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of the American Mathematical Society

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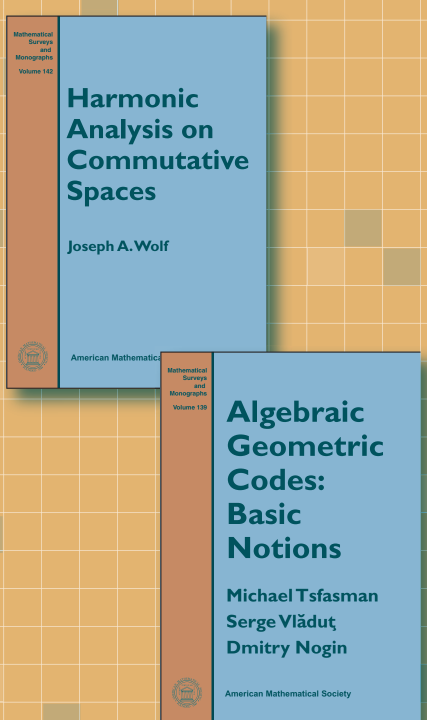

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The Misuse of the Impact Factor

The Impact Factor, as published by the Institute of Scientific Information (ISI) in Philadelphia in its Journal Citation Reports (JCR), is used by some department heads in some countries in faculty assessments. But nowhere in the world is the Impact Factor used as a criterion for rating and ranking scientists across the board nationally, as has been done in Pakistan.

ISI's website has this to say of its JCR: "The ISI Journal Citation Report is a unique multidisciplinary database, ideal for a broad range of practical applications by a variety of information professionals. It presents quantifiable statistical data that provides a systematic, objective way to determine the relative importance of journals within their subject categories." The website also mentions some possible uses of the JCR Impact Factor, including that it "enables a variety of information professionals to access key journal data, including librarians, publishers, editors, authors, and information analysts." But nowhere does it mention that the JCR should be used to determine the worth of scientists, least of all to rank them nationally in order of merit.

In Pakistan the rationale for the use of the Impact Factor is to "help the administrators of science to evaluate the quality and output of scientists who seek key positions." The National Commission on Science has made it a part of its policy to rate scientists and their work on the basis of impact factors of their research papers in accordance with the list of Impact Factors published by the ISI. However, ISI's Impact Factor puts mathematicians in a disadvantageous position, because the index is not suitable for research in mathematics.

Journals of physics and engineering for instance have much greater Impact Factors than mathematical journals, not because they are qualitatively better, but because they have a wider readership and the time spent from acceptance of a paper to its publication is much shorter. The ISI has listed 321 journals under the subject of mathematics, and only 15.58 percent of mathematics journals have impact factors greater than 1. Only four journals have impact factors greater than 2, the highest being 2.75.

The list produced by the ISI itself is defective. For instance, there are a number of high-standard journals which are not mentioned in the list. The *Mathematical Reviews* of the AMS reviews papers every month published in some 1,800 mathematical journals. There are many well-respected journals which are not included in the list.

One critical study of the ISI has revealed that there are 63 journals directly related to chemistry, 5 journals directly related to mathematics, 34 journals directly related to physics, and 430 journals directly related to biology which have an Impact Factor higher than 2. The highest Impact Factor of a sole journal in mathematics is of *Differentiation* (4.0). One notes that in medical sciences, one journal has the Impact Factor 38.854. This means that if one publishes one paper in this journal, one gets an Impact Factor equal to 38.854, whereas if a mathematician publishes 40 research papers in the best journals of mathematics, he or she will get a cumulative Impact Factor equal to only 19.844. Young Pakistani mathematicians are now reluctant to do research in mathematics, as they feel that publishing papers in top mathematical journals is not only difficult but receives no recognition or appreciation due to low Impact Factors and citations. This trend is thus damaging for mathematics.

It is unfair to rate mathematicians on the basis of Impact Factors of their research papers. It is bizarre that one's status could be determined by the arbitrary assignments of numbers to the journals in which one happened to publish. Most intelligent scientists and administrators are well aware of two facts: one, that we do not yet have reliable bibliographic measures for comparing or making absolute ratings of the value of the work done by research workers; two, that in any event, bibliographic measures appropriate in one field are inappropriate in others. An impact value based on the simple measurement of how many times a journal is cited makes no sense as a measure of the quality of the papers published in it, let alone the quality of the mathematicians publishing there. Such use of management-type figures which claim to enable comparisons to be made can be utterly misleading and damaging. Figures are only as good as the premises on which the figures are based, and often the premises of many widely touted management figures are seriously flawed, as in the case of Impact Factors. The only real criterion for an individual's scholarship is quality of work, and that does not admit of simple numerical assessment.

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Letters to the Editor

Reliable Research Literature

Surely most mathematicians know not to just trust what's in even the "better" journals. But fewer of us may realize that some prominent authors, and some of these "good" journals and their editors, aren't striving to make the research literature more reliable. Instead, they 1) recklessly publish without proofreading/refereeing, 2) irresponsibly do nothing when serious errors are found/reported, and/or 3) perversely obstruct the publication of significant corrections.

While it may be impossible to stop all the cheating, journal publishers—corporations and math societies—can oblige their editors to behave more honorably, and employers can use their leverage over irresponsible authors.

—Bryan Cain
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(Received February 21, 2007)

NSF-Sponsored Educational Programs

In his Opinion article "Because Math Matters", Solomon Garfunkel outlines true problems but draws wrong conclusions. His statement "We are not doing a very good job. U.S. students are falling behind students in most industrialized countries" is true, but his claim that the NSF [National Science Foundation] has "led the effort for innovation in mathematics education since the 1950s" is loaded as well as overtly political (something he claims we should avoid). I am not sure what the NSF was doing in the 1950s and 1960s with respect to math education, but it has been quite involved since the 1980s and in mostly bad ways. Look at some of the results of NSF programs' de-emphasis on arithmetic calculation and algebraic manipulation and the (NCTM-encouraged [National Council of Teachers of Mathematics]) substitution of calculator usage for long division. Implicit in his analysis and many such writings is the opinion that teaching children strong computational skills is bad. But the example given is the poor performance of U.S. students. However, this poor performance has taken place during the NSF's most innovative period, i.e, from the 1980s to the present. This is why the backlash against fuzzy math on the part of parents has been so extreme; during this time U.S. children have plummeted in math.

A good example to study would be the New York City public school system and the CUNY [City University of New York] college system. It is acknowledged that in the 1940s–1960s the CUNY colleges produced more scientists (including mathematicians) and doctors (and various professionals) than any other college system. Furthermore, many of these people came from the working and middle classes. Doesn't this need to be analyzed? I went through the NYC public school system and CUNY in the 1960s and 1970s, and many of my classmates ended up in highly successful professions. However, there were bad things, one of which was tracking minorities into programs where they were denied traditional approaches to education. One of the dubious achievements of reform movements of the 1980s and 1990s was that basic arithmetic competence was denied to minorities as well as to the white working and middle class children.

Let me summarize: The U.S. became a world leader in mathematics between the 1940s and the 1960s. In fact, many of the countries that are beating us now sent thousands of their future scientists (and still do) to be educated in the U.S. Since the 1980s, concomitant with the rise in "innovative" teaching techniques, the U.S. has declined considerably in international comparisons. Garfunkel is wrong in saying this isn't political; it is most definitely political. In fact, the NSF needs to immediately stop funding all education initiatives and start subjecting future education grant proposals to the same rigorous standards they use for mathematical/scientific research.

—Jerry Rosen
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(Received March 2, 2007)

Problems in Teaching through Applications

In his March 2007 Opinion piece, Solomon Garfunkel is making a point about the importance of applications in teaching mathematics. I do not think that there is any disagreement about that. Probably the vast majority of teachers would agree that both the skills and the ability to apply them are important; striking the right balance is where the disagreements start.

The only example of teaching through applications that Solomon Garfunkel gives is confusing, to say the least. He writes, "We can continue to ask students problems of the form 'solve for x in the equation $x^2 - 3x + 1 = 0$'. Or we can ask at what proportion of performance-enhancing drug use in the population is it cheaper to test two athletes by pooling their blood samples—which leads to the same equation." It would be interesting to know how much time it would take for an average reader of the *Notices* to derive the equation (actually, that should be an inequality, not an equation). The "pooling blood samples together" protocol that leads to $x^2 - 3x + 1 > 0$ is: Test a mix of blood samples. If the result is negative, then both athletes are clean. Otherwise, test the first one. In the case of the negative result, the second athlete is guilty. If the result is positive, then test the second athlete. I wonder if the author of the problem has factored in the cost of a lawsuit in the case when the second athlete is accused of cheating without his blood having ever been tested. On top of that, solving the problem requires a bit of probability theory (probability of the intersection of independent events and the notion of the expectation) that goes somewhat beyond what a student just starting quadratic equations usually knows.

Unfortunately, this is not just an isolated bad example that has accidentally found its way into an article. There is quite a number of very confusing problems in modern textbooks (I am mostly familiar with calculus textbooks). Trying to keep up with the trend, textbook authors are incorporating as many "applications" as they can. I suspect that in some cases they do not understand the "applications" themselves. And the students suffer. These "real-life problems" do not motivate students, they do not clarify the concepts. They just confuse. And they have little to do with real life as well.

—Leonid Friedlander
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(Received April 23, 2007)

Mathematics and Applications

As the healthy debate between and pure and applied mathematicians continues, I would like to recall what one of my teachers, Nicolás Martínez, used to say: "Mathematics is what is lost in its applications."

—Bernardo Recamán Santos
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(Received April 27, 2007)

Verify Authors Know Paper's Contents

It is my suggestion that every department of mathematics and statistics begin an internal and/or external investigation to scrutinize all the papers professors in their departments have written.

I feel that there is a strong need to review every professor's papers in every department. I think it is unfair to a person who puts a lot of work into one paper to get the same credit as a professor who may have just given an idea and put his or her name on a paper. To clear this possible unfairness (if any), I suggest that committees of mathematicians and statisticians (internal and external) be set up to interview the writers of every paper to see whether they know the content of each paper. This of course will require preparation on the part of the professor, but I think it will make things more fair in terms of credit attribution.

If a professor cannot describe the content of a paper that bears his or her name, then I think it is not ethically scientific that the paper should bear his or her name. If a person fails in this task in a number of them, then something is wrong with the system.

I know that this is a long process, but I feel that fairness should prevail. If an author does not know the content of a paper or did not do a fair amount of work on it, then a letter should be sent to each journal [publishing] each such paper, and a retraction should be made about that paper's authors. In addition, all the mathematical and statistical citation databases should be informed about this retraction.

In conclusion, I do not believe it is fair or ethical that a paper bear the name of a person who did minimal work on a paper or who does not know the content of the paper.

I hope that mathematical and statistical associations will consider this request in any of their future meetings.

—Petros Hadjicostas
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(Received April 28, 2007)

Reply to Rosen

Rosen misstates the actual timeframe for reform funding and as a consequence misplaces the blame for poor performance. The NCTM Standards were published in 1989. They were universally endorsed by all of the major mathematical professional societies. The Standards were in fact undertaken because of a pervasive sense that we were doing an inadequate job of educating students in mathematics at the K–12 level. NSF funding of reform efforts began in the early 1990s, and the major reform curricula did not appear until the mid- to late-1990s. And at their height (there has been some drawback of high school programs since the math wars) the elementary, middle, and high school curricula achieved no more market share than 25%, 20%, and 5% respectively. It is clearly inappropriate to blame poor performance in the 1980s and 1990s on these innovative curricula. The inconvenient truth is that there were no good old days, just a lot of hard work left to be done.

—Solomon Garfunkel
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(Received May 14, 2007)

Submitting Letters to the Editor

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

George Mackey 1916–2006

Robert S. Doran and Arlan Ramsay

Robert S. Doran

Introduction

George Whitelaw Mackey died of complications from pneumonia on March 15, 2006, in Belmont, Massachusetts, at the age of ninety. He was a remarkable individual and mathematician who made a lasting impact not only on the theory of infinite dimensional group representations, ergodic theory, and mathematical physics but also on those individuals with whom he personally came into contact. The purpose of this article is to celebrate and reflect on George's life by providing a glimpse into his mathematics and his personality through the eyes of several colleagues, former students, family, and close friends. Each of the contributors to the article has his or her own story to tell regarding how he influenced their lives and their mathematics.

