitons arising from individual flows of the Camassa-Holm hierarchy: The rise of a novel Darboux-like transform.

Miller, Laura, A computational study of flight in the smallest insects.

Mogultay, Itir, Modeling the atmospheric mixed layer.

Perez, Josi Antonio, Convergence of numerical schemes in the total variation sense.

Pignol, Ricardo, Energy transfer in systems with random forcing and nonlinear dissipation.

Plaza-Villegas, Ramon, On the stability of shock profiles.

Podesta, John, Some results concerning the MHD boundary conditions on the base of the solar corona.

Reznikoff, Maria, Rare events in finite and infinite dimensions.

Slastikov, Valeriy, Topics in micromagnetics.

Rensselaer Polytechnic Institute (5)

MATHEMATICAL SCIENCES

Basescu, Vasile, An analytic center cutting plane method in conic programming.

Bi, Jinbo, Support vector regression with applications in automated drug recovery.

Frank, Scott, Modeling nonlinear internal wave effects on broadband shallow water acoustics.

Outing, Donald, Parabolic equation methods for range dependent layered elastic media.

Renzi, Daniel, Interior elastodynamics inverse problems: Shear wave speed recovery in transient elastography using level set based inversion of arrival time.

State University of New York, Albany (3)

MATHEMATICS AND STATISTICS

Featherstonhaugh, Stephen, Abelian Hopf Galois structures on Galois field extensions of prime power order.

Kelley, Amy, Blaschke products, inner functions with finite spectrum and operators similar to a contraction.

Olsen, Darlene, The spectrum of Zd-actions in ergodic theory.

State University of New York, Binghamton (4)

MATHEMATICAL SCIENCES

Brown, Marlo, Detection of change-points in categorical data.

Donnelly, John, Properties of Richard Thompson's group F related to amenability.

Koban, Nicholas, Controlled topology invariants of translation actions.

Wang, Xueqin, The properties of the Theil-Sen estimator.

State University of New York, Buffalo (4)

MATHEMATICS

Chae, Hyungjik, Some results concerning polarized partition relations.

Chen, Qi, Integral TQFTs and periodic 3-manifolds.

Chen, Shr-jing, On nonlinear stability of spherically symmetric model of stellar dynamics under spherically symmetric perturbations.

Lo, Min-lin, Bargmann transform and windowed Fourier localization.

State University of New York, Stony Brook (15)

APPLIED MATHEMATICS AND STATISTICS

Baek, Songjoon, Variable selection for heteroscedastic data.

George, Erwin, A numerical study of Rayleigh-Taylor instability.

Greenwald, Lorraine, Performance of simulating annealing with generalized move generation.

Hsiang, Tien-Ruey, Geometric algorithms for controlling and analyzing swarms of robots and groups of aircraft.

Ji, Fei, Linkage analysis of a disease related trait using a pleiotropic analysis.
Kang, Sun Jung, Effects of errors in specification of genotypes of single nucleotide polymorphisms.
Oh, Cheongeun, Robust Bayesian variable selection.
Panini, Radha, Option pricing with Merlin transforms.
Sztainberg, Marcello, Algorithms for swarm robotics.
Wang, Xuena, Pattern detection and discrimination in MS based proteomic analysis.
Weaver, Christina, Effects of errors in specification of genotypes of single nucleotide polymorphism on the 2×3 test of independence.
Yoo, Yun Joo, Power study of likelihood based linkage statistics.

MATHEMATICS

Behrstock, Jason, Asymptotic geometry of the mapping class group and Teichmuller space.
Craig, Gordon, Dehn filling and asymptotically hyperbolic Einstein manifolds.
Panafidin, Sergei, Nevanlinna theory and Plucker identities.

Syracuse University (4)

MATHEMATICS

John, Thomas, Selection procedures for lognormal populations.
Lee, Travis, An extension of the Thom-Porteous formula to a certain class of coherent sheaves.
Subramanian, Uma, Biting convergence of null-Lagrangians.
Zangor, Roxana, Numerical methods for smooth, detectable image perturbations.

University of Rochester (4)

MATHEMATICS

Felea, Raluca, Composition of Fourier integral operators with fold and blow down singularities.
Mustafaev, Zokhrab, Some geometric inequalities in Minkowski spaces.
Voloshina, Maria, On the holomorph of a discrete group.
Zhang, Yilian, The one dimensional inverse problem and new integrable dynamical systems.

NORTH CAROLINA

Duke University (8)

MATHEMATICS

Barnes, Andrew, Electromagnetic scattering by three-dimensional periodic structures.
Benes, Christian, On some problems concerning planar random walks.
Greer, John, Fourth order diffusions for image processing.
Hale, Christopher, On calculations of leaky modes in photonic crystals.
Karp, Robert, D-branes on Calabi-Yau manifolds and II-stability in the derived category.
Kesseler, Kevin, Analysis of feedback-mediated dynamics in two coupled nephrons.
Kozdron, Michael, Simple random walk excursion measure in the plane.

STATISTICS AND DECISION SCIENCES

Molina, German, Bayesian stochastic computation, with application to model selection and inverse problems.

North Carolina State University, Raleigh (31)

MATHEMATICS

Al-Ashhab, Samer, The role of sh-Lie algebras in Lagrangian field theory.
Attiogbe, Cyril, On characterizing nilpotent Lie algebras by their multipliers.
Chen, Guo, Immersed interface method for the biharmonic equation on irregular domain and its applications.
Daily, Marilyn, L-structures on spaces of low dimension.
Dometrius, Christopher, Relationship between symmetric and skew-symmetric bilinear forms and involutions on $\mathrm{SL}(N, K)$ and $\mathrm{SO}(N, K, b)$.
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Gauvin, Jennifer, Stepwise hypothesis testing with applications in pharmaceutical responses.
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McIntyre, Julie, Density deconvolution with replicate measurements and auxiliary data.
Morris, Richard, Likelihood ratio tests for association with multiple disease susceptibility alleles genotyping errors or missing parental data.
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Tang, Yongqiang, Dirichlet process mixture models for Markov processes.
Thompson, Denis, Finding homologous genes with primers designed using evolutionary models.
Wahed, Abdus, Efficient estimation of the survival distribution and related quantities of treatment policies in two-stage randomization designs in clinical trails.
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Wu, Weiwei, Estimating value at risk and the expected shortfall for heteroscedastic financial log returns: A two-stage method.

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BIOSTATISTICS

Condon, Sean, Spatial analysis of birthweight and infant mortality.
Hu, Jianhua, Identifying differentially expressed genes, computing gene expression indexes and sample size in microarray experiments.
Lee, Ji-Hyun, Practical issues arising in clustered data: Modified GEE and goodness-of-fit test.
Leu, Szu-Yun, Non-homogeneous Poisson process models for genetic crossover interference.
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Wang, Xiaofei, Semiparametric methods for biased sampling schemes in epidemiologic studies with auxiliary covariates.

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Zink, Richard, Correlated binary regression using orthogonalized residuals.

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DeCoste, Rachelle, Density of closed geodesics in a compact nilmanifold with Chevalley rational structure.

Lau, Stephen, Rapid evaluation of radiation boundary kernels for time-domain wave propagation on blackholes.

Stevens, Laura, KZ type equations, elliptic hypergeometric functions and elliptic Selberg integrals.

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NORTH DAKOTA

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MATHEMATICS

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MATHEMATICS AND STATISTICS

Sanqui, Jose (Joel), Characterization and statistical inference for the skew-normal distribution.

Case Western Reserve University (3)

STATISTICS

Charnigo, Richard, Testing homogeneity in finite mixtures and semi-local paradigm for wavelet denoising.

Ganocy, Steve, Estimation of problems from data with change points.

Wang, Bin, Estimation problems from biased sampling.

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MATHEMATICAL SCIENCES

Ghaim, Berhane, On the geometry of Banach space operators.

Kim, Sun-mi, Orthogonal polynomials, quadrature rules and linear algebra.

Shuibi, Abdallah, Numerical methods for large-scale ill-posed problems.

Sprague, Emily, Uniform integrability and related topics.

Ohio State University (16)

MATHEMATICS

Argesanu, George, Risk analysis and hedging in incomplete markets.

Boros, Dan, On L (squared)-homology of low dimensional buildings.

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Iancu, Aniela Karina, Numerical methods for pricing basket options.

Lladser, Manuel, Asymptotic enumeration via singularity analysis.

Malyushitsky, Sergey, On Sylow 2-subgroups of finite simple groups of order up to 210.

Mendris, Robert, The link of suspension singularities and Zariski's conjecture.

Ott, Michael, Symplectic convexity theorems and applications to the structure theory of semisimple Lie groups.

Wang, Chian-Jen, On the existence of cuspidal distinguished representations of metaplectic groups.

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MATHEMATICS

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Voisei, Mircea, First-order necessary optimality conditions for nonlinear optimal control.

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MATHEMATICAL SCIENCES

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Yu, Weiming, Identification of coefficients in reaction-diffusion equations.

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MATHEMATICS

Cox, Jonathan, A presentation for the Chow ring $A^*(\overline{M}_{0,2}(p^1, 2))$.

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MATHEMATICS

White, Jonathan, Using technology to facilitate visualization in multivariable calculus.

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STATISTICS

Amer, Safaa, Neural network imputation: A new fashion or a good tool.

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MATHEMATICS AND STATISTICS

Blair, Steve, Describing undergraduates' reasoning within and across Euclidean, taxicab, and spherical geometries.

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Geer, Nathan, Link invariants, quantized superalgebras and the Kontsevich integral.

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Bocea, Marian, A Young measure approach to nonlinear membrane theory.

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Trapp, Kathryn, A class of compatible discretizations with applications to div-curl systems.

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Kheyfets, Boris, Some stochastic properties of random classical and Carlitz compositions.

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Shimkus, Beth, Limit theory for functionals on random bipartite sets.

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Talitskaya, Anna, Partially hyperbolic phenomena in dynamical systems with discrete and continuous time.

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Tan, Hensiong, Variance estimation with astronomical measurement errors.

Wang, Jiping, NPMLE in estimating the number of expressed genes using EST data while accounting for measurement error.

Wang, Lan, Testing in heteroscedastic ANOVA with large number of levels and in nonparametric ANCOVA.

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MATHEMATICS

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Yayenie, Omer, Hyperbolic convexity of a standard fundamental domain of a subgroup of the Hecke discrete groups.

University of Pennsylvania (14)

MATHEMATICS

Aker, Kursat, Higgs bundles on Del Pezzo fibrations.

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Khalid, Madeeha, $K3$ correspondences.

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Shen, Junhao, Free probability, free entropy and generator problems for von Neumann algebras.

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STATISTICS

Levins, Mihails, Variance estimation for nonparametric regression and its applications.

Li, Xuefeng, Infinitely divisible time series models.

Liu, Linxu, Semi-parametric and nonparametric models for survival data.

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Marsh, Andrew, Topology of function spaces.

Sahin, Niyazi, Derivation, analysis and testing of new near wall models for large eddy simulation.

Wisloski, Gregory, Some characterizations of generalized metric spaces using the diagonal.

STATISTICS

Auh, Sungyoung, Isotonic logistic discrimination.

Koyama, Tatsuki, A framework for design of two-state adaptive procedure.

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Yothers, Gregory, Methodologies for identifying subsets of the population where two treatments differ.

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APPLIED MATHEMATICS

Amarasingham, Asohan, Statistical methods for the assessment of temporal structure in the activity of the nervous system.

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Li, Fengyan, On locally divergence-free discontinuous Galerkin methods.

Liu, Dong, Spectral element/force coupling method: Application to colloidal devices and self-assembled structures in 3D domains.

Lucor, Didier, Generalized polynomial chaos: Applications to random oscillators and flow-structure interactions.

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Xiu, Dongbin, Generalized (Wiener-Askey) polynomial chaos.

MATHEMATICS

Christoforou, Cleopatra, Hyperbolic systems of balance laws via vanishing viscosity.

Horozov, Ivan, Euler characteristics of arithmetic groups.

Karageorgis, Paschalis, Nonlinear waves with sign-changing potentials.

Leonard, Kathryn, Measuring shape space: ε-entropy, adaptive coding and two-dimensional shape.

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MATHEMATICS

Clark, Cathy Ann, Global behavior of nonlinear difference equations and systems.

Travers, Brian, Generalized whist tournaments and generalized whist frames.

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MATHEMATICAL SCIENCES

Farr, Jeffrey, Computing Gröbner bases, with applications to Padé approximation and algebraic coding theory.

Gorka, Artur, The random multi-directional method of feasible directions.

Ntasin, Louis, A posteriori error estimation and adaptive computation of viscoelastic fluid flow.

Rodrigues, Virginia, Multivariate polynomials: Irreducibility and Gröbner bases.

Waters, Lawrence, A parallel implementation of the Glowinski-Pironneau algorithm for the modified Stokes problem.

Medical University of South Carolina (2)

BIOMETRY AND EPIDEMIOLOGY

Khedouri, Christopher, Use of global tests for multiple outcomes with applications in psychiatry.

Sadler, Zara, An approach to estimating relative goodness of fit with application to the diagnostic interview schedule for selected ethnic groups in the US.

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MATHEMATICS

Park, Kyungwon, Bivariate rational approximation and anisotropic Franklin bases.

Ryan, Pamela, Hardy-Sobolev spaces and Banach algebras on the unit ball of $C^{(n)}$.

STATISTICS

Bhargava, Parul, Confidence bound comparing two regression lines with control regression line.

Nitcheva, Daniela, Multiple comparisons in low-dose risk assessment with quantal response data.

Tomlinson, Meredith, Inference for accelerated test models based on failures or degradation data from cumulative damage processes.

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University of Memphis (4)

MATHEMATICAL SCIENCES

Cutler, Jonathan, Extremal and algebraic graph theory.

Hubenko, Alice, Cliques, strong packing and cycle covers.

Kombe, Ismail, Linear and nonlinear parabolic partial differential equations with singular lower order term.

Liang, Yulan, Gene expression temporal patterns classification with hierarchical Bayesian neural networks and time lagged recurrent neural networks.

University of Tennessee (4)

MATHEMATICS

Battle, Laurie, Eigenvalue dependence on problem: Parameters for Stieltjes Sturm-Liouville problems.

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Salinas, René, Modeling the effects of alternative harvesting strategies on the black bear population of the southern Appalachians.

Smith, Neal, Graph-theoretic properties of the zero-divisor graph of a ring.

Vanderbilt University (3)

MATHEMATICS

Alewine, John Alan, An inductive unit topology on the Denjoy space.

Jennings, Dana Lynn Gaston, Separating cycles in triangulations of the double torus.

Stephens, David Christopher, The nonorientable genus of the complete tripartite graph.

TEXAS

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MATHEMATICS

Singh, Parmjeet, Existence of positive solutions to singular boundary value problems.

STATISTICAL SCIENCE

Boese, Doyle, Likelihood-based confidence intervals for proportion parameters with binary data subject to misclassification.

Elsalloukh, Hassan, The epsilon-skew-exponential power distribution.

Guardiola, Jose, The semicircular normal distribution.

Maddox, Amy, Regression effect models.

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Rice University (11)

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Husband, Christopher, Stochastic optimization applications in molecular electronics.

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Gwosdz-Gee, Carol, Strong S-equivalence of ordered links.

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Swartz, Michael, Stochastic search gene suggestion: Hierarchical Bayesian model selection meets gene mapping.

Southern Methodist University (5)

MATHEMATICS

Li, Baoyan, A control volume function approximation method and reservoir simulation with flexible grids.

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Cohlmia, Krista, Filtering M-stationary processes.

Jiang, Huiping, Time-frequency analysis Q(lambda) stationary process.

Shen, Shuyi, Minimum L_2 estimation for Poisson mixtures.

Spence, Jeffrey, A spatial analysis of SPECT brain imaging data: Optimal predictions in regions of interest.

Texas A&M University (15)

MATHEMATICS

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STATISTICS

Boucher, Thomas, V-uniform ergodicity of threshold autoregressive nonlinear time series.

Guan, Yongtao, Nonparametric methods of assessing spatial isotropy.

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Lee, Kyeong Eun, Bayesian models for DNA microarray data analysis.

Lee, Sang-Joon, Asymptotics and computations for approximation of method of regularization estimators.

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Zhao, Caixia, One-sided cross-validation for a model motivated by variable star data.

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MATHEMATICS AND STATISTICS

Emmert, Keith, Deterministic and stochastic discrete-time epidemic models with applications to amphibians.

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Lee, Seung-Hwan, Checking the censored two-sample accelerated life model using integrated cumulative hazard difference.

Navaratna, Channa, Estimation of the origin of contaminent particles using point measurements in a fluid flow.

Omolo, Bernard, Aligned rank test for repeated observation models with orthonormal design.

Perera, Pantaleon, Asymptotic feedback controllability and topological structure of controllable linear switched systems.

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MATHEMATICS

Ahmed-Zaid, Abdelnour, Boundary stabilization of wave equation type models: A numerical approach.

Holmes, Roderick, Optimal frames.

Kaneda, Masayoshi, Multipliers and algebraizations of operator spaces.

Yi, Eunjeong, Nevanlinna theory and iteration of rational maps.

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MATHEMATICS

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Boykin, Charles, The study of translation equivalence on integer lattices.

Ghenciu, Ioana, Spaces of compact operators.

Muller, Kimberly, Polish spaces and analytic sets.

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MATHEMATICS

Kadjo, Hilaire, Age structured population model: Interaction between nutrients and phytoplankton.

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Nguyen, Vinh, Regression model with explanatory variable subject to asymmetric measurement errors.

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University of Texas, Austin (7)

COMPUTATIONAL AND APPLIED MATHEMATICS

Aizinger, Vadym, A discontinuous Galerkin method for two and three-dimensional shallow-water equations.

Carnes, Brian Ross, Adaptive finite elements for nonlinear transport equations.

Pardo, David, Integration of hp-adaptivity with a two grid solver: Applications to electromagnetics.

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MATHEMATICS

Goodman, Noah, Contact structures and open books.

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Petsche, Clayton, The distribution of Galois orbits of low heights.

University of Texas, Dallas (3)

MATHEMATICAL SCIENCES

Schmegner, Claudia, Decision theoretic results for sequentially planned procedures.

Seida, David Lee, Estimation of attitude parameters from variation in image overlap.

Wang, Jin, On nonparametric multivariate scale, kurtosis, and tailweight measures.

UTAH

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MATHEMATICS

Guy, Robert, A continuum model of platelet aggregation: Closure, computational methods and simulation.

Kohler, Brynja, T-lymphocyte population dynamics in health and auto immunity.

Lukic, Denis, Twisted Harish-Chandra sheaves and Whittaker modules.

Piepmeyer, Gregory, Constructing perfect complexes with given intersection properties.

Robbins, Thomas, Seed dispersal and biological invasion: A mathematical analysis.

Utah State University (2)

MATHEMATICS AND STATISTICS

Biesecker, Matthew, Geometric studies in hyperbolic systems in the plane.

Zhu, Zewen, Optimal experimental designs with correlated observations.

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MATHEMATICS, APPLIED SCIENCE

Milligan, Thomas, On certain sets of matrices: Euclidean squared distance matrices, ray-nonsingular matrices, and matrices generated by reflections.

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MATHEMATICS AND STATISTICS

Feldman, Gary, A forward-backward fluence model for the low-energy neutron Boltzmann equation.

Novaprateep, Boriboon, Superconvergence of iterated solutions for linear and nonlinear integral equations: Wavelet applications.

Plungpongpun, Kusaya, Analysis of multivariate data using Kotz type distribution.

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Bhattacharya, Chirashree, Free groups and their automorphisms.

Carley, Holly, The strong-coupling limit for the ground state of a particle harmonic oscillator interaction.

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Tomita, Yuji, On properties of multivariate mixture vector autoregressive models.

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Campbell, Leanne, Futility analysis with covariables.

Eckel, Jeanette, Statistical analyses of time-course and dose-response microarray experiments.

Hamm, Adam, Analysis of an interaction threshold in drug/chemical mixtures.

Massie, Tammy, Testing genetic hypothesis on bivariate dichotomous twin data using repeated measures logistic regression.

Rutledge, Brandy, A comparison of twin methods when the liability is non-normal.

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Buterakos, Lewis, The exit time distribution for small random perturbations of dynamical systems with a repulsive type stationary point.

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Kim, Keun Pyo, Process monitoring with multivariate data: Varying sample sizes and linear profiles.

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MATHEMATICS

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Wang, Yi, Fast wavelet collocation methods for second kind integral equations on polygons.

Xu, Rui, On flows of graphs.

Zhan, Mingquan, Eulerian subgraphs and Hamiltonicity of claw-free graphs.

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MATHEMATICS, STATISTICS AND COMPUTER SCIENCE

Oliveira, Luis, Varieties of pseudosemilattices.

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BIOSTATISTICS

Bajorunaite, Ruta, Comparison of failure probabilities in the presence of competing risks.

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Chakrabarti, Manish, Representations of modular and quantum Weyl algebras and of generalized Heisenberg algebras.

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Lau, Michael, Fock representations and central extensions.

Lee, Youngsuk, Anisotropic energy transfer in beta-plane and rotating flows.

Ondrus, Matthew, Whittaker modules, central characters, and tensor products for quantum enveloping algebras.

Thiem, F. Nathaniel, Unipotent Hecke algebras: The structure, representations, and combinatorics.

Unlu, Ozgun, Constructions of free group actions on products of spheres.

Velikina, Julia, Twisting transform and replicable functions.

STATISTICS

Ahn, Hongyup, Restricted likelihood ratio tests for fixed effects in mixed effects models.

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Leng, Chenlei, Some problems in model selection.

Li, Liang, Modeling the measurement error of apnea-hypopnea index.

Li, Ruojia, Some new multivariate quality monitoring procedures.

Ma, Shuangge, Penalized M-estimation for partly linear transformation models with current status data.

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Yuan, Ming, Automatic smoothing and variable selection via regularization.

PMET PREPARING MATHEMATICIANS TO EDUCATE TEACHERS

A growing set of national reports calls for better preparation of the nation's mathematics teachers by mathematics faculty. The Mathematical Association of America has developed a multifaceted program, Preparing Mathematicians to Educate Teachers (PMET) to help meet this need. During the spring and summer 2005, PMET will offer eight new workshops for college and university faculty who teach mathematics courses taken by prospective teachers. Each workshop will focus on preparing teachers for elementary, middle and/or secondary school mathematics. Participants will examine how pre-service teachers learn mathematics; make sense of mathematical ideas, and how they integrate their knowledge of mathematics into their thinking about teaching. Participants will also have opportunities to share ideas, discuss, and learn more about appropriate content and effective ways of helping pre-service teachers learn mathematics. They will explore specific topics including the use of technology and statistics education in school mathematics. Costs of lodging and food while at the workshops are covered by the program. Questions regarding the PMET workshops may be addressed to Ed Dubinsky at edd@math.kent.edu

Additional details, workshop descriptions and application materials are available at the PMET website

http://www.maa.org/PMET.

A PMET workshop is an opportunity to explore ways of improving the mathematical background and pedagogical practice of future teachers.

AMERICAN MATHEMATICAL SOCIETY

Leroy P. Steele Prizes

Call for Nominations

The selection committee for these prizes requests nominations for consideration for the 2006 awards. Further information about the prizes can be found in the November 2003 *Notices*, pp. 1288-1302 (also available at http://www.ams.org/prizes-awards).

Three Leroy P. Steele Prizes are awarded each year in the following categories: (1) the Steele Prize for Lifetime Achievement: for the cumulative influence of the total mathematical work of the recipient, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students; (2) the Steele Prize for Mathematical Exposition: for a book or substantial survey or expository-research paper; and (3) the Steele Prize for Seminal Contribution to Research: for a paper, whether recent or not, that has proved to be of fundamental or lasting importance in its field, or a model of important research. In 2006 the prize for Seminal Contribution to Research will be awarded for a paper in Applied Mathematics.

Nominations with supporting information should be submitted to the Secretary, Robert J. Daverman, American Mathematical Society, 312D Ayres Hall, University of Tennessee, Knoxville, TN 37996-1330. Include a short description on the work that is the basis of the nomination, including complete bibliographic citations. A curriculum vitae should be included. The nominations will be forwarded by the Secretary to the prize selection committee, which will, as in the past, make final decisions on the awarding of prizes.

Deadline for nominations is March 31, 2005.

AMS
AMERICAN MATHEMATICAL SOCIETY

2004 Election Results

In the elections of 2004 the Society elected a vice president, a trustee, five members at large of the Council, two members of the Editorial Boards Committee, and three members of the Nominating Committee. Terms for these positions are three years beginning on 1 February 2005 and ending on 31 January 2008, except for the trustee, whose term is for five years ending on 31 January 2010. Members elected to the Nominating Committee begin serving immediately, and their terms end on 31 December 2007.

Vice President

Elected as the new vice president is **Haïm Brezis** from the Université Paris VI and Institut Universitaire de France.

Trustee

Re-elected as trustee is **Eric M. Friedlander** from Northwestern University.

Members at Large of the Council

Elected as new members at large of the Council are

Sara C. Billey from the University of Washington

Carolyn S. Gordon from Dartmouth College

Sheldon H. Katz from the University of Illinois at Urbana-Champaign

Michael F. Singer from North Carolina State University

Catherine H. Yan from Texas A&M University

Editorial Boards Committee

Elected as new members of the Editorial Boards Committee are

Margaret Cheney from Rensselaer Polytechnic Institute

Abigail A. Thompson from the University of California at Davis

Nominating Committee

Elected as new members of the Nominating Committee are

Phillip A. Griffith from the University of Illinois at Urbana-Champaign

David Jerison from the Massachusetts Institute of Technology

Linda Keen from Lehman College and Graduate Center, City University of New York

Suggestions for elections to be held in the fall of 2005 are solicited by the 2005 Nominating Committee. Positions to be filled in the 2005 election are: president elect, vice president, trustee, and five members at large of the Council. The candidates for president elect will be James G. Glimm and Ronald J. Stern. Suggestions concerning the other posts should be sent to the secretary.

Suggestions for nominations for two positions on the Editorial Boards Committee and three positions on the 2006 Nominating Committee can also be sent to the secretary:

Robert J. Daverman, Secretary
American Mathematical Society
312D Ayres Hall
University of Tennessee
Knoxville, TN 37996-1330
secretary@ams.org

The deadline for suggestions is **26 February 2005.**

There will be a number of contested seats in the 2005 AMS Elections. Your suggestions are wanted by:

CALL FOR SUGGESTIONS

The Nominating Committee
for vice president, trustee,
and five members at large of the Council

and by

The President
for three Nominating Committee members
and two Editorial Boards Committee members.

In addition

The Editorial Boards Committee
requests suggestions for appointments to
various editorial boards of Society publications.

Send your suggestions for any of the above to:

Robert J. Daverman, Secretary
American Mathematical Society
312D Ayres Hall
University of Tennessee
Knoxville, TN 37996-1330
e-mail: secretary@ams.org

The deadline for suggestions is 26 February 2005.

2005 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 2005. 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, and must arrive by 26 February 2005.
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 (ams@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. Copies may be obtained from the secretary; however, 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 2005 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, 2006.

Name and address (printed or typed)	Signature
	Signature
	Signature
	Signature
	Signature
	Signature
	Signature

Mathematics Calendar

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

February 2005

*28-March 4 **Conference on Arithmetic Geometry: Gainesville 2005**, University of Florida, Gainesville, Florida.
Topic: p-adic methods in arithmetic and algebraic geometry.
Organizers: Richard Crew, Kevin Keating, Norm Levin.
Information: http://www.math.ufl.edu/~crew/agconf.html.

March 2005

*9-13 **Minimal Surfaces, Sub-Elliptic PDE's and Geometric Analysis**, Dartmouth College, Hanover, New Hampshire.
Workshop Topics: Minimal Surfaces, Sub-Elliptic PDE's and Geometric Analysis.
Focus: On contemporary developments in the study of several problems from analysis and geometry in the setting of Carnot-Carathéodory metrics. Most of the invited lecturers will address a variety of interrelated topics, such as: "best-constant" type problems concerning Sobolev and isoperimetric inequalities; the study of minimal and constant-curvature submanifolds; rectifiability and geometric measure theory; quasiconformal maps and potential theory; geometric flows and applications.
Participants: Richard Beals (Yale University), Bill Beckner (University of Texas, Austin), Giovanna Citti (Universita' di Bologna, Italy), Michael Cowling (University of New South Wales, Australia), Nicola Garofalo (Purdue University), Piotr Hajlasz (University of Pittsburgh), Ilkka Holopainen (University of Helsinki, Finland), Juan Manfredi (University of Pittsburgh), Severine Rigot (Universite' de Paris-Sud XI Orsay, France).
Information: http://www.math.dartmouth.edu/~ccworkshop/index.htm.

April 2005

*25-29 **Analytical Methods in Number Theory, Probability Theory and Mathematical Statistics**, Euler IMI, St. Petersburg, Russia.
Organizers: St. Petersburg Department of Steklov Institute of Mathematics, Euler International Mathematical Institute.
Topics: The conference is dedicated to the 90th anniversary of the prominent Russian mathematician, Yuri V. Linnik (1915-1972). The conference will be devoted to recent achievements in branches of mathematics close to Linnik's interests. Two parallel sections are supposed: Number Theory; Probability Theory and Mathematical Statistics.
Deadlines: For submission is March 1, 2005. For abstract submission is April 15, 2005.
Information: email: linnik90@imi.ras.ru; http://www.pdmi.ras.ru/EIMI/2005/Linnik90/.

May 2005

*17-21 **Lie algebras, Vertex operator algebras and their applications**, North Carolina State University, Raleigh, North Carolina.
Main Topics: Lie algebras, Quantum groups and their representations; Vertex operator algebras and their representations; Applications to number theory, combinatorics, conformal field theory and statistical mechanics.
Organizers: Kailash C. Misra, email: misra@math.ncsu.edu, Yi-Zhi Huang, email: yzhuang@math.rutgers.edu.
Deadline: For registration is April 20, 2005.
Information: http://www.math.ncsu.edu/~misra/LieConf2005.

*18-21 **Combinatorial and additive number theory (CANT 2005): A conference in celebration of Mel Nathanson's 60th birthday**,

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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/.

CUNY Graduate Center, 365 Fifth Avenue, New York, New York.
Description: The conference will cover all areas of combinatorial and additive number theory, and related parts of mathematics, such as harmonic analysis, ergodic theory, and probability. There will be invited lectures as well as sessions for contributed papers. To lecture at the conference, please submit a title and brief abstract to the conference co-chair Xingde Jia at cant2005@hotmail.com or jia@txstate.edu by April 20, 2005. It is anticipated that some travel support will be available. Younger mathematicians, and especially graduate students, are encouraged to attend.
Information: Please send an email message to cant2005@hotmail.com. Information is also available on the website http://www.theoryofnumbers.com.