I first became aware of George Mackey forty-five years ago through his now famous 1955 Chicago lecture notes on group representations and also through his early fundamental work on the duality theory of locally convex topological vector spaces. I had taken a substantial course in functional analysis, and Mackey's Chicago notes were a rather natural next step resulting from my interest in C*-algebras and von Neumann algebras—an interest instilled in me by Henry Dye and Sterling Berberian, both inspiring teachers who, at the time, were themselves fairly young Chicago Ph.D.'s. I purchased a copy of Mackey's notes through the University of Chicago mathematics department and had them carefully bound in hard cover. They became my constant companion as I endeavored to understand this beautiful and difficult subject. In this regard it is certainly not an exaggeration to say that Mackey's notes were often the catalyst that led many mathematicians to study representation theory. As one important example I mention J. M. G. (Michael) Fell, who, with the late D. B. Lowdenslager, wrote up the original 1955 Chicago lecture notes. Fell makes it clear in the preface of our 1988 two-volume work [1, 2] on representations of locally compact groups and Banach *-algebraic bundles that the basic direction of his own research was permanently altered by his experience with Mackey's Chicago lectures. The final chapter of the second volume treats generalized versions of Mackey's beautiful normal subgroup analysis and is, in many respects, the apex of the entire work. It is perhaps safe to say that these volumes stand largely as a tribute to George Mackey's remarkable pioneering work on induced representations, the imprimitivity theorem, and what is known today as the "Mackey Machine".

In 1970 I contacted George to see if he would be interested in coming to TCU (Texas Christian University) to present a series of lectures on a topic in which he was currently interested. In spite of being very busy (at the time, as I recall, he was in Montecatini, Italy, giving lectures) he graciously accepted my invitation, and I enthusiastically submitted a grant to the NSF for a CBMS (Conference Board of the Mathematical Sciences) conference to be held at TCU with George as the principal

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Arlan Ramsay is emeritus professor of mathematics at the University of Colorado at Boulder. His email address is `ramsay@colorado.edu`.

lecturer. Although the grant was carefully prepared, including a detailed description provided by George of his ten lectures titled "Ergodic theory and its significance in statistical mechanics and probability theory", the grant was not funded. Given George's high mathematical standing and reputation, I was of course surprised when we were turned down. Fortunately, I was able to secure funding for the conference from another source, and in 1972 George came to TCU to take part as originally planned. True to form he showed up in Fort Worth with sport coat and tie (even though it was quite hot) and with his signature clipboard in hand. Many of the leading mathematicians and mathematical physicists of the day, both young and old, attended, and the result was a tremendously exciting and meaningful conference. To put the cherry on top, Mackey's ten conference lectures were published in [3], and he received a coveted AMS Steele Prize in 1975 for them.

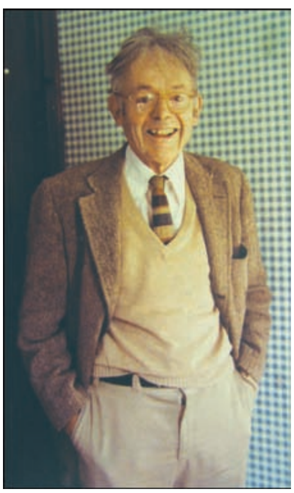

Photo courtesy of Ann Mackey.

George Mackey, on vacation in 1981.

From these early days in the 1970s George and I became good friends, and we would meet for lunch on those occasions that we could get together at meetings and conferences (lunches are a pattern with George, as you will note from other writers). It seemed that we agreed on most things mathematical—he of course was the master, I was the student. On the other hand, he particularly liked to debate philosophical and spiritual matters, and we held rather different points of view on some things. These differences in no way affected our relationship. If anything, they enhanced it. Indeed, George honestly enjoyed pursuing ideas to the very end, and he doggedly, but gently, pushed hard to see if one could defend a particular point of view. I enjoyed this too, so it usually became a kind of sparring match with no real winner. The next time we would meet (or talk on the phone) it would start all over again. Although at times he could be somewhat brusque, he was always kind, compassionate, and highly respectful, and, I believe, he genuinely wanted to understand the other person's viewpoint. It seemed to me that he simply had a great deal of difficulty accepting statements that he personally could not establish through careful logical reasoning or through some kind of mathematical argument. Perhaps this, at least in part, is why he had a particularly strong affinity for mathematics, a discipline where proof, not faith, is the order of the day.

Following the biography below, Calvin Moore provides an overview of George's main mathematical contributions together with some personal recollections. Then each of the remaining writers shares personal and mathematical insights resulting from his or her (often close) association with George. Arlan Ramsay and I, as organizers, are deeply grateful to all of the writers for their contributions, and we sincerely thank them for honoring an esteemed colleague, mentor, family member, and friend who will be greatly missed.

Biography of George W. Mackey

George Whitelaw Mackey was born February 1, 1916, in St. Louis, Missouri, and died on March 15, 2006, in Belmont, Massachusetts. He received a bachelor's degree from the Rice Institute (now Rice University) in 1938. As an undergraduate he had interests in chemistry, physics, and mathematics. These interests were developed during his early high school years. After briefly considering chemical engineering as a major his freshman year in college, he decided instead that he wanted to be a mathematical physicist, so he ended up majoring in physics. However, he was increasingly drawn to pure mathematics because of what he perceived as a lack of mathematical rigor in his physics classes. His extraordinary gift in mathematics became particularly clear when he was recognized nationally as one of the top five William Lowell Putnam winners during his senior year at Rice. His reward for this accomplishment was an offer of a full scholarship to Harvard for graduate work, an offer that he accepted.

Photo courtesy of Ann Mackey.

A young George Mackey.

He earned a master's degree in mathematics in 1939 and a Ph.D. in 1942 under the direction of famed mathematician Marshall H. Stone, whose 1932 book *Linear Transformations in Hilbert Space* had a substantial influence on his mathematical point of view. Through Stone's influence, Mackey was able to obtain a Sheldon Traveling Fellowship allowing him to split the year in 1941 between Cal Tech and the Institute for Advanced Study before completing his doctorate. While at the Institute he met many legendary figures, among them Albert Einstein, Oswald Veblen, and John von Neumann, as well as a host of young Ph.D.'s such as Paul Halmos, Warren Ambrose, Valentine Bargmann, Paul Erdős, and Shizuo Kakutani.

After receiving his Ph.D. he spent a year on the faculty at the Illinois Institute of Technology and then returned to Harvard in 1943 as an instructor in the mathematics department and remained there until he retired in 1985. He became a full professor in 1956 and was appointed Landon T. Clay Professor of Mathematics and Theoretical Science in 1969, a position he retained until he retired.

His main areas of research were in representation theory, group actions, ergodic theory, functional analysis, and mathematical physics. Much of his work involved the interaction between infinite-dimensional group representations, the theory of operator algebras, and the use of quantum logic in the mathematical foundations of quantum mechanics. His notion of a system of imprimitivity led naturally to an analysis of the representation theory of semidirect products in terms of ergodic actions of groups.

He served as visiting professor at many institutions, including the George Eastman professor at Oxford University; the University of Chicago; the University of California, Los Angeles; the University of California, Berkeley; the Walker Ames professor at the University of Washington; and the International Center for Theoretical Physics in Trieste, Italy. He received the distinguished alumnus award from Rice University in 1982 and in 1985 received a Humboldt Foundation Research Award, which he used at the Max Planck Institute in Bonn, Germany.

Mackey was a member of the the National Academy of Sciences, the American Academy of Arts and Sciences, and the American Philosophical Society. He was vice president of the American Mathematical Society in 1964–65 and again a member of the Institute for Advanced Study in 1977.

His published works include *Mathematical Foundations of Quantum Mechanics* (1963), *Mathematical Problems of Relativistic Physics* (1967), *Induced Representations of Groups and Quantum Mechanics* (1968), *Theory of Unitary Group Representations* (1976), *Lectures on the Theory of Functions of a Complex Variable* (1977), *Unitary Group Representations in Physics, Probability, and Number Theory* (1978), and numerous scholarly articles.

George's final article [4], published in December of 2004, contains in-depth descriptions of some of the items mentioned in this biography as well as his interactions with Marshall Stone and others while he was a Harvard graduate student. He was not in good health at the time, and his devoted wife, Alice, typed some of his handwritten notes and helped get the article completed and in print. Dick Kadison and I, as editors of the volume in which the paper appeared, are extremely grateful for her kindness and help.

Ph.D. Students of George Mackey, Harvard University

Lawrence Brown, 1968
Paul Chernoff, 1968
Lawrence Corwin, 1968
Edward Effros, 1962
Peter Forrest, 1972
Andrew Gleason, 1950
Robert Graves, 1952
Peter Hahn, 1975
Christopher Henrich, 1968
John Kalman, 1955
Adam Kleppner, 1960
M. Donald MacLaren, 1962
Calvin Moore, 1960
Judith Packer, 1982
Richard Palais, 1956
Arlan Ramsay, 1962
Caroline Series, 1976
Francisco Thayer, 1972
Seth Warner, 1955
John Wermer, 1951
Thomas Wieting, 1973
Neal Zierler, 1959
Robert Zimmer, 1975

References

[1] J. M. G. Fell and R. S. Doran, *Representations of *-algebras, locally compact groups, and Banach *-algebraic bundles, Vol. 1 (General representation theory of groups and algebras)*, Pure and Applied Mathematics 125, Academic Press, New York, 1988.

[2] ———, *Representations of *-algebras, locally compact groups, and Banach *-algebraic bundles, Vol. 2 (Banach *-algebraic bundles, induced representations, and the generalized Mackey analysis)*, Pure and Applied Mathematics 126, Academic Press, New York, 1988.

[3] G. W. Mackey, Ergodic theory and its significance in statistical mechanics and probability theory, *Advances in Mathematics* **12** (1974), 178–268.

[4] ———, Marshall H. Stone: Mathematician, statesman, advisor and friend, *Operator Algebras, Quantization, and Noncommutative Geometry*, Contemporary Mathematics 365 (eds., R. S. Doran and R. V. Kadison), Amer. Math. Soc., Providence, RI, 2004, pp. 15–25.

Calvin C. Moore

George Mackey's Mathematical Work

After graduating from the Rice Institute (as Rice University was known at the time) in 1938 with a major in physics and a top five finish in the Putnam Exam, George Mackey entered Harvard University for doctoral study in mathematics. He soon came under the influence of Marshall Stone and in 1942 completed a dissertation under Stone entitled "The Subspaces of the Conjugate of an Abstract Linear Space". In this work he explored the different locally convex topologies that a vector space can carry. The most significant result to emerge can be stated as follows. Consider two (say real) vector spaces V and W that are in perfect duality by a pairing

$$V \times W \to R$$

so that each may be viewed as linear functionals on the other. It was obvious that there is a weakest (smallest) locally convex topology on V (or W) such that the linear functionals coming from W (or V) are exactly the continuous ones, called the weak topology. What Mackey proved was that there is a unique strongest (largest) locally convex topology such that the linear functionals coming from W are the continuous ones. This is the topology of convergence of elements of V, now viewed as linear functionals on W uniformly on weakly compact convex subsets of W. All locally convex topologies on V for which the linear functionals from W are exactly the continuous ones lie between these two [Ma1, Ma2]. This topology became known generally as the Mackey topology.

Mackey retained a life-long interest in theoretical physics, no doubt inspired initially by his undergraduate work, and soon after his initial work, he turned his attention to the theorem of Stone [S] and von Neumann [vN] that asserts that a family of operators $p(i)$ and $q(i)$ on a Hilbert space satisfying the quantum mechanical commutation relations $[p(k), q(j)] = i\delta(k, j)I$ is essentially unique. Mackey realized that it was really a theorem about a pair of continuous unitary representations, one U of an abelian locally group A, and the other V of its dual group $\hat{A}$ which satisfied

$$U(s)V(t) = (s, t)V(t)U(s)$$

where (s, t) is the usual pairing of the group and its dual. He showed [Ma3] that such a pair is unique if they jointly leave no closed subspace invariant and in general any pair is isomorphic to a direct sum of copies of the unique irreducible pair. When A is Euclidean n-space, this result becomes the classic theorem about the quantum mechanical commutation relations. He then also saw immediately that there was a version for nonabelian locally compact groups, which appeared in [Ma4], but this is really part of the next phase in Mackey's work, to which we turn now. Mackey initiated a systematic study of unitary representations of general locally compact second countable (and all groups will be assumed to be second countable without further mention) groups, work for which he is most famous. Von Neumann had developed a theory of direct integral decompositions of operator algebras in the 1930s as an analog of direct sum decompositions for finite-dimensional algebras, but he did not publish it until F. I. Mautner persuaded him to do so in 1948.