27–30 **Scattering theory and singular spaces**, Northwestern University, Evanston, Illinois.
Organizers: Andras Vasy and Jared Wunsch.
Information: http://www.math.northwestern.edu/~jwunsch/scattering.html.

31–June 4 **2nd Conference on Analysis and Probability on Fractals**, Cornell University, Ithaca, New York.
Description: Analysis and probability on fractals is an exciting new area of mathematical research that studies basic analytic operators and stochastic processes when the underlying space is fractal.
Speakers: Martin Barlow (University of British Columbia), Zhen-Qing Chen (University of Washington), Kenneth Falconer (University of St. Andrews), Peter Grabner (Technical University of Graz), Ben Hambly (Oxford University), Masanori Hino (Kyoto University), Jun Kigami (Kyoto University), Takashi Kumagai (Kyoto University), Michel Lapidus (University of California, Riverside), Ka-Sing Lau (The Chinese University of Hong Kong), Volker Metz (Bielefeld University), Christophe Sabot (University of Paris), Robert Strichartz (Cornell University), Alexander Teplyaev (University of Connecticut), Martina Zaehle (University of Jena).
Applications: For financial support received by January 15, 2005, will receive preference. No registration fee.
Information: More information and an application form can be found at: http://www.math.cornell.edu/Colloquia/fractals.html or fractals05@math.cornell.edu.

June 2005

1–4 **ACMS 15th Biennial Conference**, Huntington College, Huntington, Indiana.
Description: The Association of Christians in the Mathematical Sciences will sponsor their 15th conference since 1977.
Featured speaker: Fernando Gouvéa from Colby College.
Conference Chair: W. Wetherbee, Dept. of Mathematics, Huntington College, Huntington, IN 46750; email: wwetherb@huntington.edu.
Information: General information is at http://www.acmsonline.org. Abstracts of proposed papers may be sent to the conference chair.

2–10 **Seventh International Conference on Geometry, Integrability and Quantization with a special session on Multisymplectic Geometry and Classical Field Theory**, Sts. Constantine and Elena resort (near Varna), Bulgaria.
Goal: This seventh edition of the conference aims like the previous ones to bring together experts in the Classical and Modern Differential Geometry, Complex Analysis, Mathematical Physics and related fields in order to assess recent developments in these areas and to stimulate research in intermediate topics.
Organizers: Ivailo M. Mladenov (Sofia), Allen Hirshfeld (Dortmund) and Manuel de Leon (Madrid).
Information: I. M. Mladenov, email: mladenov@obzor.bio21.bas.bg; A. C. Hirshfeld, email: hirsh@physik.uni-dortmund.de; Manuel de Leon, email: mdeleon@imaff.cfmac.csic.es. or visit the Conference Web page: http://www.bio21.bas.bg/conference/.

* 6–8 **Nonlinear Partial Differential Equations and Applications: Conference in honor of Jim Serrin on the occasion of the awarding of the title of Doctor Honoris Causa of Université François Rabelais**, Faculty of Sciences-Université, François Rabelais-Tours, France.
Description: Besides the official ceremony of the delivery of the diploma, we intend to put into light the numerous contributions of Professor Serrin and his collaborators in the domain of nonlinear partial differential equations. We also strongly wish to associate younger brilliant mathematicians with this celebration.
Invited speakers: D. Aronson (Univ. Minnesota), H. Berestycki (E.H.E.S.S., Paris), F. Bethuel (Univ. Paris 6), L. Boccardo (Univ. Roma I), H. Brezis (Univ. Paris 6 & Rutgers), X. Cabre (I.C.R.E.A. & Univ. Poli. Catal.), J. M. Coron (Univ. Paris 11), J. I. Diaz (Univ. Complutense, Madrid), M. Escobedo (Univ. Bilbao), R. Finn (Univ. Stanford), Y. Y. Li (Univ. Rutgers), M. Marcus (Technion, Haifa), J. Mawhin (Univ. Louvain), F. Merle (Univ. Cergy-Pontoise), P. Mironescu (Univ. Lyon 1), L. A. Peletier (Univ. Leiden), P. Pucci (Univ. Perugia), D. Smets (Univ. Paris 6), Ph. Souplet (Univ. Amiens), J. L. Vazquez (Univ. Autônoma, Madrid).
Information: http://www.phys-univ-tours.fr; email: serrin05@lmpt.univ-tours.fr, address: Conference J. Serrin 05, Laboratoire de Mathématiques et Physique Théorique, Faculté des Sciences, Parc de Grandmont F. 37200 Tours, France. Tel. (33) (0)2 47 36 69 25 (secret.), (33) (0)2 47 36 70 68 (fax).

* 6–11 **14th Summer St. Petersburg Meeting in Mathematical Analysis**, Euler IMI, St. Petersburg, Russia.
Organizers: St. Petersburg Department of Steklov Institute of Mathematics; Euler International Mathematical Institute.
Information: email: analysis@pdmi.ras.ru; http://www.pdmi.ras.ru/EIMI/2005/analysis14.

* 7–12 **25th Great Plains Operator Theory Symposium (GPOTS-05)**, University of Central Florida, Orlando, Florida.
Description: GPOTS is one of the largest annual conferences in the area of operator theory/operator algebras/applications. There are generally more than ten main invited speakers whose lectures emphasize break-through areas and applications of interest to the participants. Many of the regular participants give shorter talks, including many graduate students currently working on their doctorates.
Support: Each year GPOTS receives funding from the National Science Foundation specifically to provide partial support for young faculty, postdocs, graduate students, and other active researchers who do not currently have a federal research grant. The same level of support from NSF for GPOTS-05 is expected.
Information: email: gpots05@math.ucf.edu (for general inquiry) or email: dhan@mail.ucf.edu (for conference program inquiry); http://gauss.math.ucf.edu/~gpots05.

* 8–12 **Computability in Europe 2005 (CiE 2005): New Computational Paradigms**, Amsterdam, The Netherlands.
Description: CiE 2005 will have 3-hour tutorials on Quantum Computation (H. Buhrman) and Computability over the Reals (K. Weihrauch) and invited talks by S. Abramsky, J.D. Hamkins, U. Kohlenbach, J. van Leeuwen, Y. Matiyasevich, Y.N. Moschovakis and U. Schoening. There will be two-hour special sessions on Biological Computation, Complexity, Epistemology and Methodology of Computing, Proofs and Computation, Real Computation, and Relative Computation.
Organizers: Barry Cooper, Benedikt Lowe, Leen Torenvliet, Peter van Emde Boas.
Program Committee: Klaus Ambos-Spies (Heidelberg), Albert Atserias (Barcelona), Barry Cooper (Leeds, co-chair), Sergei Goncharov (Novosibirsk), Benedikt Loewe (Amsterdam, co-chair), Dag Normann (Oslo), Helmut Schwichtenberg (Mnchen), Andrea Sorbi (Siena), Ivan Soskov (Sofia), Leen Torenvliet (Amsterdam), John Tucker (Swansea), Johan van Benthem (Amsterdam/Stanford), Peter van Emde Boas

(Amsterdam), Jiri Wiedermann (Praha).
Sponsors: ASL, EATCS, NW.
Information: http://www.illc.uva.nl/CiE/CiE2005.html or contact one of the organizers.

*12-July 23 **DIMACS Reconnect Conferences 2005: Reconnecting Teaching Faculty to the Mathematical Sciences Research Enterprise**, DIMACS, CoRE Building, 4th Floor, Rutgers, the State University of New Jersey, 96 Frelinghuysen Road, Piscataway, New Jersey.
Description: About the Reconnect Conferences: These conferences expose faculty teaching undergraduates to the mathematical sciences research enterprise by introducing them to a current research topic relevant to the classroom through a series of lectures by a leading expert and involving them in writing materials useful in the classroom.
These workshops offer the opportunity for junior faculty as well as mid-level and senior faculty to advance to research questions in a new area of the mathematical sciences. Participants will also acquire materials and gain ideas for seminar presentations and for undergraduate research projects.
These conferences are also aimed at reconnecting faculty to the mathematical sciences enterprise by involving them in a leading research center, which is a consortium of Princeton University, Rutgers University, AT&T Labs, Bell Labs/Lucent Technologies, NEC Research and Telcordia Technologies. There will be opportunities to follow up after the conference by getting connected to DIMACS researchers and other DIMACS programs throughout the year.
Conference Organizers: Rochelle Leibowitz, Wheaton College, email: rochelle_leibowitz@wheatonma.edu; Fred S. Roberts, Rutgers University, email: roberts@dimacs.rutgers.edu.
Description: In Summer 2005, DIMACS will hold two Satellite "Reconnect Conferences".
1st Satellite Program: Montclair State University. Topic: Mathematics of Elections and Decisions. Principal Speaker: Donald G. Saari, University of California, email: dsaari@uci.edu. Guest Speaker: Michael A. Jones, Montclair State University, email: jonesm@mail.montclair.edu. Dates: June 12-June 18, 2005.
2nd Satellite Program: Spelman College. Topic: The Mathematics of Medical Imaging. Principal Speakers: Lawrence Shepp, Rutgers University, email: shepp@stat.rutgers.edu. Martin Lindquist, Columbia University, email: mal2053@columbia.edu. Dates: July 17-July 23, 2005.
Information: http://dimacs.rutgers.edu/reconnect/. Or, contact the Reconnect Program Coordinator, at email: reconnect@dimacs.rutgers.edu, phone: 732-445-4304.

*17-23 (NEW DATE) **Algebraic Geometry and Number Theory**, Euler IMI, St. Petersburg, Russia.
Organizers: St. Petersburg Department of Steklov Institute of Mathematics, Euler International Mathematical Institute, St. Petersburg State University.
Information: email: sergei@SV1005.spb.edu; http://www.pdmi.ras.ru/EIMI/2005/AG/.

*20-24 **The Fourth International Conference on High Dimensional Probability (HDP)**, St. John's College, Santa Fe, New Mexico.
Description: The conferences on High Dimensional Probability continue a long tradition of conferences that began in the mid seventies under the title of "Probability in Banach Spaces". Remarkable advances have led to the creation or introduction of powerful tools, such as randomization, decoupling, moment and exponential inequalities, chaining, isoperimetry, concentration of measures and deviation probabilities which apply to areas well beyond those for which they were created. Gaussian processes techniques and methods from probability in Banach spaces have made a substantial impact on broad areas such as statistics, learning theory, theoretical computer sciences, convex geometry and statistical physics. The conference will bring together researchers in these areas to discuss recent results and directions for future research.
Organizers: Evarist Gine, Vladimir Koltchinskii, Wenbo Li, Joel Zinn.
Information: http://www.math.udel.edu/~wli/conf/hdp05/.

*20-July 15 **Clay Mathematics Institute Summer School: Ricci Flow, 3-Manifolds and Geometry**, MSRI, Berkeley, California.
Organizers: Gang Tian, John Lott, John Morgan, Bennett Chow, Tobias Colding, Jim Carlson, David Ellwood, and Hugo Rossi.
Program: Designed for graduate students and mathematicians within five years of their Ph.D., the program is organized around Ricci Flow and the Geometrization of 3-manifolds, particularly, the recent work of Grisha Perelman. Perelman's work builds on earlier work of Thurston and Hamilton in a deep and original way. Topics covered will include an introduction to Geometrization, Ricci Flow (both geometric and analytic aspects), Minimal Surfaces and various fundamental results in topology and differential geometry. We will also have courses dedicated to Perelman's work on general Ricci Flow as well as some results and applications in 3-dimensions. The school will consist of three weeks of foundational courses and one week of mini-courses focusing on more advanced topics.
Lecturers: Jeff Cheeger, Bennett Chow, Tobias Colding, Richard Hamilton, Bruce Kleiner, John Lott, John Morgan, Gang Tian, and others.
Funding: Funding is available to graduate students and postdoctoral fellows (within 5 years of their Ph.D.). Standard support amounts will include funds for local expenses and accommodation plus economy travel.
Deadline: February 28, 2005.
Information: http://www.claymath.org/summerschool or contact email: summerschool@claymath.org; tel.: 617-995-2600.

*25-July 1 **The Twentieth IEEE Symposium on Logic In Computer Science (LICS 2005): Call for Workshop Proposals**, Chicago, Illinois.
Description: The organizers have made arrangements for pre- and post-LICS workshops to be run in conjunction with the main conference. Possible dates are June 25 (the day before LICS) and June 30 and July 1 (the two days after LICS).
Researchers and practitioners are invited to submit proposals for workshops on topics relating logic—broadly construed—to computer science or related fields. Typically, LICS workshops feature a number of invited speakers and a smaller number of contributed presentations.
Proposals: Should include: A short scientific summary and justification of the proposed topic. This should include a discussion of the particular benefits of the topic to the LICS community.
A discussion of the proposed format and agenda and the proposed duration, which may vary from half a day to two days,and preferred dates.
Procedures for selecting participants and papers.
Expected number of participants.
Potential invited speakers.
Plans for dissemination (for example, special issues of journals).
Please note that it is expected that LICS workshop organizers should be present to run their workshops. It is also assumed that normally workshop organizers (though not necessarily participants) will register for the LICS conference.
Deadline: Proposals are due November 15, 2004, and should be submitted electronically to: Philip Scott Workshops Chair, LICS 2005; email: phil@site.uottawa.ca.
Selection Committee: Phokion Kolaitis (LICS General Chair), Prakash Panangaden (LICS 2005 Program Committee Chair), Phil Scott (LICS Workshop Chair) and Alan Jeffrey and Radha Jagadeesan (LICS 2005 Conference co-chairs). The results will be announced by November 30th, 2004.

*27-July 1 **Nonlinear Modelling and Control, An International**

Seminar, Nayanova University, Samara, Russia.
Purpose: The seminar's aim is the exchange of information about recent trends in mathematical modeling and control theory and their applications to various problems in physics, chemistry, biology, medicine, economy, and industrial concerns.
Call for Papers: Original papers related to the aim of the seminar are solicited. Potential speakers should submit an abstract before April 30. The cover page should contain title, affilation, and email address of each author. Electronic submissions in LATEX are encouraged.
Sponsors: Samara Municipal Nayanova Univ., Samara State Univ., Samara Scientific Center of RAS, Russian Academy of Natural Sciences, International Federation of Nonlinear Analysts, Univ. College Cork (Ireland).
Organizers: A. Pokrovskii (Cork, Ireland), V. Sobolev and E. Somov(Samara, Russia).
Languages: English and Russian.
Information: V. Sobolev (sable@ssu.samara.ru) or seminar coordinator: He. Gorelova (gorhel@ssu. samara.ru), Nayanova Univ., Molodogvardeiskaya 196, Samara, 443001, Russia.

July 2005

22-27 **AMSI Workshop entitled "Noncommutative Geometry and Index Theory"**, Australian National University, Canberra, Australia.
Information: http://wwwmaths.anu.edu.au/events/ngit05/.

24-27 **International Symposium in Symbolic and Algebraic Computation ISSAC'2005**, Beijing, China.
Invited Talks: Bruno Buchberger, RISC-Linz, Austria; Bruno Salvy, INRIA, France; Wen-Tsun Wu, Chinese Academy of Sciences, China.
Information: http://www.mmrc.iss.ac.cn/~issac2005/; email: issac2005@mmrc.iss.ac.cn.

25-30 **First Announcement: International Conference on Difference Equations, Special Functions and Applications**, Munich, Germany.
Description: This is a joint meeting of three communities working in the fields of difference equations, special functions and applications (OPSFA, ISDE, and SIDE).
Scientific Committee: Richard Askey (USA), Bernd Aulbach (Germany), Christian Berg (Denmark), Alexander Bobenko (Germany), Saber Elaydi (USA), Basil Grammaticos (France), Jarmo Hietarinta (Finland), Mourad Ismail (USA), Nalini Joshi (Australia), Gerry Ladas (USA), Rupert Lasser (Germany), Lance Littlejohn (USA), Vassilis Papageorgiou (Greece), Allan Peterson (USA), George Sell (USA), Alexander Sharkovsky (Ukraine), Sergei Suslov (USA), Pavel Winternitz (Canada).
Organizing Committee: Bernd Aulbach (bernd.aulbach@math.uni-augsburg.de), Rupert Lasser (lasser@gsf.de), Frank Nijhoff (frank@amsta.leeds.ac.uk), Andreas Ruffing (ruffing@ma.tum.de).
Information: More information about registration, housing, deadlines, etc. will be available shortly on the website of the conference at: http://www-m6.ma.tum.de/~ruffing/Conference2005/.

September 2005

5-11 **The Seventh International Workshop on Differential Geometry and its Applications**, Deva, Romania.
Program: 50 minute lectures and 25 minute talks. Poster communications are also envisaged.
Main Topics: Riemannian geometry and generalizations, nonassociative algebra methods in (finite- and infinite-dimensional) differential geometry, complex and quaternionic geometry, foliation theory, critical point theory and applications.
Foreign Invited Speakers (confirmed until the end of August 2004): W. Bertram (France), C.-H. Chu (England), J. Dorfmeister (Germany), L. Funar (France), W. Kaup (Germany), O. Kowalski (Czech Republic), E. Macias-Virgos (Spain), S. Marchiafava (Italy), N. Teleman (Italy).
Organizers: D. Andrica,"Babes-Bolyai", Univ.-Cluj-Napoca, email: dandrica@math.ubbcluj.ro; R. Iordanescu, Institute of Mathematics of the Romanian Academy-Bucharest, email: Radu.Iordanescu@imar.ro; I. Mos, Department of Colleges for Teachers of the Univ. of the West from Timisoara in Deva, email: mos@isj.hd.edu.ro; M. Puta, Univ.of the West, Faculty of Mathematics, Timisoara, email: puta@math.uvt.ro.

*12-19 **Small Deviation Probabilities and Related Topics**, Euler IMI, St. Petersburg, Russia.
Organizers: St. Petersburg Department of Steklov Institute of Mathematics, Euler International Mathematical Institute.
Topics: The aim of the conference is to bring together outstanding researchers working on small deviation probabilities and in related fields of probability analysis, and applied mathematics such as stochastic processes, approximation theory, quantization, spectral theory of operators etc.
Information: email: smalldev@euler.pdmi.ras.ru; email: www.pdmi.ras.ru/EIMI/2005/sd/.

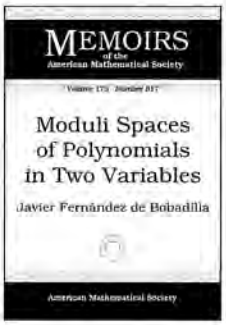
*16-20 **International Conference of Numerical Analysis and Applied Mathematics 2005 (ICNAAM 2005)**, Hotel Esperides, Rhodes, Greece.
Organizer: European Society of Computational Methods in Sciences and Engineering (ESCMCE).
Deadlines: Important Dates: Early Registration ends (i.e. fees paid and a bank Slip has arrived fax: (++ 30210 94 20 091, ++ 30 2710 237 397) to the Secretary of ICNAAM or a Visa-Master-American Express Card has been charged): April 30, 2005. Normal Registration ends (i.e. fees paid and a Bank Slip has arrived fax: (++ 30210 94 20 091, ++ 30 2710 237 397) to the Secretary of ICNAAM or a Visa-Master-American Express Card has been charged): May 31, 2005. Late Registration ends (i.e. fees paid and a bank Slip has arrived fax: (++ 30210 94 20 091, ++ 30 2710 237 397) to the Secretary of ICNAAM or a Visa-Master-American Express Card has been charged): June 30, 2005. Submission of Extended Abstract: June 30, 2005 (final date). Notification of acceptance: July 10, 2005. Submission of the source files of the camera ready extended abstracts to Wiley-VCH: July 20, 2005 (final date). Submission of the full paper for consideration for publication in the journals: September 30, 2005-November 30, 2005. The deadline for proposal submission is May 31, 2005. Send to email: icnaam@uop.gr.
Important Information: Papers for Sessions, Workshops or Minisymposia should be submitted directly to the Sessions, Workshops or Minisymposia organizers who also defines the deadline. After the selection, the Sessions, Workshops or Minisymposia organisers must send the final accepted papers to the Secretary of ICNAAM 2005.

November 2005

*25-December 1 **Reform, Revolution and Paradigm Shifts in Mathematics Education**, Johor Bharu, Southern Malaysia (very close to Singapore).
Organizer: Mathematics Education into the 21st Century Project.
Program: November 25th: Arrivals & Welcome Reception (7.00 on). Includes food and drink. November 26th: First Working Day. Includes Official Opening Ceremony, Open Forum of Ideas. November 27 or 28: All-day Conference Excursion to Malacca. November 30th: Gala Dinner. December 1st: Last working day, morning only, lunch and farewells.
Working Sessions: Plenary Speechs, Paper Presentations, Working Group Meetings.
Workshops: Open Forum of Ideas, SuperCourse Meetings for General Information and for Writers.
Information: Alan Rogerson; email: arogerson@inetia.pl.

New Publications Offered by the AMS

Algebra and Algebraic Geometry



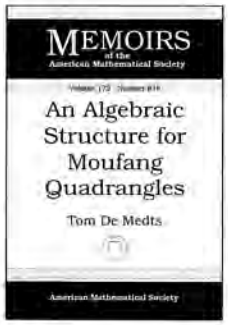
Moduli Spaces of Polynomials in Two Variables

Javier Fernández de Bobadilla, *Universiteit Utrecht, Netherlands*

Contents: Introduction; Automorphisms of the affine plane; A partition on $\mathbb{C}[x, y]$; The geometry of the partition; The action of $Aut(\mathbb{C}^2)$ on $\mathbb{C}[x, y]$; The moduli problem; The moduli spaces; Appendix A. Canonical orders; Bibliography.

Memoirs of the American Mathematical Society, Volume 173, Number 817

December 2004, 136 pages, Softcover, ISBN 0-8218-3593-9, LC 2004057486, 2000 *Mathematics Subject Classification*: 14R05, 14R10, 14H10; 14E07, 14H20, **Individual member $36**, List $60, Institutional member $48, Order code MEMO/173/817



An Algebraic Structure for Moufang Quadrangles

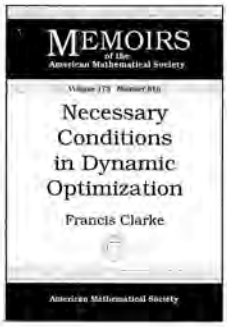
Tom De Medts, *Ghent University, Belgium*

Contents: Introduction; Definition; Some identities; From quadrangular systems to Moufang quadrangles; From Moufang quadrangles to quadrangular systems; Some remarks; Examples; The classification; Appendix A. Abelian quadrangular systems; Bibliography.

Memoirs of the American Mathematical Society, Volume 173, Number 818

December 2004, 99 pages, Softcover, ISBN 0-8218-3608-0, LC 2004057482, 2000 *Mathematics Subject Classification*: 51E12, 16W10, 20E42, **Individual member $34**, List $56, Institutional member $45, Order code MEMO/173/818

Analysis



Necessary Conditions in Dynamic Optimization

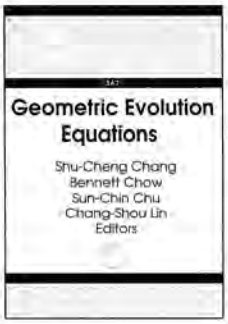
Francis Clarke, *University of Lyon, Villeurbanne, France*

Contents: Introduction; Boundary trajectories; Differential inclusions; The calculus of variations; Optimal control of vector fields; The Hamiltonian inclusion; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 173, Number 816

December 2004, 113 pages, Softcover, ISBN 0-8218-3591-2, LC 2004057483, 2000 *Mathematics Subject Classification*: 49K15, 49K05, **Individual member $34**, List $57, Institutional member $46, Order code MEMO/173/816

Differential Equations



Geometric Evolution Equations

Shu-Cheng Chang, *National Tsing Hua University, Hsinchu, Taiwan*, **Bennett Chow**, *University of California San Diego, La Jolla*, and **Sun-Chin Chu** and **Chang-Shou Lin**, *National Chung Cheng University, Chia-Yi, Taiwan*, Editors

The Workshop on Geometric Evolution Equations was a gathering of experts that produced this comprehensive collection of articles. Many of the papers relate to the Ricci flow and Hamilton's program for understanding the geometry and topology of 3-manifolds.

The use of evolution equations in geometry can lead to remarkable results. Of particular interest is the potential solution of Thurston's Geometrization Conjecture and the Poincaré Conjecture. Yet applying the method poses serious technical problems. Contributors to this volume explain some of these issues and demonstrate a noteworthy deftness in the handling of technical areas.

Various topics in geometric evolution equations and related fields are presented. Among other topics covered are minimal surface equations, mean curvature flow, harmonic map flow, Calabi flow, Ricci flow (including a numerical study), Kähler-Ricci flow, function theory on Kähler manifolds, flows of plane curves, convexity estimates, and the Christoffel-Minkowski problem.

The material is suitable for graduate students and researchers interested in geometric analysis and connections to topology.

Related titles of interest include *The Ricci Flow: An Introduction.*

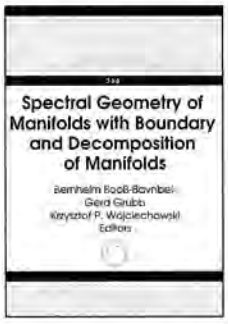
This item will also be of interest to those working in geometry and topology.

Contents: S. Angenent and **J. Hulshof**, Singularities at $t = \infty$ in equivariant harmonic map flow; **S.-C. Chang**, Recent developments on the Calabi flow; **A. Chau**, Stability of the Kähler-Ricci flow at complete non-compact Kähler Einstein metrics; **B. Chow**, A survey of Hamilton's program for the Ricci flow on 3-manifolds; **S.-C. Chu**, Basic properties of gradient Ricci solitons; **D. Garfinkle** and **J. Isenberg**, Numerical studies of the behavior of Ricci flow; **P. Guan** and **X.-N. Ma**, Convex solutions of fully nonlinear elliptic equations in classical differential geometry; **R. Gulliver**, Density estimates for minimal surfaces and surfaces flowing by mean curvature; **D. Knopf**, An introduction to the Ricci flow neckpinch; **L. Ni**, Monotonicity and Kähler-Ricci flow; **M. Simon**, Deforming Lipschitz metrics into smooth metrics while keeping their curvature operator nonnegative; **L.-F. Tam**, Liouville properties on Kähler manifolds; **D.-H. Tsai**, Expanding embedded plane curves; **M.-T. Wang**, Remarks on a class of solutions to the minimal surface system.

Contemporary Mathematics, Volume 367

February 2005, 235 pages, Softcover, ISBN 0-8218-3361-8, LC 2004046440, 2000 *Mathematics Subject Classification*: 53C44, 53C21, 35K55, 57M50, 35K57, 53C42, 53C43, 58J05, 53C35, 58J35, **All AMS members $55**, List $69, Order code CONM/367

Geometry and Topology



Spectral Geometry of Manifolds with Boundary and Decomposition of Manifolds

Bernhelm Booß-Bavnbek, *Roskilde University, Denmark*, **Gerd Grubb**, *University of Copenhagen, Denmark*, and **Krzysztof P. Wojciechowski**, *Indiana University-Purdue University, Indianapolis*, Editors

In recent years, increasingly complex methods have been brought into play in the treatment of geometric and topological problems for partial differential operators on manifolds. This collection of papers, resulting from a Workshop on Spectral Geometry of Manifolds with Boundary and Decomposition of Manifolds, provides a broad picture of these methods with new results.

Subjects in the book cover a wide variety of topics, from recent advances in index theory and the more general theory of spectral invariants on closed manifolds and manifolds with boundary, to applications of those invariants in geometry, topology, and physics.

Papers are grouped into four parts: Part I gives an overview of the subject from various points of view. Part II deals with spectral invariants, such as traces, indices, and determinants. Part III is concerned with general geometric and topological questions. Part IV deals specifically with problems on manifolds with singularities. The book is suitable for graduate students and researchers interested in spectral problems in geometry.

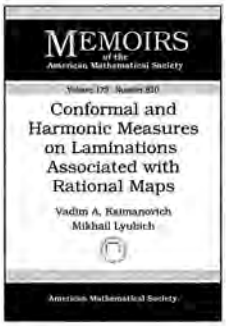
This item will also be of interest to those working in analysis.

Contents: *Part I. Basic material–Reviews:* **D. V. Vassilevich**, Spectral problems from quantum field theory; **G. Esposito**, Euclidean quantum gravity in light of spectral geometry; **G. Grubb**, Analysis of invariants associated with spectral boundary problems for elliptic operators; *Part II. Spectral invariants and asymptotic expansions:* **G. Grubb**, A resolvent approach to traces and zeta Laurent expansions; **Y. Lee**, Asymptotic expansion of the zeta-determinant of an invertible Laplacian on a stretched manifold; **J. Park** and **K. P. Wojciechowski**, Agranovich-Dynin formula for the zeta-determinants of the Neumann and Dirichlet problems; *Part III. Geometric and topological problems:* **H. U. Boden**, **C. M. Herald**, and **P. Kirk**, The Calderón projector for the odd signature operator and spectral flow calculations in 3-dimensional topology; **E. Leichtnam** and **P. Piazza**, Cut-and-paste on foliated bundles; **M. Lesch**, The uniqueness of the spectral flow on spaces of unbounded self-adjoint Fredholm operators;

M. Marcolli and **B.-L. Wang**, Variants of equivariant Seiberg-Witten Floer homology; *Part IV. Manifolds with singularities:* **P. Loya**, Dirac operators, boundary value problems, and the b-calculus; **V. E. Nazaikinskii, G. Rozenblum, A. Yu. Savin**, and **B. Yu. Sternin**, Guillemin transform and Toeplitz representations for operators on singular manifolds; **V. Nistor**, Pseudodifferential operators on non-compact manifolds and analysis on polyhedral domains.

Contemporary Mathematics, Volume 366

February 2005, 328 pages, Softcover, ISBN 0-8218-3536-X, LC 2004053991, 2000 *Mathematics Subject Classification*: 19K56, 35S15, 46L80, 47A53, 58J30, 58J32, 58J35, 58J42, 81T20, 83C45, **All AMS members $71**, List $89, Order code CONM/366



Conformal and Harmonic Measures on Laminations Associated with Rational Maps

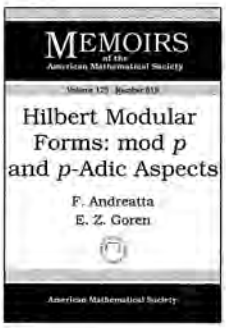
Vadim A. Kaimanovich, *Université Rennes, France*, and **Mikhail Lyubich**, *SUNY at Stony Brook, NY*

Contents: Introduction; Affine and hyperbolic laminations; Measures and currents on laminations; Laminations associated with rational maps; Measures on laminations associated with rational maps; Appendix A. Laminations associated with Kleinian groups; List of notations; Bibliography.