Adapted to representation theory, direct integral theory became a crucial tool that Mackey used and developed. For representations of finite groups, induced representations whereby one induces a representation of a subgroup H of G up to the group G are an absolutely essential tool. Mackey in a series of papers [Ma5, Ma6, Ma7] defined and studied the process of induction of a unitary representation of a closed subgroup H of a locally compact group G to form the induced representation of G. When the coset space G/H has a G-invariant measure, the definition is straightforward, but when it has only a quasi-invariant measure, some extra work is needed. Mackey developed analogs of many of the main theorems about induced representations of finite groups. In particular he established his fundamental imprimitivity theorem, which characterizes when a representation is induced. The process of induction had appeared in some special cases a year or two earlier in the work of Gelfand and his collaborators on unitary representations of the classical Lie groups.

This imprimitivity theorem states that a unitary representation U of a group G is induced by a unitary representation V of a closed subgroup H of G if and only if there is a normal representation of the von Neumann algebra $L^\infty(G/H, \mu)$ on the same Hilbert space as U (or equivalently that there is a projection-valued measure on G/H absolutely continuous with respect to μ) which is covariant with respect to U in the natural sense. Here μ is a quasi-invariant measure on G/H. Moreover, U and V uniquely determined each other up to unitary equivalence. Mackey's theorem above on unicity of pairs of representations of an abelian group A and its dual group $\hat{A}$ is a special case of applying the imprimitivity theorem to a generalized Heisenberg group built from A and $\hat{A}$.

These results laid the basis for what was to become known as the Mackey little group method, or as some have called it, the Mackey machine, for calculating irreducible unitary representations

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of a group knowing information about subgroups. But before this program could get under way, Mackey had to put in place some building blocks or preliminaries. First some basic facts about Borel structures needed to be laid out, which Mackey did in [Ma9]. A Borel structure is a set together with a σ-field of subsets. He identified two kinds of very well-behaved types of Borel structures that he called standard and analytic based on some deep theorems in descriptive set theory of the Polish school. An equivalence relation on a Borel space leads to a quotient space with its own Borel structure. If the original space is well behaved, the quotient can be very nice—one of the two well-behaved types above—or if not, it is quite pathological. If the former holds, then the equivalence relation is said to be smooth. The set of concrete irreducible unitary representations of a group G can be given a natural well-behaved Borel structure, and then the equivalence relation of unitary equivalence yields the quotient space—that is, the set of equivalence classes of irreducible unitary representations, which he termed the dual space $\hat{G}$ of G. If the equivalence relation is well-behaved, $\hat{G}$ is a well-behaved space, and Mackey said then that G had smooth dual. This was a crucial concept in the program.

Mackey developed some additional facts about actions of locally compact groups on Borel spaces. A group action ergodic with respect to a quasi-invariant measure—and ergodicity is a concept that played such a central role in Mackey's work over decades—is one whose only fixed points in the measure algebra are 0 and 1. An important observation is that if the equivalence relation induced on X by the action of G is smooth, then any ergodic measure is concentrated on an orbit of G, and so up to null sets the action is transitive. Another related issue concerned point realizations of actions of a group. Suppose that G acts as a continuous transformation group on the measure algebra $M(X, \mu)$ of a measure space, where X is a well-behaved Borel space. Then, can one modify X by μ-null sets if necessary and show that this action comes from a Borel action of G on the underlying space X that leaves the measure quasi-invariant? In [Ma12] Mackey showed that the answer is affirmative, extending an earlier result of von Neumann for actions of the real line.

Also, by adapting von Neumann's type theory for operator algebras, Mackey introduced the notion of a type I group, by which he meant that all its representations were type I or equivalently all of its primary representations were multiples of an irreducible representation. On the basis of his work in classifying irreducible representations of a group—e.g., calculating $\hat{G}$—Mackey observed that the property of a group G having a smooth dual seemed to be related to and correlated with the absence of non-type I representations of G. Mackey then made a bold conjecture that a locally compact group G had a smooth dual if and only if it is type I. It was not too long before James Glimm provided a proof of this conjecture [Gl].

Another element was to deal with what one would call projective unitary representations of a group G, which are continuous homomorphisms from G to the projective unitary group of a Hilbert space. Such projective representations not only arise naturally in the foundations of quantum mechanics, but as was clear, when one started to analyze ordinary representations, one was led naturally to projective representations. By using a lifting theorem from the theory of Borel spaces, Mackey showed that a projective representation could be thought of as a Borel map U from G to the unitary group satisfying

$$U(s)U(t) = a(s,t)U(st),$$

where A is a Borel function from $G \times G$ to the circle group T that satisfies a certain cocycle identity. For finite groups, it was clear that any projective representation of a group G could be lifted to an ordinary representation of a central extension of G by a cyclic group. In the locally compact case one would like to have the same result but with a central extension of G by the circle group T. If the cocycle above were continuous, it would be obvious how to construct this central extension. Mackey, by a very clever use of Weil's theorem on the converse to Haar measure, showed how to construct this central extension. He also began an exploration of some aspects of the cohomology theory that lay in the background [Ma8].

Mackey's little group method starts with a group G for which we want to compute $\hat{G}$, and it is assumed that N is a closed normal subgroup that has a smooth dual (and is hence now known to be type I). It is assumed that $\hat{N}$ is known, and then G (or really G/N) acts on $\hat{N}$ as a Borel transformation group. Any irreducible representation U of G yields upon restriction to N a direct integral decomposition into multiples of irreducible representations with respect to a measure μ on $\hat{N}$, which Mackey showed was ergodic. Then if the quotient space of $\hat{N}$ by this action is smooth, any ergodic measure is transitive and is carried on some orbit $G \cdot V$ of G on $\hat{N}$. Hence the representation U has a transitive system of imprimitivity based on G/H where H is the isotropy group of V. Hence U is induced by a unique irreducible representation of H, whose restriction to N is a multiple of V, and these can be classified in terms of irreducible representations or projective representations of H/N, which is called the "little group". In an article in 1958 Mackey laid out his systematic theory of projective representations [Ma11]. Mackey's work also builds on Wigner's analysis in 1939 of the special case of unitary representations of the inhomogeneous

Lorentz group [W]. Mackey's little group method, an enormously effective, systematic tool for analyzing representations of many different groups, was used to good effect by many workers, and has been extended in different directions.

In the summer of 1955 Mackey was invited to be a visiting professor at the University of Chicago, and he gave a course that laid out his theory of group representations that we have briefly described. Notes from the course prepared by J. M. G. Fell and D. B. Lowenslager circulated informally for years, and generations of students (including the author) learned Mackey's theory from these famous notes. In 1976 Mackey agreed to publish an edited version of these notes, together with an expository article summarizing progress in the field since 1955 [Ma16]. Of course the Mackey machine runs into trouble when the action of G on $\hat{N}$ is not smooth, and nontransitive ergodic measures appear in the analysis above. In his 1961 AMS Colloquium Lectures [Ma13] Mackey laid out a new approach to this problem and introduced the notion of virtual group. He observed that a Borel group action of a group G on a measure space Y defines a groupoid—a set with a partially defined multiplication where inverses exist. The groupoid consists of $Y \times G$ where the product $(y, g) \cdot (z, h)$ is defined when $z = y \cdot g$, and the product is (y, gh) where it is convenient to write G as operating on the right. This set has a Borel structure and a measure—the measure μ on Y cross Haar measure that has the appropriate "invariance" properties. If the measure μ is ergodic, then Mackey called the construction an ergodic measured groupoid. Mackey realized that different such objects needed to be grouped together under a notion he called similarity, and he defined a virtual group to be an equivalence class under similarity of ergodic measure groupoids. In the case of a groupoid coming from a transitive action of G on a coset space $H\backslash G$ of itself, the similarity notion makes the measured groupoid $H\backslash G \times G$ similar to the measured groupoid that is simply the group H (with Haar measure) and so puts them in the same equivalence class. Hence in this case the transitive measured groupoid is literally a subgroup of G, and Mackey's point here is that it would be very productive to look at a general ergodic action of G as a kind of generalized (or virtual) subgroup of G via the language of groupoids and virtual groups. Then one could begin a systematic study of the representations of virtual groups, induced representations, etc. The imprimitivity theorem remains true in the ergodic nontransitive case in that the irreducible representation of G is now induced by an irreducible representation of a virtual subgroup.

Mackey laid out his theory in two subsequent publications in 1963 and 1966 [Ma14, Ma15]. His initial notion of similarity had to be adjusted a bit in subsequent work to make it function properly. In a real sense, the point of view introduced here by Mackey was the opening shot in the whole program of noncommutative topology and geometry that was to develop. One particularly rich theme has emerged from the special case when the group action is free, in which case the groupoid is simply an equivalence relation, and Mackey defines what one means by a measured ergodic equivalence relation. Isomorphism of measured equivalence relations amounts to orbit equivalence of the group actions, a notion that was foreign in ergodic theory up to that point but which has been of overriding importance in developments since then. In fact [Ma14] adumbrates some of the subsequent developments that have sprung from his work.

Photo courtesy of Ann Mackey.

Mackey at the University of Chicago, 1955.

As has already been suggested, Mackey maintained a lively and inquiring lifelong interest in mathematical physics and especially the foundations of quantum theory, quantum field theory, and statistical mechanics. In [Ma10] Mackey explored the abstract relationship between quantum states and quantum observables and raised the question of whether some very general axioms about that relationship necessarily led to the classical von Neumann formulation. This exposition inspired Andrew Gleason to prove a strengthened version of Mackey's results, which then enabled him to formulate a general result that showed that the von Neumann formulation followed from a much weaker set of axioms. Also Mackey's work on the unicity of the Heisenberg commutation relations gave an indication why, when the number of $p(i)$'s and $q(i)$'s is infinite (quantum field theory), the uniqueness breaks down.

In his later years Mackey wrote a number of fascinating historical and integrative papers and books about group representations, and harmonic analysis and its applications and significance for other areas of mathematics and in the mathematical foundations of physics. The theme of Norbert Wiener's definition of chaos, or homogeneous chaos, was a favorite theme in his writings. Also applications of group representations to number theory was another common theme, among many others. Mackey was invited to be the George Eastman Visiting Professor at Oxford University for 1966–67, and he and Alice spent the year in Oxford. He gave a broad-ranging series of lectures during the year, which he subsequently published in 1978 as *Unitary Group Representations in Physics, Probability, and Number Theory* [Ma17]. George Mackey will be remembered and honored for his seminal contributions to group representations and ergodic theory and mathematical physics and for his fascinating expositions on these subjects.

Let me close this summary of Mackey's research contributions with some personal thoughts. I first met George Mackey in 1956 when I was entering my junior year at Harvard. He became my advisor and mentor both as an undergraduate and when I continued as a graduate student at Harvard. I learned how to be a mathematician from him, and I valued his friendship, guidance, and encouragement for over fifty years. Many of my own accomplishments can be traced back to ideas and inspirations coming from him. George was a uniquely gifted and inspiring individual, and we miss him very much.

Photo courtesy of Arthur Jaffe.

George and Alice Mackey, May 1984, Berkeley Faculty Club, at a conference in honor of Mackey.

George visited Berkeley on several occasions, and two incidents stick in my mind that are in some ways characteristic of him. One time, probably in the 1960s or 1970s when George was visiting Berkeley, a group of us were walking to lunch and talking mathematics. In this discussion I described a certain theorem that was relevant for the discussion (unfortunately I cannot recall what the theorem was), and George remarked to the effect, "Well, that's a very nice result. Who proved it?" My response was "You proved it." Well, from one perspective it is nice to have proved so many good theorems that you can forget a few.

The other incident or series of incidents occurred in 1983–84, when I had arranged for George to visit at the Mathematical Sciences Research Institute (MSRI) for a year. The housing officer at MSRI found him and Alice a beautiful rental house for the year that belonged to Geoff Chew, a faculty member in physics who was on sabbatical for the year. The only problem was that the house came with some animals, cats and dogs, that the tenants would have to take care of. But the Mackeys said that would be no problem. George arrived a month or two before Alice could come so that the house would not be vacant with no one to take care of the animals. George truly had his hands full with the animals, and even after Alice arrived to take over housekeeping, they had many amusing incidents. When they returned to Cambridge after their year in the "Wild West", Alice wrote a fascinating and hilarious article for the Wellesley alumni magazine about George's and her travails with the Chew menagerie.

References

[Gl] James Glimm, Type *I* C^*-Algebras, *Ann. Math.* **73** (1961), 572–612.

[Ma1] George W. Mackey, On convex topological linear spaces, *Proc. Nat. Acad. Sci. U.S.A.* **29** (1943), 315–319, and Erratum 30, 24.

[Ma2] ———, On convex topological linear spaces, *Trans. Amer. Math. Soc.* **60** (1946), 519–537.

[Ma3] ———, A theorem of Stone and von Neumann, *Duke Math. J.* **16** (1949), 313–326.

[Ma4] ———, Imprimitivity for representations of locally compact groups, I. *Proc. Nat. Acad. Sci. U.S.A.* **35** (1949), 537–545.

[Ma5] ———, On induced representations of groups, *Amer. J. Math.* **73** (1951), 576–592.

[Ma6] ———, Induced representations of locally compact groups, I, *Ann. of Math.* (2) **55** (1952), 101–139.

[Ma7] ———, Induced representations of locally compact groups, II, The Frobenius reciprocity theorem, *Ann. of Math.* (2) **58** (1953), 193–221.

[Ma8] ———, Les ensembles boréliens et les extensions des groupes, *J. Math. Pures Appl.* (9) **36** (1957), 171–178.

[Ma9] ———, Borel structure in groups and their duals, *Trans. Amer. Math. Soc.* **85** (1957), 134–165.

[Ma10] ———, Quantum mechanics and Hilbert space, *Amer. Math. Monthly* **64** (1957), no. 8, part II, 45–57.

[Ma11] ———, Unitary representations of group extensions, I, *Acta Math.* **99** (1958), 265–311.

[Ma12] ———, Point realizations of transformation groups, *Illinois J. Math.* **6** (1962), 327–335.

[Ma13] ———, Infinite-dimensional group representations, *Bull. Amer. Math. Soc.* **69** (1963), 628–686.

[Ma14] ———, Ergodic theory, group theory, and differential geometry, *Proc. Nat. Acad. Sci. U.S.A.* **50** (1963), 1184–1191.

[Ma15] ——— , Ergodic theory and virtual groups, *Math. Ann.* **166** (1966), 187–207.

[Ma16] ———, *The Theory of Unitary Group Representations*, based on notes by James M. G. Fell and David B. Lowdenslager of lectures given at the University of Chicago, Chicago, IL, 1955, Chicago

Lectures in Mathematics, University of Chicago Press, Chicago, IL/London, 1976, x+372 pp.

[Ma17] ——, *Unitary Group Representations in Physics, Probability, and Number Theory*, Mathematics Lecture Note Series, 55, Benjamin/Cummings Publishing Co., Inc., Reading, MA, 1978, xiv+402 pp.

[vN] John von Neumann, Die eindeutigkeit der Schrödingerschen operatoren, *Math. Ann.* **104** (1931), 570–578.

[S] M. H. Stone, Linear transformations in Hilbert space III, operational methods and group theory, *Proc. Nat. Acad. Sci. U.S.A.* **16** (1930), 172–175.

[W] Eugene Wigner, Unitary representations of the inhomogeneous Lorentz group, *Ann. Math.* **40** (1939), 149–204.

J. M. G. (Michael) Fell

Recollections of George Mackey

If there was one individual who influenced the course of my mathematical life more than any other, it was George Mackey. I first met George (about four years after receiving my Ph.D.) at the 1955 Summer Conference on Functional Analysis and Group Representations, held at the University of Chicago. George's lectures there on group representations were an inspiration to me. His contagious enthusiasm spurred me to join with David Lowenslager in writing up the notes of his lectures and aroused in me an enthusiasm for his approach to the subject which has lasted all through my mathematical life.

I would like to make a few remarks about why I found George's approach to group representations so appealing (though I must apologize here for the fact that these remarks say more about me than about George!). His approach fascinated me because it seemed to have a beauty and universality that were almost Pythagorean in scope. We live in a universe whose laws are invariant under a certain symmetry group (for example, the Lorentz group in the case of the universe of special relativity). It seems plausible that the kinds of "irreducible" particles that can exist in a quantum-mechanical universe should be correlated with the possible irreducible representations of its underlying symmetry group. If this is so, then it should be a physically meaningful project to classify all the possible irreducible representations of that group. And now here in George's lectures was a three-phase program laid out as a first step toward just that purpose—indeed, for classifying the irreducible representations of all possible symmetry groups! To my mind this was an extremely exciting and emotionally satisfying idea, though, in hindsight, I think I conceived of it in a naive and narrow manner. But it appealed to me because of the beauty of the concept of symmetry as a fundamental fact of nature. Never mind whether it was in conformity with recent discoveries in physics!!

But George's mind was much broader than this. He seemed willing to embrace scientific reality wherever he found it. One of the aspects of his mathematical creativity that especially struck me was his interest—and success—in finding applications of the theory of group representations to quite different fields of mathematics, including mathematical physics! It seems that his mind was impelling him toward the ideal of a universal mathematician, so hard to attain these days of ever-increasing specialization.

Moreover, he had an idealistic, one might say "aristocratic", view of what it takes to be a true mathematician. I remember him saying once that there are two kinds of mathematicians (and I suppose that he would have made the same distinction for any field of intellectual endeavor): there are those who are "inner-directed" who work because they are impelled by something within them, and there are those who are "outer-directed" who are content to have their work directed for them by the force of outward circumstances. There is no doubt which of these two classes George Mackey was able to belong to.

Unfortunately I had little or no personal contact with George after about 1970. But in the years when we knew him personally, my wife and I always found George—and his good wife, Alice, also—to be very friendly and approachable. Along with his absorption in mathematics, he had an interest in other people. He also had a dry though ready sense of humor. I remember hearing of one episode in the Harvard mathematics department when a young secretary was telling this distinguished professor what he ought to do in a rather bossy manner. George's reply to her was simply "You're talking to me just as if you were my mother."

Now that George is no longer with us, I am one of those who regret not taking the opportunity to meet him and his family during his later years. And my wife and I want to join with all his other friends in condolences to his family over the departure of a great man from our midst.

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Roger Howe

Recollections of George Mackey

George Mackey was my mathematical grandfather. That is, he was the advisor of my advisor, Calvin Moore of the University of California at Berkeley. According to the Mathematics Genealogy Project, this is a mathematical lineage that goes back to Euler and Leibniz through Marshall Stone, G. D. Birkhoff, E. H. Moore, and Simeon Poisson. The Genealogy Project lists nearly 40,000 mathematical descendants for Euler, of which about 300 come from Mackey. The genealogy lists are updated regularly, so these numbers will increase in the future. Also, the Genealogy Project now lists me as a mathematical grandfather, so George died at least a mathematical great great-grandfather.

Although George was mathematically speaking my grandfather, his influence on me was direct, not just through Calvin Moore. In fact, I met George before I met Cal. This is something you can't do in ordinary genealogy.

I took a course from George in my senior year at Harvard. I had gotten interested in harmonic analysis and representation theory, and everyone spoke of Professor Mackey (as we called him) as the local guru on these subjects. In my last semester, he was giving a course on representation theory. I very much wanted to take it, but it would not fit in my schedule. When I spoke to him about the problem, he volunteered that he was planning to produce detailed written notes and I could take it as a reading course, so that's what I did.

Photo courtesy of Ann Mackey.

George Mackey (left) with his Ph.D. advisor Marshall Stone, 1984.

The last semester of senior year is a time when one's attention is often not on studies. I turned in a five-page paper for an art history course a month late. Also, I had to write my senior thesis. That was my first encounter with mathematics research, and it was very unsettling—somewhat like being possessed. It cost me a lot of sleep. Anyway, it was late in the semester before I even looked at the course notes.

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They were not at all what I expected. I had been attracted to representation theory by neat formulas: Schur orthogonality relations, Bessel functions, convolution products. But George's notes were full of Borel sets and Polish spaces and projection-valued measures. They were hard to understand, had a lot of unproved assertions, and were all in all quite strange. Also, they were long! I despaired of making any sense of them at all in the short time I had.

I studied what I could, and George did pass me. He was known for his directness, and his remarks at the end of the exam were quite representative. He didn't say I had done well. He said that I had learned "enough" and that I had done "better than he expected".

In retrospect, I think three things saved me:

1) The exam was postponed. This was actually not on my account; George discovered conflicts and moved the date.

2) There were no proofs to learn. George was not particularly interested in the details of proofs, but much more concerned with the overall structure of the subject. It was easier to get the gist of this than to put together the details of an intricate proof.

3) George really was a wonderful expositor. I didn't understand this at the time because of the newness and strangeness of the material, but since then I have read with pleasure and benefit many of his expositions—of quantum mechanics, induced representations, applications of and history of representation theory. He had a marvelous talent for combining simple ideas to construct rich and coherent pictures of broad areas of mathematics. I continue to recommend his works to younger scholars.

I am grateful that that exam was not the last time I saw George. In fact, our paths crossed regularly, and we developed a cordial relationship. The next time I saw him after Harvard was at a conference at the Battelle Institute in Seattle in the summer of 1969. It was my first professional conference and one of the most delightful I have ever attended. It was intended to encourage interaction between mathematicians and physicists around the applications of representation theory to physics, so there were both mathematicians and physicists there and a sense of addressing important issues. Using representation theory in physics was perhaps George's favorite topic of thought and conversation. I have memories of basking in the sun around the Battelle Institute grounds or on various excursions and in the conversations of the senior scholars: George, in his signature seersucker pinstripe jacket; Cal Moore; B. Kostant; V. Bargmann; and others.

Over the years since, I enjoyed many conversations with George, sometimes in groups and occasionally one-on-one. I have always been impressed by the independence of his views—he came to his own conclusions and advanced them with conviction born of long thought—and by his scholarship—he carefully studied relevant papers in mathematics or physics and took them into account, sometimes accepting, sometimes not, according to what seemed right. I particularly remember a short but highly referenced oral dissertation on the Higgs Boson, delivered for my sole benefit.

I forget when George took to referring to me as his grandstudent, but a particularly memorable occasion when he did so was in introducing me to his advisor, Marshall Stone. The Stone-von Neumann Theorem, which originated as a mathematical characterization of the Heisenberg canonical commutation relations, was reinterpreted by Mackey as a classification theorem for the unitary representations of certain nilpotent groups. Both Cal Moore and I have found new interpretations and applications for it, and now my students use it in their work. In fall 2004 I attended a program at the Newton Institute on quantum information theory (QIT). There I learned that QIT had spurred new interest in Hilbert space geometry. One topic that had attracted substantial attention was *mutually unbiased bases.* Two bases $\{u_j\}$ and $\{v_j\}$, $1 \le j \le \dim H$, of a finite-dimensional Hilbert space H, are called *mutually unbiased* if the inner product of u_j with v_k has absolute value $\left(\frac{1}{\dim H}\right)^{\frac{1}{2}}$, independent of j and k. A number of constructions of such bases had been given, and some relations to group theory had been found. The topic attracted me, and in thinking about it, I was amazed and delighted to see that George's work on induced representations, systems of imprimitivity, and the Heisenberg group combined to give a natural and highly effective theory and construction of large families of mutually unbiased bases. It seemed quite wonderful that ideas that George had introduced to clarify the foundations of quantum mechanics would have such a satisfying application to this very different aspect of the subject. I presented my preprint on the subject to George, but at that time his health was in decline, and I am afraid he was not able to share my pleasure at this unexpected application.

I hadn't expected the strange-seeming ideas in George's notes for that reading course to impinge on my research. I had quite different, more algebraic and geometric, ideas about how to approach representation theory. But impinge they did. When I was struggling to understand some qualitative properties of unitary representations of classical Lie groups, I found that the ideas from that course were exactly what I needed. And I am extremely happy not only to have used them (and to have had them to use!) but also to have passed them on: my latest student, Hadi Salmasian, has used these same ideas to take the line of work further and show that what had seemed perhaps ad hoc constructions for classical groups could be seen as a natural part of the representation theory of any semisimple or reductive group. George's body may have given up the ghost, but his spirit and his mathematics will be with us for a long time to come.

Arthur Jaffe

Lunch with George

Background

I was delighted to see that the program of the 2007 New Orleans AMS meeting listed me correctly as a student; in fact I have been a student of George Mackey practically all my mathematical life. George loved interesting and provoking mathematical conversations, and we had many over lunch, explaining my congenial title.

Mackey in Harvard office.

Most of our individual meetings began at the Harvard Faculty Club. George walked there from working at home to meet for our luncheon, and I often watched him pass the reading room windows. Generally our conversations engaged us so we continued afterward in one of our offices, which for years adjoined each other in the mathematics library. Some other occasions also provided opportunity for conversation: thirty years ago the department met over lunch at the Faculty Club. Frequently we also exchanged invitations for dinner at each other's home. Both customs had declined significantly in recent years. Another central fixture revolved about the mathematics colloquium, which for years George organized at Harvard. George and Lars Alfhors invariably attended the dinner, and for many years a party followed in someone's home. George also made sure that each participant paid their exact share of the bill, a role that could not mask the generous side of his character.

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George also enjoyed lunch at the "long table" in the Faculty Club, where a group of regulars gathered weekly. Occasionally I joined him there or more recently at the American Academy of Arts and Sciences, near the Harvard campus. I could count on meeting George at those places without planning in advance. Through these interactions my informal teacher became one of my best Harvard friends. So it was natural that our conversations ultimately led to pleasant evenings at 25 Coolidge Hill Road, where Alice and George were gracious and generous hosts, and on other occasions to 27 Lancaster Street.