Memoirs of the American Mathematical Society, Volume 173, Number 820

December 2004, 119 pages, Softcover, ISBN 0-8218-3615-3, LC 2004057484, 2000 *Mathematics Subject Classification*: 37F10, 37F35, 57R30; 37D40, 37F30, 53C12, 57M50, 58J65, **Individual member $35**, List $58, Institutional member $46, Order code MEMO/173/820

Number Theory



Hilbert Modular Forms: mod p and p-Adic Aspects

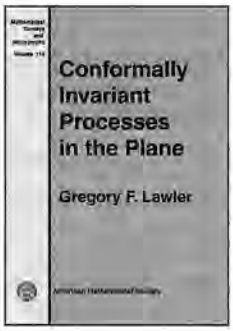
F. Andreatta, *University Degli Studi, Padova, Italy*, and **E. Z. Goren**, *McGill University, Montreal, PQ, Canada*

Contents: Introduction; Notations; Moduli spaces of abelian varieties with real multiplication; Properties of G; Hilbert modular forms; The q-expansion map; The partial Hasse invariants; Reduceness of the partial Hasse invariants; A compactification of $\mathfrak{M}(k, \mu_{pN})^{\mathrm{Kum}}$; Congruences mod p^n and Serre's p-adic modular forms; Katz's p-adic Hilbert modular forms; The operators $\Theta_{\mathfrak{P},i}$; The operator V; The operator U; Applications to filtrations of modular forms; Theta cycles and parallel filtration (inert case); Functorialities; Integrality and congruences for values of zeta functions; Numerical examples; Comments regarding values of zeta functions; References.

Memoirs of the American Mathematical Society, Volume 173, Number 819

December 2004, 100 pages, Softcover, ISBN 0-8218-3609-9, LC 2004057485, 2000 *Mathematics Subject Classification*: 11G18, 14G35, 11F33, 11F41, **Individual member $34**, List $56, Institutional member $45, Order code MEMO/173/819

Probability



Conformally Invariant Processes in the Plane

Gregory F. Lawler, *Cornell University, Ithaca, NY*

Theoretical physicists have predicted that the scaling limits of many two-dimensional lattice models in statistical physics are in some sense conformally invariant. This belief has allowed physicists to predict many quantities for these critical systems. The nature of these scaling limits has recently been described precisely by using one well-known tool, Brownian motion, and a new construction, the Schramm-Loewner evolution (SLE).

This book is an introduction to the conformally invariant processes that appear as scaling limits. The following topics are covered: stochastic integration; complex Brownian motion and measures derived from Brownian motion; conformal mappings and univalent functions; the Loewner differential equation and Loewner chains; the Schramm-Loewner evolution (SLE), which is a Loewner chain with a Brownian motion input; and applications to intersection exponents for Brownian motion. The prerequisites are first-year graduate courses in real analysis, complex analysis, and probability. The book is suitable for graduate students and research mathematicians interested in random processes and their applications in theoretical physics.

This item will also be of interest to those working in analysis and mathematical physics.

Contents: Some discrete processes; Stochastic calculus; Complex Brownian motion; Conformal mappings; Loewner differential equation; Brownian measures on paths; Schramm-Loewner evolution; More results about SLE; Brownian intersection exponent; Restriction measures; Hausdorff dimension; Hypergeometric functions; Reflecting Brownian motion; Bibliography; Index; Index of symbols.

Mathematical Surveys and Monographs, Volume 114

March 2005, approximately 242 pages, Hardcover, ISBN 0-8218-3677-3, 2000 *Mathematics Subject Classification*: 30C35, 31A15, 60H30, 60J65, 81T40, 82B27, **All AMS members $47**, List $59, Order code SURV/114

Classified Advertisements

Positions available, items for sale, services available, and more

MASSACHUSETTS

WILLIAMS COLLEGE
Department of Mathematics

The Williams College Department of Mathematics and Statistics invites applications for one tenure-track position in mathematics, beginning fall 2005, at the rank of assistant professor (in an exceptional case, a more advanced appointment may be considered). We are seeking a highly qualified candidate who has demonstrated excellence in teaching and research, and who will have a Ph.D. by the time of appointment.

Williams College is a private, residential, highly selective liberal arts college with an undergraduate enrollment of approximately 2,000 students. The teaching load is two courses per 12-week semester and a winter term course every other January. In addition to excellence in teaching, an active and successful research program is expected.

To apply, please send a vita and have three letters of recommendation on teaching and research sent to the Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluations of applications will begin on or after November 15 and will continue until the position is filled. Williams College is dedicated to providing a welcoming intellectual environment for all of its faculty, staff and students; as an EEO/AA employer, Williams especially encourages applications from women and minorities. For more information on the Department of Mathematics and Statistics, visit http://www.williams.edu/Mathematics.

000151

WILLIAMS COLLEGE
Department of Mathematics

The Williams College Department of Mathematics and Statistics invites applications for one tenure-track position in statistics, beginning fall 2005, at the rank of assistant professor (in an exceptional case, a more advanced appointment may be considered). We are seeking a highly qualified candidate who has demonstrated excellence in teaching and research, and who will have a Ph.D. by the time of appointment.

Williams College is a private, residential, highly selective liberal arts college with an undergraduate enrollment of approximately 2,000 students. The teaching load is two courses per 12-week semester and a winter term course every other January. In addition to excellence in teaching, an active and successful research program is expected.

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000152

MICHIGAN

MICHIGAN STATE UNIVERSITY
East Lansing, MI 48824
proMSc Program in
Industrial Mathematics

Direct your students toward one of the professional M.Sc. programs. Industry needs business-savvy mathematicians. See http://www.sciencemasters.com/.

000019

MISSISSIPPI

UNIVERSITY OF MISSISSIPPI
Department of Mathematics

The department of mathematics seeks to fill a tenure-track assistant professor position beginning August 2005. Ole Miss has 13,513 full time students on the Oxford Campus. The Department of Mathematics has 16 tenure-track faculty, 7 instructors, 51 undergraduate majors, 11 M.S. students, and 20 Ph.D. students. All candidates should have a Ph.D. (or equivalent) by August 2005 in mathematics, statistics or the mathematical sciences, and outstanding potential in both research and teaching. Candidates whose research interests coincide with those of existing faculty are sought in the areas of statistics and analysis. Applicants in statistics should have demonstrated research excellence in bioinformatics or semiparametric models or nonparametric methods. The successful applicant will teach 6 hours per semester and is also expected to conduct a vigorous research program.

Applicants should complete the application form, cover letter and curriculum vitae online at http://jobs.olemiss.edu.

Suggested uses for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The 2005 rate is $100 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified ads.

Upcoming deadlines for classified advertising are as follows: March 2005 issue-December 29, 2004; April 2005 issue-January 28, 2005; May 2005 issue-February 25, 2005; June/July 2005 issue-April 27, 2005; August 2005 issue-May 26, 2005; September 2005 issue-June 27, 2005.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to classads@ams.org. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

A one-page statement on the applicant's research interest, three letters of recommendation about the applicant's research, and at least one letter of recommendation about the applicant's teaching must be sent to:

Department of Mathematics
Chairman of Tenure-Track Search Committee
305 Hume Hall
University, MS 38677

The letters of recommendation must be submitted directly by the referees. Inquiries about this position may be sent to mdepart@olemiss.edu. Screening of applications will begin on January 31, 2005, and will continue until the position is filled.

The University of Mississippi is an EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA employer.

000032

NEW YORK

ST. JOHN'S UNIVERSITY
Assistant Professor of Mathematics

Bringing knowledge to life. Working for a better world.

St. John's University, founded by the Vincentian Fathers, one of the largest Catholic universities in the nation, currently has one tenure-track position available in the Dept. of Mathematics & Computer Science of St. John's College.

The position is at the assistant professor rank in mathematics on the Queens campus for September 2005. Applicants should possess a Ph.D. in mathematics and a commitment to both teaching and research.

We offer competitive compensation, excellent benefits and talented professional colleagues. To apply, please send letter of application, curriculum vitae, three letters of reference, and graduate transcripts to: SEARCH COMMITTEE, Dept. of Mathematics & Computer Science SJH 334, St. John's University, 8000 Utopia Pkwy, Queens, NY 11439; email: trainac@stjohns.edu.

St. John's is an Equal Opportunity Employer and encourages applications from women and minorities.

000033

TEXAS

SAM HOUSTON STATE UNIVERSITY
Mathematics Position in Mathematics Education

The Department of Mathematics and Statistics is seeking to fill two or more assistant/associate tenure-track positions in mathematics education. Candidates must have the equivalent of a master's degree in mathematics and hold a doctorate in mathematics education or equivalent. Teaching, service, and scholarly activities are required. The review will begin November 2004, and continue until the positions are filled. Submit a letter of interest, full curriculum vitae, transcripts, and three letters of reference to: Mathematics Education Search Committee, Department of Mathematics and Statistics, Sam Houston State University, Box 2206, Huntsville, TX 77341-2206.

Sam Houston State University is an EEO/AAP employer.

000031

UNIVERSITY OF TEXAS AT EL PASO
Mathematical Sciences
Assistant/Associate Professor (Pure Math)

DESCRIPTION: The Department of Mathematical Sciences seeks to hire a tenure-track assistant or associate professor in algebra, analysis, combinatorics, or topology. The successful candidate will show demonstrated research and teaching potential, with preference given to those whose research may lead to collaboration with that of current faculty members.

The University of Texas at El Paso has an enrollment of almost 19,000 students, and is located in high, mountainous country in the Chihuahuan Desert along the US-Mexico border. El Paso and its sister city Ciudad Juarez have a combined population of about two million. The Department of Mathematical Sciences, one of the larger departments on campus, offers bachelor's and master's degrees in mathematics and statistics, as well as a Master of Arts in Teaching Mathematics degree. The University has recently been awarded a prestigious NSF ADVANCE grant in the amount of 3.5 million dollars to fund 26 graduate research assistants over 5 years to support research teams with a female faculty lead investigator.

QUALIFICATIONS REQUIRED: A doctorate in mathematics is required.

APPLICATION PROCEDURE: Send a letter of interest, a complete curriculum vitae and three letters of recommendation to the Faculty Hiring Committee, Department of Mathematical Sciences, UTEP, El Paso, TX 79968-0514. Consideration of applicants will begin immediately and continue until the position is filled or the search is abandoned. The University of Texas at El Paso does not discriminate on the basis of race, color, national origin, sex, religion, age, disability, veteran's status or sexual orientation in employment or in the provision of services.

000034

CANADA

UNIVERSITY OF ALBERTA
Department of Mathematical and Statistical Sciences Tenure-track University Faculty Award Position

The Department of Mathematical and Statistical Sciences is actively seeking to nominate a candidate for an NSERC University Faculty Award in the fall 2005 competition.

The University Faculty Award was created by NSERC to encourage Canadian universities to appoint outstanding women and aboriginal researchers to tenure-track positions in science and engineering. Further information on the program can be found be found at the following web page: http://www.nserc.ca/professors_e.asp?nav=profnav&lbi=c7/.

The nominee will have an outstanding record of research and publication. We are particularly interested in a field related to an area of existing or emerging strength in the department, although other areas will be considered too. Some areas of research excellence, recently highlighted by the University of Alberta Faculty of Science, include: algebra, functional analysis, fluid dynamics, statistics, mathematical biology and scientific computing. The candidate will also have a strong commitment to and aptitude for teaching undergraduate students, and will be expected to supervise graduate theses.

This tenure-track appointment is scheduled to begin on or near July 1, 2006.

Applications should be sent to the Chair at the address below. Applications should include a curriculum vitae and research and teaching profiles, outlining experience and/or interests. Candidates should arrange for at least three confidential letters of reference to be sent to the Chair at the address below:

Anthony To-Ming Lau, Chair
Department of Mathematical and Statistical Sciences
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Edmonton, Alberta, Canada
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The closing date for applications is March 1, 2005. Early applications are encouraged.

The University of Alberta hires on the basis of merit. We are committed to the principle of equity in employment. We welcome diversity in the workplace and encourage applications from all qualified individuals, including aboriginal peoples, persons with disabilities, and members of visible minorities. According to NSERC regulations applicants must be Canadian citizens or permanent residents of Canada.

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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/`. Programs and abstracts will continue to be displayed on the AMS website in the Meetings and Conferences section until about three weeks after the meeting is over. Final programs for Sectional Meetings will be archived on the AMS website in an electronic issue of the *Notices* as noted below for each meeting.

Bowling Green, Kentucky

Western Kentucky University

March 18–19, 2005

Friday - Saturday

Meeting #1004

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January 2005
Program first available on AMS website: February 3, 2005
Program issue of electronic *Notices*: March 2005
Issue of *Abstracts*: Volume 26, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 25, 2005

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Bennett Chow, University of California San Diego, *Title to be announced.*

Robert McCann, University of Toronto, *Optimal convergence rates for the fastest conservative nonlinear diffusions.*

M. Susan Montgomery, University of Southern California, *Some applications of group theory to classifying Hopf algebras.*

James J. Zhang, University of Washington, *Searching for quantum projective spaces.*

Special Sessions

Advances in the Study of Wavelets and Multiwavelets (Code: SS 5A), **Douglas P. Hardin**, Vanderbilt University, and **Bruce Kessler**, Western Kentucky University.

Commutative Ring Theory (Code: SS 11A), **Michael C. Axtell**, Wabash College, and **Joe Alyn Stickles, Jr.**, University of Evansville.

Dynamic Equations on Time Scales and Applications (Code: SS 3A), **Ferhan M. Atici** and **Daniel C. Biles**, Western Kentucky University, and **Billur Kaymakcalan**, Georgia Southern University.

Geometric Topology and Group Theory (Code: SS 14A), **Jens E. Harlander**, Western Kentucky University.

Graph Theory (Code: SS 2A), **Mustafa Atici**, Western Kentucky University.

Hopf Algebras and Related Topics (Code: SS 10A), **David E. Radford**, University of Illinois at Chicago, and **Bettina Richmond**, Western Kentucky University.

Knot Theory and Its Applications (Code: SS 4A), **Yuanan Diao**, University of North Carolina, Charlotte, and **Claus Ernst**, Western Kentucky University.

L-Functions (Code: SS 9A), **Heather Russell**, **Nilabh Sanat**, and **Dominic Lanphier**, Western Kentucky University.

Nonlinear Analysis and Applied Mathematics (Code: SS 13A), **Robert J. McCann**, University of Toronto, and **Daniel P. Spirn**, University of Minnesota.

Numerical Analysis, Approximation, and Computational Complexity: Interdisciplinary Aspects (Code: SS 1A), **David Benko**, Western Kentucky University, and **Steven B. Damelin**, Georgia Southern University.

Partial Differential Equations and Their Applications (Code: SS 12A), **Zhongwei Shen** and **Changyou Wang**, University of Kentucky.

Recent Advances in Noncommutative Algebra (Code: SS 15A), **Ellen E. Kirkman**, Wake Forest University.

Representation Theory (Code: SS 6A), **Markus Hunziker**, University of Georgia.