While the main topic of our luncheons focused on mathematics, it was usual that the topic of conversation veered to a variety of other subjects, including social questions of the time and even to novels by David Lodge or Anthony Trollope. George seemed to come up with a viewpoint on any topic somewhat orthogonal to mine or to other companions, but one that he defended both with glee as well as success.

George began as a student of physics and found ideas in physics central to his mathematics. Yet George could be called a "quantum field theory skeptic". He never worked directly on this subject, and he remained unsure whether quantum mechanics could be shown to be compatible with special relativity in the framework of the Wightman (or any other) axioms for quantum fields.

When we began to interact, the possibility to give a mathematical foundation to any complete example of a relativistic, nonlinear quantum field appeared far beyond reach. Yet during the first ten years of our acquaintance these mathematical questions underwent a dramatic transition, and the first examples fell into place. George and I discussed this work many times, reviewing how models of quantum field theory in two- and three-dimensional Minkowski space-time could be achieved. While this problem still remains open in four dimensions, our understanding and intuition have advanced to the point that suggests one may find a positive answer for Yang-Mills theory. Yet George remained unsure about whether this culmination of the program is possible, rightfully questioning whether a more sophisticated concept of space-time would revolutionize our view of physics.

Despite this skepticism, George's deep insights, especially those in ergodic theory, connected in uncanny ways to the ongoing progress in quantum field theory throughout his lifetime.

Early Encounters

I first met George face-to-face during a conference organized in September 1965 by Irving Segal and Roe Goodman at Endicott House. Some 41+ years ago, the theme "The Mathematical Theory of Elementary Particles" represented more dream than reality.

I knew George's excellent book on the mathematical foundations of quantum theory, so I looked forward to meeting him and to discussing the laws of particle physics and quantum field theory. George was forty-nine, and I was still a student at Princeton. Perhaps the youngest person at the meeting, I arrived in awe among many experts whose work I had come to admire. George and I enjoyed a number of interesting interactions on that occasion, including our first lunch together.

Our paths crossed again two years later, only weeks before my moving from Stanford to Harvard. That summer we both attended the "Rochester Conference", which brought together particle physicists every couple of years. Returning in 1967 to the University of Rochester where the series began, the organizers made an attempt to involve some mathematicians as well.

The Rochester hosts prepared the proceedings in style. Not only do they include the lectures, but they also include transcripts of the extemporaneous discussions afterward. Today those informal interchanges remain of interest, providing far better insights into the thinking of the time than the prepared lectures that precede them. The discussion following the lecture by Arthur Wightman includes comments by George Mackey, Irving Segal, Klaus Hepp, Rudolf Haag, Stanley Mandelstam, Eugene Wigner, C.-N. Yang, and Richard Feynman. It is hard to imagine that diverse a spectrum of scientists, from mathematicians to physicists, sitting in the same lecture hall—much less discussing a lecture among themselves!

Reading the text with hindsight, I am struck by how the remarks of Mackey and of Feynman hit the bull's-eye. George's comments from the point of view of ergodic theory apply to the physical picture of the vacuum. Feynman's attitude about mathematics has been characterized by "It is a theorem that a mathematician cannot prove a nontrivial theorem, as every proved theorem is trivial," in *Surely You're Joking, Mr. Feynman.* Yet in Rochester, Feynman was intent to know whether quantum electrodynamics could be (or had been) put on a solid mathematical footing. Today we think it unlikely, unlike the situation for Yang-Mills theory.

Harvard

George chaired the mathematics department when I arrived at Harvard in 1967, and from that time we saw each other frequently. We had our private meetings, and we each represented our departments on the Committee for Applied

Mathematics, yet another opportunity to lunch together.

During 1968, Jim Glimm and I gave the first mathematical proof of the existence of the unitary group generated by a Hamiltonian for a nonlinear quantum field in two dimensions. This was a problem with a long history. George's old and dear friend Irving Segal had studied this question for years, and he became upset when he learned of its solution.

At a lunch during April 1969 George asked me my opinion about "the letter", to which I responded, "What letter?" George was referring to an eight-page letter from Segal addressed to Jim and me but which neither of us had received at the time. The letter claimed to point out, among other things, potential gaps in the logic of our published self-adjointness proof. On finally receiving a copy of the letter from the author, I realized immediately that his points did not represent gaps in logic, but they would require a time-consuming response. I spent considerable effort over the next two weeks to prepare a careful and detailed answer.

This put George in a difficult position, but his reaction was typical: George decided to get to the bottom of the mess. This attitude not only reflected George's extreme curiosity but also his tendency to help a friend in need. It meant too that George had to invest considerable time and energy to understand the details of a subtle proof somewhat outside his main area of expertise. And for that effort I am extraordinarily grateful.

It took George weeks to wade through the published paper and the correspondence. Although he did ask a few technical questions along the way, George loved to work things out himself at his own pace. Ultimately George announced (over lunch) the result of his efforts: he had told his old friend Segal that in his opinion the published proof of his younger colleagues was correct. This settled the matter in George's mind once and for all.

We returned to this theme in the summer of 1970 when George, Alice, and their daughter, Ann, spent two long but wonderful months at a marathon summer school in Les Houches, overlooking the French Alps. George (as well as R. Bott and A. Andreotti) were observers for the Battelle Institute, who sponsored the school. During two weeks I gave fifteen hours of lectures on the original work and on later developments—perhaps the most taxing course I ever gave. That summer I got to know the Mackeys well, as the participants dined together almost every day over those eight weeks.

Gradually my research and publications became more and more centered in mathematics than physics, and in 1973 the mathematics department at Harvard invited me to become a full voting member while still retaining my original affiliation with physics. At that point I began to interact with George even more. Following George's retirement in 1985 as the first occupant of his named mathematics professorship, I was humbled to be appointed as the successor to George's chair. I knew that these were huge shoes to fill.

Government

George often gave advice. While this advice might appear at first to be off-the-mark, George could defend its veracity with eloquence. And only after time did the truth of his predictions emerge. One topic dominated all others about science policy: George distrusted the role of government funding.

George often expressed interest in the fact that I had a government research grant. I did this in order to be able to assist students and to hire extraordinary persons interested in collaboration. George often explained why he believed scientists should avoid taking government research money. His theory was simple: the funder over time will ultimately direct the worker and perhaps play a role out of proportion.

When the government funding of research evolved in the 1950s, it seemed at first to work reasonably well. It certainly fueled the expansion of university science in this country during the 1960s and the early 1970s. At that time I believed that the government agencies did a reasonable job in shepherding and nurturing science. The scheme attempted to identify talented and productive researchers and to assist those persons in whatever directions their research drew them. This support represented a subsidy for the universities.

But over time one saw an evolution in the 1970s, much in the way that George had warned. Today the universities have became completely dependent on government support. On the other hand, the government agencies take the initiative to direct and to micro-manage the direction of science, funneling money to programs that appear fashionable or "in the national interest". George warned that such an evolution could undermine the academic independence of the universities, as well as their academic excellence and intellectual standards. It could have a devastating effect on American science as a whole. While we have moved far in the direction of emphasizing programs over discovering and empowering talent, one wonders whether one can alter the apparent asymptotic state.

Personal Matters

George spoke often about the need to use valuable time as well as possible. And the most important point was to conserve productive time for work. Like me, George had his best ideas early in the morning. I was unmarried when our discussions began, and George emphasized to me the need to have a very clear understanding with a partner about keeping working time sacrosanct.

Photo courtesy of Arthur Jaffe.

Ushers at the wedding of Arthur Jaffe, September 1992, (left to right): Raoul Bott, Bernard Saint Donat, George Mackey, Arthur Jaffe, James Glimm, Konrad Osterwalder.

George also described at length how he enjoyed his close relationship with Alice and how they enjoyed many joint private activities, including reading novels to each other, entertaining friends and relatives, and traveling. He also described how he even limited time with daughter Ann. But when he was with Ann, he devoted his total attention to her to the exclusion of all else.

George floated multiple warnings about marriage that I undoubtedly should have taken more seriously. But years later when I remarried, George served as an usher on that occasion; he even ended up driving the minister to the wedding in the countryside. Afterwards George shared a surprising thought: my wedding was the first wedding that he thoroughly enjoyed! In honor of that convivial bond, I wore the necktie chosen for me and the ushers at my wedding at my presentation in the Special Session for George in New Orleans.

Shortly after George retired, I served as department chair. At the beginning of my term I made a strong case that the department needed more office space, as several members had no regular office. Within a year we were able to construct seventeen new offices in contiguous space that had been used for storage and equipment. But before that happened, I had to ask George if he would move from his large office of many years to a smaller one next door. As usual, George understood and graciously obliged.

George's straightforward analysis of the world left one completely disarmed. Memories of this special person abound throughout mathematics. But they also can be heard over lunch at the long table in the Faculty Club and at the weekly luncheons at the American Academy. I am not alone. Everyone misses our fascinating luncheon companion and friend.

David Mumford

To George, My Friend and Teacher*

As a mathematician who worked first in algebraic geometry and later on mathematical models of perception, my research did not overlap very much with George's. But he was, nonetheless, one of the biggest influences on my mathematical career and a very close friend. I met George in the fall of 1954—fifty-three years ago. I was a sophomore at Harvard and was assigned to Kirkland House, known then as a jock house. In this unlikely place, George was a nonresident tutor, and we began to meet weekly for lunch. My father had died three years earlier, and, my being a confused and precocious kid, George became a second father to me. Not that we talked about life! No, he showed me what a beautiful world mathematics is. We worked through his lecture notes, and I ate them up. He showed me the internal logic and coherence of mathematics. It was his personal version of the Bourbaki vision, one in which groups played the central role. Topological vector spaces, operator theory, Lie groups, and group representations were the core, but it was also the lucid sequence of definitions and theorems that was so enticing—a yellow-brick road to more and more amazing places.

This was my first exposure to what higher mathematics is all about. I had other mentors—Oscar Zariski, who radiated the mystery of mathematics; Grothendieck, who simply flew—but George opened the doors and welcomed me into the fold. In those days he led the life of an English don, living in a small apartment with one armchair and a stereo. Here was another side of the life of the intellectual: total devotion to your field, which was something I had never encountered so intensely in anyone in my family's circle. When I graduated, my mother came to Cambridge and wanted to meet one of my professors. We had lunch with George. After that, she said, "This is what I always thought a Harvard professor would be like, the real thing".

Back in the 1960s, government funding of mathematical research was just starting, so of

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**This note is adapted from David Mumford's address at G. Mackey's memorial.*

course everyone was applying. Not George. He rocked the Boston mathematical community—not for the last time—by saying what no one else dared: the government was wasting its money, because all of us would do math all year without the two-ninths raise they were offering. He would not take it. Besides, on a darker note, he predicted all too accurately that when we were bought, the government would try to influence our research. To varying degrees in different fields, this has come to pass. As an applied mathematician for the last twenty years, it is downright embarrassing to see how much government pressure is being applied to create interdisciplinary collaborations. If they happen, great. But this should be each mathematician's personal choice, governed by his interests.

George's outspokenness and his brutal honesty probably got under everyone's skin at some point. He never adjusted his message to his listener. But he often articulated thoughts that we shied away from. Certainly, his carrying his clipboard and catching an hour to do math alone while his wife and daughter went to a museum is a fantasy many mathematicians harbor. George maintained his intellectual schedule through thick and thin. Perhaps my favorite memory of when he voiced a totally unorthodox point of view is this. I asked him once how he survived his three years of Harvard's relentlessly rotating chairmanship. His reply: he was most proud of the fact that, under his watch, nothing had changed; he left everything just as he had found it. For him, a true conservative, the right values never changed.

As I said, we were close friends for all his life. In fact, we continued to meet for lunch, George's favorite way of keeping in touch, until his deteriorating health overtook him and he was forced to retreat to a nursing home. He would always walk from his house on Coolidge Hill to the Faculty Club—perhaps this was his chief source of physical exercise. Over lunch, we would first go over what kind of math each of us was playing with at that time. But then we also talked philosophy and history, both of which attracted George a great deal. He liked the idea that perhaps, as conscious beings, we might not really be living in this world. He used the metaphor, for instance (like the movie *The Matrix*), that our real body could be elsewhere but wearing a diving suit that reproduced the sensations and transmitted our motions to the object that we usually conceive of as our body. The conventional reality of our lives might be a pure illusion.