Semigroups of Operators and Applications (Code: SS 7A), **Khristo Boyadzhiev**, Ohio Northern University, **Lan Nguyen**, Western Kentucky University, and **Quoc-Phong Vu**, Ohio University.

Topology, Convergence, and Order, in Honor of Darrell Kent (Code: SS 8A), **Gary Richardson**, University of Central Florida, and **Thomas A. Richmond**, Western Kentucky University.

Newark, Delaware

University of Delaware

April 2–3, 2005

Saturday - Sunday

Meeting #1005

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: February 2005
Program first available on AMS website: February 17, 2005
Program issue of electronic *Notices*: April 2005
Issue of *Abstracts*: Volume 26, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: February 8, 2005

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Xiuxiong Chen, University of Wisconsin, Madison, *Title to be announced.*

Anna C. Gilbert, AT&T Labs-Research, *Analysis, approximations, and algorithms.*

Alexander Lubotzky, Hebrew University of Jerusalem, *Counting primes, groups, and manifolds.*

Lorenz Schwachhoefer, University of Dortmund, *Special symplectic connections.*

Special Sessions

Arithmetic Groups and Related Topics (Code: SS 9A), **Alexander Lubotzky**, Hebrew University of Jerusalem, and **Andrei Rapinchuk**, University of Virginia.

Asymptotic Behavior of Evolution Equations (Code: SS 4A), **Gaston M. N'Guerekata**, Morgan State University, and **Nguyen Van Minh**, James Madison University.

Designs, Codes, and Geometries (Code: SS 5A), **James A. Davis**, University of Richmond, **Keith E. Mellinger**, University of Mary Washington, and **Qing Xiang**, University of Delaware.

Frontiers on Complex Fluid Flows: Analytic and Computational Methods (Code: SS 7A), **L. Pamela Cook** and **Louis F. Rossi**, University of Delaware.

Geometric Analysis (Code: SS 12A), **Xiuxiong Chen**, University of Wisconsin, Madison, **Pengfei Guan**, McMaster University, **Zhiqin Lu**, University of California Irvine, and **Jeff A. Viaclovsky**, Massachusetts Institute of Technology.

High Dimensional Probability (Code: SS 6A), **Wenbo Li**, University of Delaware, and **Joel Zinn**, Texas A&M University.

Homotopy Theory (in Honor of Donald M. Davis's and Martin Bendersky's 60th Birthdays) (Code: SS 1A), **Kenneth G. Monks**, University of Scranton, and **W. Stephen Wilson**, Johns Hopkins University.

Integral and Operator Equations (Code: SS 13A), **Charles W. Groetsch**, University of Cincinnati, and **M. Zuhair Nashed**, University of Central Florida.

Mathematical Biology (Code: SS 8A), **David A. Edwards**, University of Delaware.

Mathematical Methods for Efficient Simulation of Stochastic Nonlinear Optical Systems (Code: SS 15A), **Richard O. Moore**, New Jersey Institute of Technology, and **Tobin A. Driscoll**, University of Delaware.

Mathematical Methods in Electromagnetic Wave Propagation (Code: SS 3A), **Fioralba Cakoni** and **Peter B. Monk**, University of Delaware.

Probabilistic Paradigms in Combinatorics (Code: SS 16A), **Joshua N. Cooper**, Courant Institute of Mathematics, NYU, and **Jozef Skokan**, Universidade de Sao Paulo.

Recent Progress in Thin Fluid Flows (Code: SS 11A), **Richard J. Braun**, University of Delaware.

Singular Analysis and Spectral Theory of Partial Differential Equations (Code: SS 2A), **Juan B. Gil**, Pennsylvania State University, Altoona, and **Gerardo A. Mendoza**, Temple University.

Spectral and High-Order Discretization Methods for Partial Differential Equations (Code: SS 14A), **Tobin A. Driscoll**, University of Delaware.

Symmetry Methods for Partial Differential Equations (Code: SS 10A), **Philip Broadbridge**, University of Delaware, and **Danny Arrigo**, University of Central Arkansas.

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 8%. 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 Mathemat-**

ical Society (AMS) Meeting at the University of Delaware group. Cancellation and early checkout policies vary; be sure to check when you make your reservation.

Sleep Inn Hotel, 630 S. College Ave., Newark, DE 19713; phone: 302-453-1700, fax: 302-453-1710; $69/single or double; free deluxe continental breakfast, free high-speed Internet, in-room minirefrigerator and coffeemaker; about 1 mile to the meeting site (across from the stadium). **Deadline for reservations is March 11, 2005; cite group #100924.** Be sure to check cancellation and early checkout policies.

Super 8 Motel, 268 East Main St., Newark, DE 19711; phone: 302-737-5050, fax: 302-737-4089; $48.88/single or double, free continental breakfast; about 1/2 mile to the meeting site. This is a small hotel with a limited number of rooms available. **Deadline for reservations is March 1, 2005; cite group code CGCGAM.** Be sure to check cancellation and early checkout policies.

Howard Johnson Inn & Suites, 1119 South College Ave., Newark, DE 19713; phone: 302-368-8521, fax: 302-368-9868; $56/single king bed, $59/two queen beds, $69/suite (two double beds plus separate parlor); free deluxe continental hot breakfast (eggs/waffles/fruit), in-room refrigerator/microwave/coffeemaker; about 1.5 miles to the meeting site. **Deadline for reservations is March 11, 2005; cite group #11-53.** Be sure to check cancellation and early checkout policies.

Courtyard Newark, 400 Pencader Way, Newark, DE 19716; phone: 302-737-0900, fax: 302-737-0990; $109/single or double; restaurant open for breakfast and dinner, in-room coffeemaker and refrigerator, about 1/2 mile to the meeting site. **Deadline for reservations is March 3, 2005.** Be sure to check cancellation and early checkout penalties.

Food Service

Information will be available at the meeting.

Local Information

The university's webpage is `http://www.udel.edu`; see the "Travel" section below for map links to the campus and surrounding area.

Other Activities

Book Sales: Examine the newest titles from the AMS! Many of the AMS books will be available at a special 50% discount available only at the meeting. 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 will be available in the Trabant Parking garage at the corner of West Main and Elkton (next to the Trabant University Center). The cost is $.55/hour with a maximum of $3/day.

Registration and Meeting Information

The meeting is on the main campus of the University of Delaware, Newark, Delaware. Sessions and Invited Addresses will take place in the Ewing, Kirkbride, Purnell, and Smith Halls.

The registration desk will be in Purnell Hall and will be open Saturday, April 2, 7:30 a.m. to 4:00 p.m., and Sunday, April 3, 8:00 a.m. to noon. Fees are $40 for AMS or CMS members, $60 for nonmembers; and $5 for students/unemployed/emeritus, payable on site by cash, check, or credit card.

Social Event

All participants are invited to a reception on Saturday evening. The AMS thanks the Department of Mathematics and the university for their hospitality.

Travel and Campus Map

The University of Delaware is located in downtown Newark and is approximately 35 miles from Philadelphia, 70 miles from Baltimore, MD, and 105 miles from Washington, DC. A campus map, parking map, a campus "walkabout" map, and Newark area map can be found at `http://www.udel.edu/main/campuses/printmap.html`.

The closest airport is Philadelphia International Airport (PHL) and is serviced by all major airlines. **Delta Air Lines** has been selected as the official airline for this meeting because of economical rates and convenient schedules. The following specially negotiated rates are available for this meeting exclusively for mathematicians and their families for the period March 30, 2005, through April 6, 2005. Other restrictions/discounts may apply, and seats are limited.

Delta Air Lines is offering:

- A 5% discount off Delta's published round-trip fares within the continental United States, excluding A, D, I, U and T classes of service.
- A 10% discount off Delta's domestic published unrestricted round-trip coach fares (Y06/YR06) rates. No advance reservations or ticketing is required.
- An additional 5% bonus discount if you purchase your ticket 60 days or more prior to your departure through Meeting Network Reservations or your travel agent; online not applicable.

To take advantage of these discounts and make immediate reservations, visit `http://www.delta.com` or call Delta Meeting Network at 1-800-241-6760 between 8:00 a.m. and 11:00 p.m. Eastern Standard Time, Monday through Sunday, referencing **File Number 205779A.**

Shuttle service between the Philadelphia International Airport and Newark, Delaware (to your hotel, campus, or other location and back), can be arranged through Delaware Express Shuttle (phone 800-648-5466 or online at `http://www.delexpress.com`) for about $36 (plus tip) each way for individuals.

Getting to the University by Car

From the north: Take I95 South to Delaware Exit 1B, Route 896 North, which becomes South College Avenue at the

intersection of Route 4. Continue on South College Avenue (past Fred P. Rullo Stadium, the Bob Carpenter/Sports Convocation Center, Delaware Stadium, and the Delaware Field House) until you come to Main Street. Turn left onto West Main Street; the Trabant Garage is on your left just past Trabant University Center.

From the south: Take I95 North to Delaware Exit 1, Route 896 North, which becomes South College Avenue at the intersection of Route 4. Continue on South College Avenue (past Fred P. Rullo Stadium, the Bob Carpenter/Sports Convocation Center, Delaware Stadium, and the Delaware Field House) until you come to Main Street. Turn left onto West Main Street; the Trabant Garage is on your left just past Trabant University Center.

From the west: Take the Pennsylvania Turnpike East to Route 283 South. Continue on Route 283 South, which becomes Route 30 East outside of Lancaster, to Route 896 South. As you reach campus and cross the railroad tracks, immediately turn left onto Delaware Avenue, right (at the second traffic light) onto South College Avenue, then left onto West Main Street. The Trabant Garage is on your left just past Trabant University Center.

Information for International Participants

International participants should view this important information about traveling to the United States: `http://www7.nationalacademies.org/visas/Traveling_to_US.html`.

Weather

Weather conditions in Newark during early April are cool to moderate, with nighttime lows of about 40°F and daytime highs around 60°F.

Lubbock, Texas

Texas Tech University

April 8–10, 2005

Friday - Sunday

Meeting #1006

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2005
Program first available on AMS website: February 24, 2005
Program issue of electronic *Notices*: April 2005
Issue of *Abstracts*: Volume 26, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: February 15, 2005

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Nikolai Ivanov, Michigan State University, *Title to be announced.*

Mattias Jonsson, University of Michigan, *Title to be announced.*

Nicolas Monod, University of Chicago, *Title to be announced.*

Hee Oh, California Institute of Technology, *Title to be announced.*

Special Sessions

Classical and Differential Galois Theory (Code: SS 3A), **Lourdes Juan** and **Arne Ledet**, Texas Tech University, and **Andy R. Magid**, University of Oklahoma.

Differential Geometry and Its Applications (Code: SS 2A), **Josef F. Dorfmeister**, Munich University of Technology, **Magdalena D. Toda**, Texas Tech University, and **Hongyou Wu**, Northern Illinois University.

Discrete Groups, Homogeneous Spaces, Rigidity (Code: SS 15A), **Alex Gorodnik**, University of Michigan, Ann Arbor, **Hee Oh**, California Institute of Technology, and **Nicolas Monod**, University of Chicago.

Extinction, Periodicity, and Chaos in Population and Epidemic Models (Code: SS 10A), **Linda J. S. Allen**, Texas Tech University, **Sophia Ruey-Jen Jang**, University of Louisiana at Lafayette, and **Lih-Ing W. Roeger**, Texas Tech University.

Future Directions in Mathematical Systems and Control Theory (Code: SS 11A), **David Gilliam** and **W. P. Dayawansa**, Texas Tech University.

Graph Theory (Code: SS 12A), **John C. George**, Eastern New Mexico University, and **Walter D. Wallis**, Southern Illinois University at Carbondale.

Homological Algebra and Its Applications (Code: SS 4A), **Alex Martsinkovsky**, Northeastern University, and **Mara D. Neusel**, Texas Tech University.

Invariants of Links and 3-Manifolds (Code: SS 8A), **Mieczyslaw Krzysztof Dabkowski**, University of Texas at Dallas, **Razvan Gelca**, Texas Tech University, and **Jozef Henryk Przytycki**, George Washington University.

Partial Differential Equation and Its Application in Biomedical Study (Code: SS 16A), **Jay R. Walton**, Texas A&M University, and **Padmanabhan Seshaiyer** and **Akif Ibragimov**, Texas Tech University.

Real Algebraic Geometry (Code: SS 6A), **Anatoly Korchagin** and **David Weinberg**, Texas Tech University.

Recent Advances in Complex Function Theory (Code: SS 5A), **Brock Williams**, **Roger W. Barnard**, and **Kent Pearce**, Texas Tech University.

Statistical Image Processing and Analysis and Applications (Code: SS 13A), **Victor Patrangenaru**, Texas Tech University.

Theory and Application of Stochastic Differential Equations (Code: SS 9A), **Edward J. Allen**, Texas Tech University, and **Armando Arciniega**, University of Texas at San Antonio.

Topology of Continua (Code: SS 1A), **Wayne Lewis**, Texas Tech University.

Topology of Dynamical Systems (Code: SS 7A), **Brian Raines**, Baylor University.

Undergraduate and Graduate Student Research (Code: SS 14A), **Ali Khoujmane**, **Edward W. Swim**, **Edward J. Allen**, and **Padmanabhan Seshaiyer**, Texas Tech University.

Poster Session

Poster session organized by **Ali Khoujmane** and **Mara D. Neusel**, Texas Tech.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice and state that they will be attending the AMS meeting. The AMS is not responsible for rate changes or for the quality of the accommodations. Rates quoted do not include sales tax. **Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation.**

Four Points Sheraton, 505 Avenue Q, Lubbock, TX 79401; phone: 806-747-0171, fax: 806-747-9243. Group rate of $58 per night plus 13% local tax. Doubles and kings reserved. Hotel provides complimentary 24-hour airport shuttle. Near Civic Center and Buddy Holly Walk of Fame. Approximately one mile east of campus. Deadline for reservations is March 8. Limited shuttle service to and from the campus will be provided by the Department of Mathematics and Statistics.

La Quinta Inn, Civic Center, 601 Avenue Q, Lubbock, TX 79401; phone: 806-763-9441, fax: 806-747-9325. Group rate of $56 per night plus 13% local tax. One block south of Four Points. Deadline for reservations is March 31. Limited shuttle service to and from the campus will be provided by the Department of Mathematics and Statistics.

Hawthorn Suites, 2515–19th Street, Lubbock, TX 79410; phone: 806-765-8900, fax: 806-765-5322. Group rate of $80 per night plus 13% local tax for queen suite. Located across the street (19th Street, six-lane U.S. 62/Texas 114) from southeast corner of campus. Deadline for reservations is March 7.

Food Service

Information will be provided on site.

Local Information and Campus Map

Please visit the websites maintained by the Department of Mathematics and Statistics at `http://www.math.ttu.edu/~wlewis/amscs/amscs.html` and `http://www.math.ttu.edu`, the Texas Tech University website at `http://www.ttu.edu` and for a campus map: `http://www.ttu.edu/campusmap/`.

Other Activities

AMS Book Sale: Examine the newest titles from the AMS! Complimentary coffee will be served, courtesy of AMS Membership Services. The AMS Book Sale will operate during the same hours as registration. The location of the Book Sale will be announced at a later date.

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 on campus is regulated during weekdays. Upon entering campus inform the attendant at the entry station that you are here for the mathematics conference. You will be directed either to visitor parking or to metered parking. The Broadway entrance is the main entrance to campus, with the Mathematics Building on the northwest side of the circle. On weekends parking is available in any marked parking spot not indicated as reserved 24 hours.

Registration and Meeting Information

The registration desk will be open 8:00 a.m. to 4:00 p.m. on Friday, and 8:00 a.m. to noon on Saturday, in the Mathematics Building.

Registration Fees: (payable on-site only) $40/AMS members; $60/nonmembers; $5/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Social Event

The Department of Mathematics and Statistics will host a reception for all conference participants Friday evening, April 8, 2005, at a time and location to be announced.

Travel

Lubbock (airport code LBB) is served by American, Continental, and Southwest Airlines. (Though a fourth airline, Delta, currently serves Lubbock, it will discontinue service at the end of January 2005.)

From the Lubbock Airport: Leaving the Lubbock airport, one will be heading south on M. L. King Boulevard. At the first intersection (a four-way stop with Budget Rent-A-Car and the Airport Shelter Parking facility on the corners) turn right and proceed to Interstate 27. Turn left and enter Interstate 27 South. For the Four Points and La Quinta, take Exit 4, U.S. 82, and turn right on 4th street, then left on Ave. Q. The hotels will be in the second and third blocks on the left after turning onto Ave. Q. To reach campus, proceed down Ave. Q to Broadway (which would otherwise be 12th Street in the numbering) and turn right. Broadway goes directly into the main entrance to campus.

For the Hawthorn, take Exit 3, U.S. 62/Texas 114, and turn right onto 19th Street. Proceed west on 19th Street past the southern part of downtown. At University Avenue turn left and then immediately right into the Hawthorn parking lot. The Texas Tech University campus will be on the other side of 19th Street. See the maps for more information.

From Interstate 27 South (from the direction of Amarillo): Follow the directions from the airport from the point where one gets on Interstate 27 South.

From U.S. 62/82/Texas 114 West (from the direction of Wichita Falls or Denton): U.S. 82 approaches Lubbock from Wichita Falls and Sherman. For the last 150 miles it

coincides with Texas 114, which approaches Lubbock from just west of Denton. For the last 30 miles these coincide with U.S. 62, which approaches Lubbock from Childress. On the northeast edge of Lubbock, just after passing under Loop 289, U.S. 62/Texas 114 diverges to the right from U.S. 82. U.S. 82 becomes 4th Street, and the directions from the airport apply after crossing under Interstate 27, while U.S. 62/Texas 114 becomes 19th Street, and the directions from the airport apply after crossing under Interstate 27.

From U.S. 84 North (from the direction of Abilene or Sweetwater): U.S. 84 North enters Lubbock at the southeast corner of town. After entering town, proceed under Loop 289 to Interstate 27. Turn right to enter Interstate 27 North and proceed to Exit 3, U.S. 62/Texas 114 (from this direction also labelled 19th Street). Take Exit 3 and turn left for 19th Street heading west. From this point follow the directions provided from the airport.

From U.S. 84 South (from the direction of Clovis or Santa Rosa, New Mexico): Follow U.S. 84 South under Loop 289. U.S. 84 South becomes Ave. Q just after a slight turn before 4th Street. The Four Points and La Quinta are on the left side of Ave. Q in the second and third blocks after 4th Street. To reach campus, turn right on Broadway (which would otherwise be 12th Street in the numbering) and proceed directly to the main entrance to campus. (Alternatively, to reach campus after coming into town, turn right onto University Avenue from U.S. 84 South before reaching Ave. Q and proceed to Broadway, where a left turn immediately takes you into the campus.) To reach the Hawthorn Suites, from U.S. 84 South turn right onto University Avenue. Hawthorn Suites will be on the right just after passing campus and crossing 19th Street.

Car Rental

Avis is the official car rental company for the sectional meeting in Lubbock, Texas. All rates include unlimited free mileage. Weekend daily rates are available from noon Thursday to Monday at 11:59 p.m. and start at $27 per day. Rates for this meeting are effective April 1, 2005–April 17, 2005. 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 lower. Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges. Renters must meet Avis's age, driver, and credit requirements. Reservations can be made by calling 1-800-331-1600 or online at `http://www.avis.com`. **Meeting Avis Discount Number B159266.**

Weather

Please visit `http://www.accuweather.com/adcbin/public/local_index.asp?zipcode=79401` for current and future weather conditions in Lubbock.

Santa Barbara, California

University of California Santa Barbara

April 16–17, 2005

Saturday - Sunday

Meeting #1007

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2005
Program first available on AMS website: March 3, 2005
Program issue of electronic *Notices*: April 2005
Issue of *Abstracts*: Volume 26, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: February 22, 2005

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Mei-Chu Chang, University of California Riverside, *Set addition and set multiplication.*

Mischa Kapovich, University of California Davis, *Title to be announced.*

Mihai Putinar, University of California Santa Barbara, *Positive polynomials, a hilbertian perspective.*

James Sethian, University of California Berkeley, *Advances in advancing interfaces: New techniques for propagating fronts in wave propagation and materials sciences.*

Special Sessions

Algebraic Geometry and Combinatorics (Code: SS 14A), **Alexander Yong** and **Allen Knutson**, University of California Berkeley.

Arithmetic Geometry (Code: SS 13A), **Adebisi Agboola**, University of California Santa Barbara, and **Cristian Dumitru Popescu**, University of California San Diego.

Automorphisms of Surfaces (Code: SS 4A), **Anthony Weaver**, Bronx Community College of the City University of New York, and **Peter Turbek**, Purdue University Calumet.

Complexity of Computation and Algorithms (Code: SS 10A), **Mark Burgin**, University of California Los Angeles.

Curvature in Group Theory and Combinatorics (Code: SS 11A), **Laura M. Anderson**, State University of New York at Binghamton, **Noel Patrick Brady**, University of Oklahoma, **Robin Forman**, Rice University, and **Jonathan P. McCammond**, University of California Santa Barbara.

Dynamical Systems in Neuroscience (Code: SS 1A), **Eugene M. Izhikevich**, The Neurosciences Institute.

Function Theory (Code: SS 12A), **Mihai Putinar** and **Stephan R. Garcia**, University of California Santa Barbara.

Geometric Methods in Three Dimensions (Code: SS 6A), **Daryl Cooper**, **David Darren Long**, and **Martin G. Scharlemann**, University of California Santa Barbara.

Geometry and Physics (Code: SS 8A), **Xianzhe Dai**, University of California Santa Barbara, and **Zhiqin Lu**, University of California Irvine.

History of Mathematics (Code: SS 2A), **Shawnee L. McMurran**, California State University, San Bernardino, and **James J. Tattersall**, Providence College.

Noncommutative Geometry and Algebra (Code: SS 5A), **Kenneth R. Goodearl**, University of California Santa Barbara, **J. T. Stafford**, University of Michigan, and **J. J. Zhang**, University of Washington.

Recent Advances in Combinatorial Number Theory (Code: SS 3A), **Mei-Chu Chang**, University of California Riverside, and **Van Ha Vu**, University of California San Diego.

Representation Theory of Algebras (in Honor of Claus Michael Ringel) (Code: SS 7A), **Alex Martsinkovsky**, Northeastern University, **Dan Zacharia**, Syracuse University, and **Birge K. Huisgen-Zimmermann**, University of California Santa Barbara.

Ricci Flow/Riemannian Geometry (Code: SS 9A), **Guofang Wei** and **Rugang Ye**, University of California Santa Barbara.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice and request the UCSB discount. The AMS is not responsible for rate changes or for the quality of the accommodations. Rates quoted do not include sales tax of 10%. **Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation.**

Best Western South Coast Inn, 5620 Calle Real, Goleta, CA 93117; 805-967-3200; $112 single/double. Free shuttle to/from the airport and UCSB between 7:30 a.m. and 10:30 p.m., complementary continental breakfast. Rooms have high-speed Internet connections. For further information visit `http://www.BWSCI.com`. **Deadline for reservations is March 15.**

Motel 6, 5897 Calle Real, Goleta, CA; 805-964-6241; rates start at $59/single or double. **Reservations are on a first-come-first-served basis.**

Ramada Limited, 4770 Calle Real, Goleta, CA: 805-964-3511; from $120/night. Complimentary transportation provided between airport and inn, complementary continental breakfast. Rooms have high-speed Internet connections. For further information visit `http://www.SBRAMADA.COM`. **Deadline for reservations is March 1.**

Food Service

There are a number of restaurants adjacent to the campus. A list of restaurants will be available at the registration desk. Food service will also be available in the University Center and the Arbor located on campus.

Local Information and Campus Map

Please visit the website maintained by the Department of Mathematics at `http://www.math.ucsb.edu`, campus map at `http://www.aw.id.ucsb.edu/ucsbmap.html`, Santa Barbara Visitors Bureau site at `http://www.santabarbaraca.com`, or the site maintained by the city of Santa Barbara at `http://www.ci.santa-barbara.ca.us`.

Other Activities

AMS Book Sale: Examine the newest titles from the AMS! Complimentary coffee will be served, courtesy of AMS Membership Services. The AMS Book Sale will operate during the same hours as registration. The location of the Book Sale will be announced at a later date.

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

After 5:00 p.m. on weekdays and virtually all day and evening on weekends, most campus lots are open to all parkers. There are a few exceptions to this, so be sure to read lot signage or any special notations on parking stalls in spaces that are marked "R" or "Service Vehicle" or the like. There is no need to obtain a parking permit unless on campus during the work week (M-F 8–5). The kiosks at the east and west gates are open on weekends and are a good check-in point for a campus map and further information. Campus parking: `http://www.tps.ucsb.edu/Paybyspace.html` and `http://www.tps.ucsb.edu/visitor.html`.

Registration and Meeting Information

The registration desk (location to be announced) will be open 8:00 a.m. to 4:00 p.m. on Saturday and 8:00 a.m. to noon on Sunday.

Registration fees (payable on-site only) are $40/AMS members; $60/nonmembers; $5/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Travel

By Air: UCSB is served by the Santa Barbara Airport (SBA), `http://www.flysba.com/?pageID=42`. Most people traveling by air will initially land at Los Angeles International Airport (LAX), approximately 2.5 hours driving time from Santa Barbara. Options for travel to UCSB from LAX include the Santa Barbara Airbus or car rental. The Santa Barbara Airbus provides several daily trips from LAX to Santa Barbara. For fare information phone 800-423-1618 (within the U.S./Canada) or 805-964-7759 (outside U.S./Canada) or visit `http://www.santabarbaraairbus.com`.

Delta Air Lines has been selected as the official airline for this meeting. The following specially negotiated rates are available for this meeting exclusively for mathematicians and their families for the period April 13, 2005, through April 20, 2005. Other restrictions/discounts may apply and seats are limited.

Delta Air Lines is offering:

• A 5% discount off Delta's published round-trip fares within the continental United States, excluding A, D, I, U and T classes of service.

• A 10% discount off Delta's domestic published unrestricted round-trip coach fares (Y06/YR06) rates. No advance reservations or ticketing is required.

• An additional 5% bonus discount if you purchase your ticket 60 days or more prior to your departure through Meeting Network Reservations or your travel agent; online not applicable.

To take advantage of these discounts and make immediate reservations, call Delta Meeting Network at 1-800-241-6760 between 8:00 a.m. and 11:00 p.m. Eastern Standard Time, Monday through Sunday, referencing **File Number 205779A**.

Car Rental

Avis is the official car rental company for the sectional meeting in Santa Barbara, California. All rates include unlimited free mileage. Special rates for this meeting are effective April 9, 2005–April 24, 2005, and begin at $26/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 lower. Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges. Renters must meet Avis's age, driver, and credit requirements. Reservations can be made by calling 1-800-331-1600 or online at `http://www.avis.com`. **Meeting Avis Discount Number B159266.**

Driving: UCSB is easily accessible from U.S. 101. From the south take the UCSB/Highway 217 exit. From the north take Storke Road/UCSB exit and drive south (toward the ocean) to the junction with El Colegio Road. Turn left onto El Colegio Road and proceed to the west gate kiosk.

Other: Santa Barbara is also served by Amtrak train service and Greyhound bus service.

Weather

Located on the coast of California, Santa Barbara County's climate is mild and sunny all year, with an average daytime temperature between 60°F and 70°F (16°C and 21°C). Santa Barbara attire is generally California casual.

Mainz, Germany

Johannes Gutenberg University

June 16–19, 2005

Thursday - Sunday

Meeting #1008

Joint International Meeting with the Deutsche Mathematiker-Vereinigung (DMV) and the Oesterreichische Mathematische Gesellschaft (OMG)
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: March 2005
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: To be announced
For abstracts: March 31, 2005

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

Invited Addresses

Helene Esnault, University of Essen, *Deligne's Integrality Theorem in unequal characteristic and rational points over finite fields.*

Richard Hamilton, Columbia University, *The Ricci flow.*

Michael J. Hopkins, Massachusetts Institute of Technology, *Title to be announced.*

Christian Krattenthaler, University of Lyon-I, *Exact and asymptotic enumeration of vicious walkers with a wall interaction.*

Frank Natterer, University of Muenster, *Imaging and inverse problems for partial differential equations.*

Horng-Tzer Yau, New York University and Stanford University, *Dynamics of Bose-Einstein condensate.*

Special Sessions

Affine Algebraic Geometry, **Shreeram Abhyankar**, Purdue University, **Hubert Flenner**, Fakultät für Mathematik, and **Makar Limanov**, Wayne State University.

Algebraic Combinatorics, **Patricia Hersh**, University of Michigan, **Christian Krattenthaler**, University of Lyon-I, and **Volkmar Welker**, Philipps University Marburg.

Algebraic Cryptography, **Dorian Goldfeld**, Columbia University, **Martin Kreuzer** and **Gerhard Rosenberger**, Universität Dortmund, and **Vladimir Shpilrain**, City College of New York.

Algebraic Cycles, **Eric Friedlander** and **Marc Levine**, Northwestern University, and **Fabien Morel**, Université Paris.

Algebraic Geometry, **Yuri Tschinkel**, Georg-August-Universität Göttingen, and **Brendan E. Hassett**, Rice University.

Dirac Operators, Clifford Analysis and Applications, **Klaus Gürlebeck**, University of Weimar, **Mircea Martin**, Baker University, **John Ryan**, University of Arkansas, and **Michael Shapiro**, IPN Mexico.

Discrete Geometry, **Jacob Eli Goodman**, The City College of New York (CUNY), **Emo Welzl**, Eidgen Technische Hochschule, and **Gunter M. Ziegler**, Technical University of Berlin.

Function Spaces and Their Operators, **Ernst Albrecht**, Universität des Saarlandes, **Raymond Mortini**, Université de Metz, and **William Ross**, University of Richmond.

Functional Analytic and Complex Analytic Methods in Linear Partial Differential Equations, **R. Meise**, University of Dusseldorf, **B. A. Taylor**, University of Michigan, and **Dietmar Vogt**, University of Wuppertal.

Geometric Analysis, **Victor Nistor**, Pennsylvania State University, and **Elamr Schrohe**, Universität Hannover.

Geometric Topology and Group Theory, **Cameron McA Gordon**, University of Texas at Austin, **Cynthia Hog-Angeloni**, Johann Wolfgang Goethe-Universität, and **Wolfgang Metzler**, University of Frankfurt.

Group Theory, **Luise-Charlotte Kappe**, SUNY at Binghamton, **Robert Fitzgerald Morse**, University of Evansville, and **Gerhard Rosenberger**, University of Dortmund.

Hilbert Functions and Syzygies, **Uwe Nagel**, University of Kentucky, **Irena Peeva**, Cornell University, and **Tim Römer**, Universität Osnabrück.