George was not religious in the conventional sense. He would certainly reject the following if he were alive today, but I think it is fair to say that math was his church. Taking this further, I think his proof of the existence of God was the intertwining of all branches of mathematics and physics. He devoted many years to making manifest the links between mathematics and physics. Many mathematicians have been frustrated by the seeming intractability of the problem of reducing quantum field theory to precise mathematics. But here George was the perennial optimist: for the whole of life he remained sure that the ultimate synthesis was around the corner, and he never dropped this quest. As I learned many years ago from reading about them in his notes, intertwining operators were one of George's favorite mathematical constructs. But I think they are a metaphor for much more in George's life. His wife and daughter were his wonderful support system, and they intertwined George with the real world. There were many wonderful gatherings at their house. George and Alice maintained the long tradition of proper and gracious dinner parties for the mathematical community in Cambridge, long after it had gone out of fashion for the younger generations. His family was truly his lifeline, the hose bringing air to that diving suit.

Judith A. Packer

George Mackey: A Personal Remembrance

George, or Professor Mackey, as I addressed him during my graduate school years, made an indelible impression on me and changed my life for the better, several times: firstly as a brilliant mathematician and my thesis advisor, secondly as a mentor, and finally, as a very kind and sympathetic friend who seemed always to give good advice.

He first entered my radar screen in the fall of 1978, just after I had entered Harvard University's mathematics department graduate program. My undergraduate advisor, Ethan Coven, had suggested that I talk with Mackey, since I had just finished a senior thesis on symbolic dynamics and I thought I knew some ergodic theory. "You must meet George Mackey; he works in ergodic theory," said Ethan, "but you might not recognize it from what you have been studying in your senior thesis. He has a broader approach." This turned out to be an understatement of some large order of magnitude. At the first tea I attended that fall, I immediately spotted George. He was hard to miss, standing in the center of the tea room in his tweed jacket, holding forth on some topic of import and being gregarious to all who came his way, especially if they wanted to talk to him about mathematics or mathematical personalities. I met him and told him of my interest in analysis in

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general and ergodic theory in particular; he was enthusiastic, and I first began to get a sense that to him analysis was a powerful influence on all areas of mathematics, just as other areas influenced the development of analysis. He immediately gave me the galley proofs of his book *Unitary Group Representations in Physics, Probability, and Number Theory* that had just been published [4] and directed me to the chapter in question. I was stunned, of course: I had thought I knew a lot about an area, and I began to see how I just knew a lot about a teeny speck in a corner of one of the chapters of the book. From a small subset of shift-invariant subspaces, I stared down into the deep ocean of locally compact group actions on standard Borel spaces, neither of which, the groups nor the spaces, I knew much about. Also, Mackey's use of ergodic theory in the *Unitary Group Representations* book was aimed towards an understanding of certain quasi-orbits arising from the theory of induced representations. Going back to the drawing board, I told him I needed to know more analysis; I had studied most of first-year analysis, but knew nothing about the spectral theory of normal operators. Well, he said, why didn't I grade homework for the first-year analysis course he was teaching? It would be a good way to earn a bit of pocket money and learn more analysis at the same time, he opined, and we agreed that when the lectures arrived at spectral theory, I could leave my grading duties aside and take notes. I did as he suggested, feeling a bit guilty on behalf of the students enrolled in the course, but I knew I was fortunate.

The spring semester of my first year in graduate school I took a course on the history of harmonic analysis from Professor Mackey. The point of view in this course, as it was in all of his mathematics, was that harmonic analysis gave a unified way to attack problems in physics, probability, and number theory. His approach to mathematics was much more broad than any I had experienced before. Rather than focusing on any specific problem and performing narrow problem solving (which he must have had an obvious talent for, being one of the first Putnam fellows), he preferred to give a very broad overview so that we could view everything from a high perch looking down. "I want to use a telescope, not a microscope!" he said. He felt deeply that so many aspects of mathematics were "seemingly distinct, yet inseparably intertwined." Every lecture in this course would start out with him writing down the names of five, six, sometimes up to twelve, famous mathematicians who were contemporaries. One would think he would never be able to get through all of the mathematicians in one lecture, but by the end of the lecture he would have connected them all. His enthusiasm was such that he would often lean against the board, and if one's concentration dipped right after lunch, when the class was held, one could entertain oneself by reading the names "Bernoulli", "Euler", "D'Alembert", "Lagrange", "Laplace", "Legendre", etc., outlined in mirror symmetry across his jacket.

Mackey was fascinated by this intertwining of different areas for as long as I knew him, and whenever he gave a lecture, be it public or private, one could see that he was totally immersed in the mathematics that he so loved. His private lectures were just as well prepared and thought-out as his public ones. Whenever he came back from an important conference, he would give me a series of lectures on the main topic of the day. "K-theory for C^*-algebras! You must learn K-theory for C^*-algebras!" he said after returning from Europe one August, and he proceeded to give me a private series of three lectures that he had carefully crafted himself.

All the professors at Harvard were world famous of course, and all were powerful mathematicians, including the Benjamin Peirce Assistant Professors. At the time I was in graduate school, the department was particularly well known in the areas of algebraic geometry and number theory. Because of this and because of Mackey's "telescope rather than microscope" approach, a few "youngsters" did not know of his technical prowess. I remember a colleague was shocked when he was informed that George had been one of the first Putnam fellows. This surprise would have been avoided if he had read some of Mackey's deep papers on Borel spaces, for example "Borel structure in groups and their duals", appearing in 1957 [2], or "Point realizations of transformation groups", appearing in 1962 [4], both showing a total mastery of powerful techniques needed for specific results.

A few graduate students of my era, maybe because they were in a different area and did not know much of his work, wondered why Mackey did not support the department by getting National Science Foundation (NSF) grants. At that time, George's opposition on principle to accepting grant money might not have been widely known among graduate students. This was just five years after Watergate and the end of the Vietnam War, but only one or two years prior to the election of Ronald Reagan. Not many people at the time were suspicious of the NSF's control over research, which George had predicted decades earlier could arise. He told me that he found it impossible to write up a plan saying what he was going to do in the future with any precision and to write out progress reports to explain to what extent he had stuck to his "research plan". He also did not see any reason why an organization funded by the government should need such a plan anyway. "I will go where the mathematics leads me," he said. "Why would I follow any preassigned plan if I found something even better?" He did not seem to get involved in the interdepartmental politics of academe and completely enjoyed his mathematics and his world travels, where he had an amazing amount of recognition at other institutions in the U.S. and overseas.

I want to discuss a little bit of George's mathematics that most influenced me. The paper "Unitary representations of group extensions, I" [3], which appeared in 1958, was a beautiful combination of theory and technical prowess used towards the goal of understanding the theory of unitary representations. In this particular paper a variety of different areas of his expertise were apparent: induced representations, the use of group actions on standard Borel spaces, and projective representations. He formalized a method, the "Mackey machine", which allowed one to deduce all the equivalence classes of unitary representations of a locally compact group G if one knew them a priori for a closed normal subgroup N of G (e.g., if N were abelian) and if G/N acted on $\hat{N} = \{$unitary equivalence classes of unitary representations of $N\}$ in a nice enough way.

Indeed, Mackey showed in the above article that if N were type I and regularly embedded in G, then the set-theoretic structure of the dual of G could be described completely in terms of $\hat{N}$, $\widehat{G/N}$, and certain projective dual spaces of subgroups of G/N. In such a case, the Mackey machine can roughly be described as follows:

(1) Fix $\chi \in \hat{N}$.
(2) Let $K = G/N$; then K acts on $\hat{N}$ via $g \cdot \chi(n) = \chi(gng^{-1})$. Let K_χ be the stabilizer subgroup of χ, and let $G_\chi = \pi^{-1}(K_\chi)$. The group K_χ is called, following E. Wigner, the "little group".
(3) Extend χ from a unitary representation of N to a possibly projective unitary representation on L on G_χ with a representation space $\mathcal{H}_\chi$. The representation χ of N uniquely determines the equivalence class of the multiplier σ on G_χ. This is the "Mackey obstruction". One can choose things so that σ is a lift of a multiplier ω on the quotient group K_χ.
(4) If ω is nontrivial, let M be any irreducible $\overline{\omega}$ representation of K_χ and lift it to an irreducible representation of G_χ on the Hilbert space $\mathcal{H}_{\overline{\sigma}}$, also denoted by M. The tensor product representation $L \otimes M$ will then be an irreducible (nonprojective) unitary representation of G_χ.
(5) There may be many such choices, depending on the σ-representation theory of G_χ.
(6) Form the induced representation $\mathrm{Ind}_{G_\chi}^{G}(L \otimes M)$. Again, under appropriate conditions, this representation will be an irreducible representation of G.

This procedure provided up to unitary equivalence all possible irreducible representations of G. One sees here how Mackey used the induction process, the action of the group K on the Borel space $\hat{N}$, and the theory of projective representations—all were unified towards the solution of the problem of describing the structure of $\hat{G}$. With the Mackey machine, new technical difficulties arose in studying the action of K on $\hat{N}$; this was one reason for his initial interest in ergodic theory. Moreover, projective representations arose very naturally in mathematical physics, so it was not at all surprising that he was drawn to projective multipliers on locally compact groups. I think this paper is characteristic of George's method of drawing together tools from seemingly disparate areas towards giving a solution of a particular problem. At the end of this and many other papers, he was often more intrigued by any new questions that had arisen while solving the given problem. His approach led to certain developments in the theory of operator algebras; in particular the study of the structure of certain crossed product C^*-algebras was very much influenced by the "Mackey machine".

Meanwhile, to jump forward in time a bit, I kept attending George's courses in graduate school, even those in topics where my background was less than ideal. He encouraged me to attend his course on quantum mechanics, and when I remarked that I had just had one year of college physics, he said that was plenty for what he would do. I still remember when he told us in an excited manner that the mathematics behind quantum field theory could explain "...why copper sulfate was blue! Boiling points, colors of chemicals, all of these can be worked mathematically!" I remember being particularly struck by the fact that some chemical compound was blue precisely because of the mathematics rather than the physics. This appealed to me greatly, because it gave me hope that I could understand a bit of physics after all if I only could learn the mathematics.

I continued to lurk in George's peripheral vision, and both of us gradually realized that I wanted to be his student. When that propitious moment came, he went to the corner of his office and picked up a huge stack of preprints from the previous five years or so. "I was going to throw these away, because I have the offprints now, but maybe you will find something interesting here," he said. I hauled the stack of thirty or so preprints in various stages of development off to my cubicle, wondering if this would be like looking for a needle in a haystack. But I did look through all of them; it turned out there were many needles and hardly any strands of hay in the pile. I still have most of these preprints in my files, and most were written by a variety of luminaries (E. Effros, C. C. Moore, A. Ramsay, M. Rieffel, M. Takesaki, C. Series, R. Zimmer, to name just a few) whom I later had the good fortune to be able to meet in my postdoc year at UC Berkeley and during trips to UCLA, Penn, and Colorado through the years. As time went on and I became more mathematically mature, I realized that George had given me a gold mine of information. He turned out to be an excellent advisor, one who gave me wide latitude to think about and work on the thesis problem that was most interesting to me, in my case a study of the relationship between the structure of von Neumann algebras and some subalgebras constructed using ergodic actions and quotient actions. He gave me many great leads and mathematical ideas on my thesis, and on other of my papers because of his all-encompassing knowledge of the literature and understanding of the big picture. Whenever I came in with a question about something, even if I was not able to formulate exactly what I needed to know, he seemed to know what I needed. I remember querying him in a confused fashion about masa's (maximal abelian self-adjoint subalgebras) of von Neumann algebras. "Well, do you know about the paper of Singer? You must read the paper of Singer!" and he zipped out of his office on the third floor to the conveniently located math library just outside of it, and found the paper by I. M. Singer [6] in question in a jiffy. As he had indicated, it was extremely insightful and useful, and invaluable in my thesis work.