History of Mathematics: Mathematics and War, **Thomas W. Archibald**, Acadia University, **John H. McCleary**, Vassar College, **Moritz Epple**, University of Stuttgart, and **Norbert Schappacher**, Technische Universität Darmstadt.

Homotopy Theory, **Paul G. Goerss**, Northwestern University, **Hans-Werner Henn**, Institut de Recherche Mathématique Avancée, Strasbourg, and **Stefan Schwede**, Universität Bonn.

Hopf Algebras and Quantum Groups, **Susan Montgomery**, University of Southern California, and **Hans-Jurgen Schneider**, University of Munich.

Mathematics Education, **Gunter Torner**, Universität Duisburg-Essen, and **Alan Schoenfeld**, School of Education, Berkeley.

Modules and Comodules, **Sergio López-Permouth**, Ohio University, and **Robert Wisbauer**, University of Düsseldorf.

Multiplicative Arithmetic of Integral Domains and Monoids, **Scott Chapman**, Trinity University, San Antonio, **Franz Halter-Koch**, University of Graz, and **Ulrich Krause**, Universität Bremen.

Nonlinear Elliptic Boundary Value Problems, **Thomas Bartsch**, Universität Giessen, and **Zhi-Qiang Wang**, Utah State University.

Nonlinear Waves, **Herbert Koch**, University of Dortmund, and **Daniel I. Tataru**, University of California Berkeley.

Ordinary Differential, Difference, and Dynamic Equations, **Werner Balser**, Universität Ulm, **Martin Bohner**, University of Missouri-Rolla, and **Donald Lutz**, San Diego State University.

Quantum Knot Invariants, **Anna Beliakova**, Universität Zürich, and **Uwe Kaiser**, Boise State University.

Representations and Cohomology of Groups and Algebras, **Dave Benson**, University of Georgia, and **Henning Krause**, Universität Paderborn.

Set Theory, **Joel Hamkins**, City University New York, **Peter Koepke**, Universität Bonn, and **Benedikt Löwe**, Universiteit van Amsterdam.

Spectral Analysis of Differential and Difference Operators, **Evgeni Korotyaev**, Humboldt-University Berlin, **Boris Mityagin**, The Ohio State University, and **Gerald Teschl**, University of Vienna.

Stochastic Analysis on Metric Spaces, **Laurent Saloff-Coste**, Cornell University, **Karl-Theodor Sturm**, University of Bonn, and **Wolfgang Woess**, Graz Technical University.

Topics in Applied Mathematics and Mechanics: Mathematical Control Theory and Numerical Methods, **Peter Benner**, Fakultät für Mathematik.

Topics in Applied Mathematics and Mechanics: Mechanics, **Friedrich Pfeiffer**, Technical University of Munich.

Topics in Applied Mathematics and Mechanics: Multiscale Problems, Oscillations in PDEs, and Homogenization, **Alexander Mielke**, University of Hannover.

Topics in Applied Mathematics and Mechanics: Numerical PDEs, Equations with Inherent Conditions, **Rolf Jeltsch**, Eidgen Technische Hochschule, **Maria Lukacova**, Technical University of Brno, and **Mac Hyman**, Los Alamos National Laboratory.

Topics in Applied Mechanics: Algebraic Approaches to Preconditioning, **Heike Fassbender**, Technical University of Braunschweig, and **Andreas Frommer**, University of Wuppertal.

Topology of Manifolds, **Matthias Kreck**, University of Heidelberg, and **Andrew Ranicki**, University of Edinburgh.

Annandale-on-Hudson, New York

Bard College

October 8–9, 2005
Saturday - Sunday

Meeting #1009
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2005
Program first available on AMS website: August 25, 2005
Program issue of electronic *Notices*: October 2005
Issue of *Abstracts*: Volume 26, Issue 4

Deadlines

For organizers: March 8, 2005
For consideration of contributed papers in Special Sessions: June 21, 2005
For abstracts: August 16, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Persi Diaconis, Stanford University, *Title to be announced* (Erdős Memorial Lecture).

Harold Rosenberg, University of Paris VII, *Title to be announced.*

Alice Silverberg, University of California Irvine, *Title to be announced.*

Christopher Sogge, Johns Hopkins University, *Title to be announced.*

Benny Sudakov, Princeton University, *Title to be announced.*

Special Sessions

Geometric Group Theory (Code: SS 1A), **Sean Cleary**, The City College of New York, and **Melanie I. Stein**, Trinity College.

Geometric Transversal Theory (Code: SS 3A), **Richard Pollack**, Courant Institute, New York University, and **Jacob Eli Goodman**, The City College of New York.

Global Theory of Minimal Surfaces (Code: SS 6A), **David A. Hoffman**, Mathematical Sciences Research Institute, and **Harold Rosenberg**, University of Paris VII.

The History of Mathematics (Code: SS 2A), **Patricia R. Allaire**, Queensborough Community College, CUNY, **Robert E. Bradley**, Adelphi University, and **Jeff Suzuki**, Bard College.

Homological Aspects of Commutative Algebra (Code: SS 4A), **Alexandre Tchernev**, University of Albany, SUNY, and **Janet Vassilev**, University of Arkansas.

Special Functions and Orthogonal Polynomials: Theory and Applications (Code: SS 7A), **Diego Dominici**, State University of New York at New Paltz.

Theory of Infinite-Dimensional Lie Algebras, Vertex Operator Algebras, and Related Topics (Code: SS 5A), **Antun Milas**, SUNY at Albany, **Alex J. Feingold**, Binghamton University, and **Yi-Zhi Huang**, Rutgers University.

Johnson City, Tennessee

East Tennessee State University

October 15–16, 2005
Saturday - Sunday

Meeting #1010
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: August 2005
Program first available on AMS website: September 1, 2005
Program issue of electronic *Notices*: October 2005
Issue of *Abstracts*: Volume 26, Issue 4

Deadlines

For organizers: March 15, 2005
For consideration of contributed papers in Special Sessions: June 28, 2005
For abstracts: August 23, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Alberto Bressan, Pennsylvania State University, *Title to be announced.*

Assaf Naor, Microsoft Research, *Title to be announced.*

Prasad V. Tetali, Georgia Institute of Technology, *Title to be announced.*

Rekha R. Thomas, University of Washington, *Title to be announced.*

Lincoln, Nebraska

University of Nebraska in Lincoln

October 21–23, 2005
Friday - Sunday

Meeting #1011
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2005
Program first available on AMS website: September 8, 2005
Program issue of electronic *Notices*: October 2005
Issue of *Abstracts*: Volume 26, Issue 4

Deadlines

For organizers: March 22, 2005
For consideration of contributed papers in Special Sessions: July 5, 2005
For abstracts: August 30, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Howard Masur, University of Illinois at Chicago, *Title to be announced.*

Alejandro Uribe, University of Michigan, *Title to be announced.*

Judy Walker, University of Nebraska, *Title to be announced.*

Jack Xin, University of Texas, *Title to be announced.*

Special Sessions

Algebraic Geometry (Code: SS 1A), **Brian Harbourne**, University of Nebraska-Lincoln, and **Bangere P. Purnaprajna**, University of Kansas.

Recent Progress in Operator Algebras (Code: SS 2A), **Allan P. Donsig** and **David R. Pitts**, University of Nebraska.

Eugene, Oregon

University of Oregon

November 12–13, 2005

Saturday - Sunday

Meeting #1012

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: September 2005
Program first available on AMS website: September 29, 2005
Program issue of electronic *Notices*: November 2005
Issue of *Abstracts*: Volume 26, Issue 4

Deadlines

For organizers: April 12, 2005
For consideration of contributed papers in Special Sessions: July 26, 2005
For abstracts: September 20, 2005

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Matthew Foreman, University of California Irvine, *Title to be announced.*

Mark Haiman, University of California Berkeley, *Title to be announced.*

Wilhelm Schlag, California Institute of Technology, *Title to be announced.*

Hart H. Smith, University of Washington, *Title to be announced.*

Special Sessions

Noncommutative Algebra and Noncommutative Birational Geometry (Code: SS 3A), **Arkady Dmitrievich Berenstein**, University of Oregon, and **Vladimir Retakh**, Rutgers University.

Regular Algebras and Noncommutative Projective Geometry (Code: SS 2A), **Brad Shelton**, University of Oregon, **Michaela Vancliff**, University of Texas at Arlington, and **James J. Zhang**, University of Washington.

Resolutions (Code: SS 1A), **Christopher Alan Francisco**, University of Missouri, and **Irena Peeva**, Cornell University.

Taiwan

December 14–18, 2005

Wednesday - Sunday

Meeting #1013

First Joint International Meeting between the AMS and the Taiwanese Mathematical Society.
Associate secretary: John L. Bryant
Announcement issue of *Notices*: May 2005
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center

January 12–15, 2006

Thursday - Sunday

Meeting #1014

Joint Mathematics Meetings, including the 112th Annual Meeting of the AMS, 89th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2005
Program first available on AMS website: November 1, 2005
Program issue of electronic *Notices*: January 2006
Issue of *Abstracts*: Volume 27, Issue 1

Deadlines

For organizers: April 12, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Miami, Florida

Florida International University

April 1–2, 2006

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 1, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Durham, New Hampshire

University of New Hampshire

April 22–23, 2006

Saturday - Sunday
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 22, 2005
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

San Francisco State University

April 29–30, 2006

Saturday - Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Special Sessions

History of Mathematics (Code: SS 1A), **Shawnee L. McMurran**, California State University, San Bernardino, and **James J. Tattersall**, Providence College.

Fayetteville, Arkansas

University of Arkansas

November 3–4, 2006

Friday - Saturday
Southeastern Section
Associate secretary: 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 3, 2006
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 4–7, 2007

Thursday - Sunday
Joint Mathematics Meetings, including the 113th Annual Meeting of the AMS, 90th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 2006
Program first available on AMS website: To be announced

Program issue of electronic *Notices*: January 2007
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 4, 2006
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Oxford, Ohio

Miami University

March 16–17, 2007

Friday – Saturday
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: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center

January 6–9, 2008

Sunday – Wednesday
Joint Mathematics Meetings, including the 114th Annual Meeting of the AMS, 91st Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2007
Program first available on AMS website: November 1, 2007
Program issue of electronic *Notices*: January 2008
Issue of *Abstracts*: Volume 29, Issue 1

Deadlines

For organizers: April 6, 2007
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Washington, District of Columbia

Marriott Wardman Park Hotel and Omni Shoreham Hotel

January 7–10, 2009

Wednesday – Saturday
Joint Mathematics Meetings, including the 115th Annual Meeting of the AMS, 92nd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: October 2008
Program first available on AMS website: November 1, 2008
Program issue of electronic *Notices*: January 2009
Issue of *Abstracts*: Volume 30, Issue 1

Deadlines

For organizers: April 7, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 6–9, 2010

Wednesday – Saturday
Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: 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 5, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

CENTRE INTERFACULTAIRE BERNOULLI (CIB)

CALL FOR PROPOSALS

The Bernoulli Center (CIB), funded jointly by the Swiss National Science Foundation and the Swiss Federal Institute of Technology in Lausanne, has started its activity in March 2002.

Its mission is to support research in mathematics and its applications, to organize and host thematic programs, to provide a supportive and stimulating environment for researchers, and to launch and foster collaborations between mathematicians working in different areas as well as mathematicians and other scientists.

The CIB launches a call for proposals of six one-semester programs during the **period July 1, 2006 - June 30, 2009**. A thematic program consists of a six months period (January 1 - June 30 or July 1 - December 31) of concentrated activity in a specific area of current research interest in the mathematical sciences. In exceptional cases, one year and three month programs will also be considered.

Those who are interested in organizing a program at the CIB should submit a **two page letter of intent by April 1, 2005**. This letter should give the names of the organizers, of the potential visitors, and outline the program. For more details see **http://bernoulli.epfl.ch/recruiting**

Ecole Polytechnique Fédérale de Lausanne
Centre Interfacultaire Bernoulli
SB CIB-GE
AAC034 (Batîment AAC)
Station 15
CH-1015 Lausanne

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011

Wednesday - Saturday

Joint Mathematics Meetings, including the 117th Annual Meeting of the AMS, 94th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).

Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 2010
Program first available on AMS website: November 1, 2010
Program issue of electronic *Notices*: January 2011
Issue of *Abstracts*: Volume 32, Issue 1

Deadlines

For organizers: April 2, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Sproul Hall, Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 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.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at** www.ams.org/meetings/.

Meetings:

2005		
March 18–19	Bowling Green, Kentucky	p. 297
April 2–3	Newark, Delaware	p. 298
April 8–10	Lubbock, Texas	p. 300
April 16–17	Santa Barbara, California	p. 302
June 16–19	Mainz, Germany	p. 304
October 8–9	Annandale-on-Hudson, New York	p. 305
October 15–16	Johnson City, Tennessee	p. 306
October 21–23	Lincoln, Nebraska	p. 306
November 12–13	Eugene, Oregon	p. 307
December 14–18	Taiwan	p. 307
2006		
January 12–15	San Antonio, Texas Annual Meeting	p. 307
April 1–2	Miami, Florida	p. 308
April 22–23	Durham, New Hampshire	p. 308
April 29–30	San Francisco, California	p. 308
November 3–4	Fayetteville, Arkansas	p. 308
2007		
January 4–7	New Orleans, Louisiana Annual Meeting	p. 308
March 16–17	Oxford, Ohio	p. 309
2008		
January 6–9	San Diego, California Annual Meeting	p. 309
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January 7–10	Washington, DC Annual Meeting	p. 309
2010		
January 6–9	San Franciso, California Annual Meeting	p. 309
2011		
January 5–8	New Orleans, Louisiana Annual Meeting	p. 310

Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 100 in the January 2005 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 similarly coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstracts.pl, or send mail to abs-submit@ams.org, typing help as the subject line; descriptions and instructions on how to get the template of your choice will be e-mailed to you.

Questions about abstracts may be sent to abs-info@ams.org.

Paper abstract forms may be sent to Meetings & Conferences Department, AMS, P.O. Box 6887, Providence, RI 02940. There is a $20 processing fee for each paper abstract. There is no charge for electronic abstracts. Note that all abstract deadlines are strictly enforced.

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.)

June 5–July 21, 2005: Joint Summer Research Conferences in the Mathematical Sciences, Snowbird, Utah (see November 2004 *Notices*, page 1294).

July 25–August 12, 2005: Summer Research Institute on Algebraic Geometry, Seattle, Washington (see November 2004 *Notices*, page 1293).

Co-sponsored conference: June 2006: Fifth Conference on Poisson Geometry, Tokyo, Japan (watch http://tmugs.math.metro-u.ac.jp/general.html for future information).

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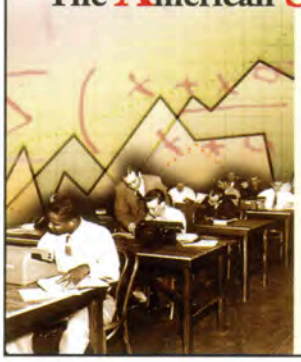

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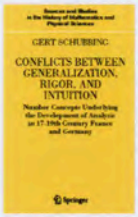

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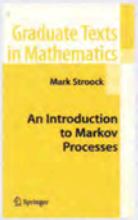

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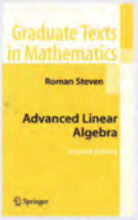

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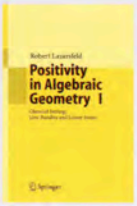

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