Since many people have asked me through the years, I feel here I should address George's views on women and their abilities in mathematics. At about the same time that I began working with George, an article by Camilla Benbow and Julian Stanley had just appeared [1], and the topic of whether or not most females aged twelve and above were indisposed by virtue of their sex to do deep mathematics was splashed across the front page of all the newspapers. The interpretation of the contents of this article became a thorn in the side of women mathematicians in general and women mathematics graduate students in particular. Of course this was talked about at the daily teas in the Harvard math department, and, as Mackey was a constant presence at teatime, he would discuss these results just as he would any other topic of the day. He would ask the graduate students what they felt and would muse on whether or not this article provided some sort of "proof" of anything and, in fact, could one obtain a "proof" of this sort rather than merely make observations, which he proceeded to make. I was very annoyed of course; it took me some time to realize that he talked about this partially for the enjoyment of provoking discussion and partially for the enjoyment of provoking. Partly for this reason, a few fellow graduate students, not knowing George well and only seeing him at teatime, thought that because of his age (at that time in his mid-sixties) and his outward manner, he must have been "sexist" as an advisor. I told them that nothing was further from the truth, that all he cared about was his students' interest and abilities in mathematics, and what he most enjoyed doing was talking about mathematics to anyone, male or female. Benbow and Stanley and their ilk were transitory, but mathematics was forever, mathematics was pure, mathematics was sacrosanct. I think that one of his students that he mentioned with the most pride while I was a student was Caroline Series (now a professor at Warwick and also contributing to this article), and when I had the opportunity to meet her, she seemed to share some similar sentiments about George. When it came to the fundamentals of advising and mentoring graduate students, by helping and encouraging them, all that mattered to him was the mathematics they were doing; in my opinion, in the treatment of women mathematicians in his own way he was far ahead of many people many years his junior. He was very comfortable with women's abilities, and with anyone's abilities for that matter, whenever they talked to him about mathematics. This may have been the case because his wife, Alice, was so accomplished and because together they had such a brilliant daughter, Ann, whom he introduced with great pride to me when she was a junior in high school at the department winter holiday party.

I now arrive at his personal kindness. Whenever I was discouraged about my mathematical ability, which was often in the early years following my Ph.D., he would always sound a positive note, telling me of some stellar mathematician who had been similarly discouraged and gone on to great achievements. I know of others who tell similar stories of his kindness and deep sense of loyalty to all of his colleagues and students, regardless of their fame or fortune.

It was fun to catch up with George throughout the years, first in 1983, right after my postdoc year in Berkeley, and finally in the summer of 1999, when my husband, my two young boys, and I visited George and Alice in their Coolidge Hill Road house. They both showed us great hospitality, and George told me of his latest enthusiastic mathematical ideas about finite simple groups and also about his great pride in his young grandson.

I believe that George was one of the great mathematicians and great mathematical characters of the past century. I can see him in my mind's eye now, with his blue seersucker jacket, often with chalk dust on the back of it, with a smile on his face as he is describing the latest advance in mathematical research that either he has uncovered or heard about in the latest conference he has attended. It is hard to think of this world without George in it. I will miss him greatly.

References

[1] C. P. Benbow and J. C. Stanley, Sex differences in mathematical ability: Fact or artifact?, *Science* **210** (1980), 1262–1264.

[2] G. W. Mackey, Borel structure in groups and their duals, *Trans. Amer. Math. Soc.* **85** (1957), 134–165.

[3] ———, Unitary representations of group extensions, I, *Acta Math.* **99** (1958), 265–311.

[4] ———, Point realizations of transformation groups, *Illinois J. Math.* **6** (1962), 327–335.

[5] ———, *Unitary Group Representations in Physics, Probability, and Number Theory*, Benjamin/Cummings Publishing Co., Boston, MA, 1978.

[6] I. M. Singer, Automorphisms of finite factors, *Amer. J. Math.* **77** (1955), 117–133.

Richard Palais

George Mackey had a pivotal influence on my life: my contacts with him, early and late, determined who I was, what I would become, and how my life and career would play out. He was in many ways a model for me, and throughout my career as mathematician and teacher I have frequently realized that in some important decision I made or in some way that I behaved I was attempting to emulate him. If I were an isolated case, this would hardly be worth noting here, but there is considerable evidence and testimony that George influenced very many others with whom he had contact in similar ways.

I first got to know George in 1949. I was then in my sophomore year at Harvard and took his famous Math 212 course. It started from the most elementary and fundamental part of mathematics, axiomatic set theory, proceeded through the development of the various number systems, and ended up with some highly advanced and esoteric topics, such as the Peter-Weyl Theorem. It was exciting and even breathtaking, but also very hard work, and I spent many hours following each lecture trying to digest it all. But what made it a truly life-altering experience was that George was also a tutor in my dorm, Kirkland House, and lived there himself. He encouraged me to take several meals with him each week, where we discussed my questions about the course but also about mathematics and life in general. By the end of that year I decided to switch my major from physics to mathematics, and from then on I think I took every course George gave, and our meals together became even more frequent.

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In my senior year, George said he felt that I should have some diversity in my mathematical educational experience and advised me to go elsewhere for my graduate training. But this was one piece of advice from him that I ignored, and I was very glad for his continued vital help and encouragement as I worked toward my Ph.D. degree at Harvard. While Andy Gleason became my thesis advisor (on Mackey's advice), George was still an important advisor and mentor during my graduate years, and in the Mathematics Genealogy Project I added him as my second advisor. And George also played an important role in getting me an instructorship at the University of Chicago, then the preeminent place for a first academic job. He had many friends there, and he put in a personal good word for me with them. Experiences such as mine were repeated over and over with many other young mathematicians just starting their careers. For while George was totally devoted to his mathematical research, he was never so busy that he could not spare some time to help a student or younger colleague in their studies and their research.

George and I renewed our friendship when I returned to the Boston area in 1960 to take a faculty position at Brandeis, and over the next forty years, unless one of us was away on sabbatical, we made a practice of meeting frequently for lunch in Harvard Square and discussing our respective research. This gave me a good and perhaps unique perspective of George's long-term research program and goals as he himself saw them. So, although I will leave to others in accompanying articles any detailed review or appraisal of his research, I feel it may be of some interest if I comment on his research from this unusual perspective.

If you asked Mackey what were the most important ideas and concepts that he contributed, I think he would have cited first the circle of ideas around his generalizations to locally compact groups of the imprimitivity theorem, induced representations, and Frobenius reciprocity for finite groups, and secondly what he called Virtual Groups. Indeed, his 1949 article "Imprimitivity for representations of locally compact groups I" in the *Proceedings of the National Academy of Sciences* was a ground-breaking and very highly cited paper that gave rise to a whole industry of generalizations and applications, both in pure mathematics and in physics. George himself used it as a tool to analyze the unitary representations of semidirect products, and it was an essential part of the techniques that, in the hands of Armand Borel and Harish-Chandra, led to the beautiful structure theory for the unitary representations of semisimple Lie groups. But Virtual Groups, introduced in his paper "Ergodic theory and virtual groups" (*Math. Ann.* **186**, 1966, 187–207) were another story. Even the name did not catch on, and they are now usually called groupoids, although that name is used for a great many other closely related concepts as well. Mackey always felt that people never fully understood or appreciated his Virtual Group concept and believed that eventually they would be found to be an important unifying principle. In the later years of his life he tried to work out his ideas in this direction further.

Another aspect of his research about which Mackey was justifiably proud was his contributions to developing rigorous mathematical foundations for quantum mechanics. His 1963 book *Mathematical Foundations of Quantum Mechanics* was highly influential and is still often quoted. (The title is a direct translation of von Neumann's famous and ground-breaking *Mathematische Grundlagen der Quantenmechanik*, which George told me was intentional.) His work in this area stops with the quantum theory of particle mechanics, and several times I suggested that he go further and develop a rigorous mathematical foundation for quantum field theory. But he seemed rather dismissive of quantum field theory and, as far as I could tell, was dubious that it was a valid physical theory.

George was a great believer in what Wigner called "the unreasonable effectiveness of Mathematics in the natural sciences." I want to close with a quote from a lecture that Mackey gave that I feel epitomizes his feeling of wonder at the beauty and coherence of mathematics, a feeling that motivated his whole approach to his research.

> While it is natural to suppose that one cannot do anything very useful in tool making and tool improvement, without keeping a close eye on what the tool is to be used for, this supposition turns out to be largely wrong. Mathematics has sort of inevitable structure which unfolds as one studies it perceptively. It is as though it were already there and one had only to uncover it. Pure mathematicians are people who have a sensitivity to this structure and such a love for the beauties it presents that they will devote themselves voluntarily and with enthusiasm to uncovering more and more of it, whenever the opportunity presents itself.

Arlan Ramsay

Remembering George Mackey

Like so many others, I have benefited often from the clarity of understanding and of exposition of George W. Mackey. If this had been only via his publications, it would have been quite stimulating and valuable, but it has been a truly wonderful opportunity to learn from him in courses and series of lectures and even on a one-to-one basis.

Moreover, after a time, our relationship became one of comfortable friends. My wife and I have both enjoyed knowing George and his delightful wife, Alice. The pleasures have been substantial and greatly enjoyed.

As I revise this, I am visiting at the Institut Henri Poincaré, where there have been numerous talks about uses of groupoids in physics and geometry, particularly noncommutative geometry. If George were here, he would make wonderful reports on the activities. Even with his example to learn from, I can achieve only a poor imitation. Still, I am happy to have the example as a standard.

My first encounter with George was in the undergraduate course he taught in 1958–59 on projective geometry. Already I found his attitude and style appealing.

Then I was in the class in the spring of 1960 for which he wrote the notes that became the book *Mathematical Foundations of Quantum Mechanics* [M1963]. The book by John von Neumann of the same title had aroused my curiosity about the subject, so this course was clearly a golden opportunity, but the reality far exceeded my expectations.

With his customary thoroughness, Mackey began the course with a discussion of classical mechanics in order to be able to explain the quantizing of classical systems and the need for quantum mechanics. He explained about the problem of blackbody radiation and Planck's idea for solving the problem, along with other precursors of quantum mechanics. We heard about the indistinguishability of electrons and the idea that electrons are all associated with a greater totality, like waves in a string are configurations of the string. There were many such insights to go along with the discussion of axioms for systems of states and observables that exhibit appropriate behavior to be models for quantum mechanics. This course answered many questions, and then the answers raised further questions. It was just what was needed and gave me a start on a long-term interest in quantum physics.

George had invested a great deal in support of his aim to understand quantum mechanics. He spoke of reading parts of the book by Hermann

Weyl, *The Theory of Groups and Quantum Mechanics*, and then working at length to explain the material in his own framework. Having done that, he was happy to pass along his understanding in the course and the notes. He was an example of the best practices in communicating mathematics, always ready to be a student or a teacher, as appropriate.

The course George taught in the academic year 1960–1961 was on unitary representations of locally compact groups. He also gave an informal seminar on the historical roots of harmonic analysis. His constant interest in historical relationships was well exhibited in the course and those lectures.

He connected representation theory to quantum mechanics by way of the symmetry one might expect for a single particle in Euclidean 3-space. The "total position observable" of a particle in $\mathbb{R}^3$ should be a system of imprimitivity for a representation of the Euclidean group $\mathbb{E}_3$ as explained in [M1968] and in Chapter 18 of [M1978]. The basic reason is that a Euclidean motion can be regarded as a change of coordinates, and measurements in one system should correspond to measurements in another in a systematic way. If Q_E is the question whether the particle is in a Borel set E and $g \in \mathbb{E}_3$, the relationship desired is that

$$Q_{Eg} = U(g)^{-1} Q_E U(g).$$

Moreover, if the particle is to be treated in the framework of special relativity, then U must extend to the appropriate group of space-time symmetries, the Poincaré group. By using Mackey's analysis of representations of group extensions [M1958], such representations of the Poincaré group can be classified, and the mass and spin of the particle appear from the analysis. This approach to particles as objects that can be localized was also used by A. S. Wightman in [W1962].

The connection to physics was only one of a number of reasons that Mackey was so interested in understanding and exploiting symmetry. Number theory, probability, and ergodic theory also came under that umbrella [M1978].

Over the years I had several other opportunities to learn from George's unique perspective in person. The first instance was a visit to Cambridge in the mid 1960s, and the next was at a conference in 1972 at TCU, organized by Robert Doran. There was a great deal of excitement about the relationship between virtual groups and orbit equivalence in ergodic theory. George was delighted to learn of earlier results of Henry Dye about orbit equivalence for countable abelian groups.

During the following academic year, George gave the De Long Lectures at the University of Colorado in Boulder, adding his own distinction to the list of distinguished speakers. He gave outstanding lectures on the uses of symmetry, particularly on the application of finite groups to the spectra of atoms.

Then at MSRI in 1983–1984, he gave a long series of lectures about number theory. As was his habit, the historical background was an important feature, and symmetry was the star of the show. A dinner at the Mackeys' was one of the memorable social events for us.

Almost twenty years later, in November of 2002, George had an interest in symmetry that was as intense as ever. He was also interested in discussing a variety of other topics: human nature, recently published books, etc. That was our last conversation, and I wish there could be many more. Regarding mathematics and physics, what interested him most at that time was the potential uses of symmetry.

Regarding George's papers, of special interest to me was [M1958]. In it George investigated the unitary representations of G, where G is a (second countable and) locally compact group and N is a type I normal subgroup. The idea is to gain some information from the presence of N and the way G acts on N and hence the unitary dual of N, $\hat{N}$ (unitary equivalence classes of irreducible representations of N). Composing with inner automorphisms of G restricted to N gives a natural action of G on $\hat{N}$. He proved that if L is a factor representation of G, then the canonical decomposition of $L|N$ over $\hat{N}$ uses a measure class $[\mu]$ that is quasiinvariant and ergodic for that natural action. Call $[\mu]$ the measure class *associated with* L. In many cases, N is what he called *regularly imbedded*; i.e., every measure class on $\hat{N}$ that is ergodic and quasiinvariant for the action of G is concentrated on an orbit.

The proofs used in [M1958] end by using transitivity, i.e., by working on a coset space and taking advantage of the existence of a stabilizer that carries the information that is needed. However, his proof of the Imprimitivity Theorem in particular begins in a way that works for general quasiinvariant measures, and his method for getting past the sets of measure 0 can be adapted to the general case.

Suppose that $[\mu]$ is a measure class concentrated on an orbit in $\hat{N}$ and that H is the subgroup of G/N stabilizing a point on that orbit. Then all the representations of G whose associated class is $[\mu]$ can be expressed in terms of the (possibly multiplier) representations of H/N (see the contributions above by C. C. Moore and J. Packer). Moreover, every representation produced by the construction is irreducible. The Imprimitivity Theorem plays a key role in the analysis. If N is not regularly imbedded, the required information is not contained in individual orbits, but more general quasiorbits.

In the more general case, George recognized that the action of G on $\hat{N}$ can be used to give $\hat{N} \times G$ a groupoid structure and that the first step in his proof of the Imprimitivity Theorem in [M1958] constructs a unitary valued function that satisfies the equation defining a groupoid homomorphism almost everywhere on $\hat{N} \times G$. This fact motivated his introduction of ergodic groupoids and their *similarity* equivalence classes, the latter being what he called *virtual groups.* His plan was to use virtual subgroups of G to replace the stabilizers that appear in the regularly imbedded case. In that case $\hat{N} \times G$ is equivalent to the stabilizer of any point in the orbit carrying $[\mu]$, and it follows that the representation behavior for $\hat{N} \times G$ is exactly the same as it is for the stabilizer. Of course, changing the choice of point in the orbit changes the stabilizer to a conjugate subgroup, so the action itself is equivalent to a conjugacy class of subgroups. Since a virtual group is an equivalence class of groupoids, it is essentially inevitable that one tends to work with groupoids themselves. There are also other kinds of equivalence besides similarity, and groupoids persist in all the contexts. The fundamental idea remains the same.

I want to say something about the existence of [R1976]. I inquired about whether George was planning to write the continuation of [M1958], and George generously encouraged me to carry out that project myself.

Those results were combined with other work to show that it is possible to transfer information from one nonregularly imbedded group extension to another in [BMR] and to investigate nonmonomial multiplier representations of abelian groups in [BCMR]. Of course finding all representations for a given virtual group is virtually impossible, but useful information can be obtained. George's notion of virtual group is now thriving in a number of areas, and representation theory remains part of the program.

References

[BMR] L. W. Baggett, W. Mitchell, and A. Ramsay, Representations of the discrete Heisenberg group and cocycles of an irrational rotation, *Michigan Math. J.* **31** (1984), 263–273.

[BCMR] L. W. Baggett, A. L. Carey, W. Moran, and A. Ramsay, Non-monomial multipler representations of Abelian groups, *J. Funct. Anal.* **97** (1991), 361–372.

[M1958] George W. Mackey, Unitary representations of group extensions I, *Acta Mathematica* **99** (1958), 265–311.

[M1963] ——, *The Mathematical Foundations of Quantum Mechanics,* W. A. Benjamin, Inc., New York-Amsterdam, 1963.

[M1968] ——, *Induced Representations of Groups and Quantum Mechanics*, W. A. Benjamin, Inc., New York-Amsterdam; Editore Boringhieri, Turin, 1968, viii+167 pp.

[M1978] ——, *Unitary Group Representations in Physics, Probability, and Number Theory*, Mathematics Lecture Note Series, 55, Benjamin/Cummings Publishing Co., Inc., Reading, MA, 1978, xiv+402 pp.

[R1976] Arlan Ramsay, Nontransitive quasiorbits in Mackey's analysis of group extensions, *Acta Mathematica* **137** (1976), 17–48.

[W1962] A. S. Wightman, On the localizability of quantum mechanical systems, *Rev. Modern Physics* **34** (1962), 845–872.

Caroline Series

George Mackey

In my memory, George Mackey scarcely changed from the time I first approached him as a prospective graduate student in the mid-1970s until the last time I saw him a couple of years before his death. He was a scholar in the truest sense, his entire life dedicated to mathematics. He lived a life of extraordinary self-discipline and regularity, timing his walk to his office like clockwork and managing, how one cannot imagine, to avoid teaching in the mornings, this prime time being devoted to research. I was once given a privileged view of his study on the top floor of their elegant Cambridge house. There, surrounded on all sides by books and journals shelved from floor to ceiling, he had created a private library in which he immersed himself in a quiet haven of mathematical and intellectual scholarship. I was lucky to arrive in Harvard at the time when he was working on what subsequently became his famous Oxford and Chicago lecture notes [7, 8]. These masterly surveys convey the sweep of huge parts of mathematics from group representations up. I do not know any other writer with quite his gift of sifting out the essentials and exposing the bare bones of a subject. There is no doubt that his unique ability to cut through the technicalities and draw diverse strands together into one grand story has been a hugely wide and enduring influence.

Mackey believed strongly in letting students find their own thesis problem. Set loose reading his notes, I reported to him every couple of weeks, and he was always ready to point me down some new yet relevant avenue. He never helped with technical problems, always saying, "Think about it and come back next week if you are still stuck."

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Sometimes I envied the other students, whom I, somewhat naïvely, assumed were being told exactly what to do, but in retrospect this was a most valuable training. Stemming from his interest in ergodic theory, I was given a partially guided tour of a wide swathe of dynamical systems.This loose but broad direction stood me in good stead later; I often think of it when under pressure to hand out precisely doable thesis problems when students have barely started their studies.

I finally settled for working on Mackey's wonderful invention, *virtual groups*. The idea, touched on in C. C. Moore's article, is laid out in most detail in Mackey's paper [5]. His explanation to me was characteristically simple. He was interested in group actions on measure spaces, because a measure-preserving action of a group induces a natural unitary representation on the associated L^2 space. As with any class of mathematical objects, he said, if you want to understand group actions, you should split them up into the simplest possible pieces. The simplest kind of group action is a transitive one, that is, one with a single orbit. Being a generalist, Mackey wanted to work in the category of Borel actions, so in particular the groups he cared about always had a standard Borel structure, that is, were either countable or Borel isomorphic to the unit interval. As he pointed out, an action being Borel has unexpectedly strong consequences; in particular the stabilisers of points are closed. A transitive action is clearly determined by the stabiliser of a single point or, more precisely, since the choice of point is arbitrary, by a conjugacy class of such. Thus a transitive action of a Borel group on a standard Borel space is equivalent to the specification of a conjugacy class of closed subgroups.

What is the next simplest type of action? Since we are in a category of measure spaces, an "indecomposable" action means that the underlying space should not split into nontrivial and measurable "subactions". Assuming the group preserves a measure or at least a measure class, this is precisely what is meant by the action being ergodic: there are no "nontrivial" group invariant measurable subsets, where "nontrivial" means neither a null set nor the complement of a null set. Mackey's idea was that, since a transitive action is determined by a closed subgroup, then wouldn't it be nice if an ergodic action were similarly determined by a new kind of "subobject" of the group, which he named in advance a "virtual group". There is a touch of genius in his passage from this apparently simplistic idea to a formal mathematical structure yielding deep insights. The key point is that the sought-after virtual group should be the *groupoid* $S \times G$, in which the base space is the underlying space of the action S and the arrows are pairs (s, g) where (s, g) has initial point s and final point $g \cdot s$ (or rather $s \cdot g$, since Mackey insisted on doing all his group actions from the right). Thus (s, g) could be composed with (s', g') if and only if $s' = s \cdot g$ and then $(s, g) \circ (s', g') = (s, gg')$.

The next step is perhaps the most interesting: a homomorphism from $S \times G$ to a group H should be a cocycle: that is, a map $a : S \times G \to H$ such that $a(s, g)a(sg, g') = a(a, gg')$. This led Mackey to his construction of the "range of the homomorphism". Observe that, in deference to Mackey's order, the direct product $G \times H$ acts on $S \times H$ by $(s, h) \cdot (g, h') = (sg, h'^{-1}ha(s, g))$. The "range" is essentially the action of H on the space of G orbits: if this space is not a standard Borel space, as, for example, if the G action is properly ergodic, one replaces it by the largest standard Borel quotient. Mackey saw this as the generalisation of the dynamical systems construction of a "flow built under a function". (A cocycle for a $\mathbb{Z}$-action can be defined additively given a single function from S to H.) This circle of ideas was seminal for much future work, in particular that of Mackey's former student Robert Zimmer. A special case is the Radon Nikodym derivative of a measure class preserving group action, which can be viewed as a groupoid homomorphism to $\mathbb{R}$, of which more shortly.

A special case arises when all the stabilisers of points are trivial. Mackey's natural relation of similarity between groupoids leads to the classification of free ergodic actions up to "orbit equivalence". Two measure-class-preserving actions of groups G, G' on spaces S, S' are called *orbit equivalent* if there is a Borel measure-class-preserving map $\phi : S \to S'$ with the property that two points in the same G-orbit in S are mapped to points in the same G'-orbit in S'. (This is *much* weaker than the usual notion of conjugacy, in which one insists that $G = G'$ and that $\phi(sg) = \phi(s)g$.) Just how much weaker is expressed in a remarkable theorem discovered by Mackey's student Peter Forrest: *any* two finite measure-preserving actions of $\mathbb{Z}$ are orbit equivalent [3]. Subsequently, Mackey learnt that the theorem had previously been proved by H. Dye [2] and became a great publicist. He took pleasure in telling me it had also been proved by the Russian woman mathematician R. M. Belinskaya [1]. More generally, any equivalence relation orbit equivalent to a $\mathbb{Z}$-action is called *hyperfinite*. Dye's theorem extends to show that actions of a much wider class, including all abelian groups, are hyperfinite, culminating in Zimmer's result [9] that an action is hyperfinite if and only if the equivalence relation is amenable in a suitable sense.

The classification of non-measure-preserving $\mathbb{Z}$-actions up to orbit equivalence is even more remarkable. Regarding the Radon Nikodym derivative as a cocycle to $\mathbb{R}$ as above, Mackey's "range" is known to dynamicists as the Poincaré flow. At the time Mackey did not perhaps appreciate just how far-reaching a construction this was. If the original $\mathbb{Z}$-action is measure-preserving, it is called Type I, II_0, II_∞, depending on whether the range $\mathbb{R}$-action is transitive or preserves a finite or infinite measure respectively. If the original action only preserves a measure class, it is called Type III_1, III_λ, and III_0, depending on whether the range groupoid is $\{\mathrm{id}\}, \lambda\mathbb{Z}$ for some $\lambda \in \mathbb{R}^+$, or properly ergodic. In a beautiful and remarkable piece of mathematics, pushed to its conclusion by W. Krieger [4], it turns out that the range completely classifies the original $\mathbb{Z}$-action up to orbit equivalence. The same construction gives rise to a rich fund of examples of von Neumann algebras, a fact widely exploited by A. Connes. My training under Mackey was an ideal foundation from which to appreciate all this work, which was developing rapidly in the late 1970s just about the time I finished my thesis.

Photo courtesy of Richard Palais.

Andrew Gleason (left) with Mackey at an 80th birthday party for Alice Mackey.

To return to Mackey as a person. Everyone who knew him will remember his uncompromising and sometimes uncomfortably forthright intellectual honesty. He took pleasure in following through a line of thought to its conclusion: political correctness was not for him. He wrote several articles about the invidious effects of federal research funding [6]. He may have lost the battle, but what he said was quite true.

I must say something about the widely held view that Mackey was against women mathematicians. All that I can say is that I never experienced the slightest prejudice from him and am proud to be what he referred to as "his first mathematical daughter." His straightforwardness was perhaps easy to misinterpret. For example, he might say something like "There have been historically

Eulogy by Andy Gleason

It was nearly sixty years ago that I first met George. The circumstances were that I had just arrived here in Cambridge myself, and I started to listen to his course. He was then an assistant professor, and he gave a course on locally compact groups, something he did many, many times thereafter—a course he gave often.

And I went to his course and listened, and pretty soon we started having after-class conversations. And then I began a policy of frequently going around to his rooms and talking mathematics. Just about general parts of mathematics. Not about his course particularly, maybe a little of this, maybe a little of that, but whatever it was.

And I, in any event, learned a great deal from these conversations. And yet, when I look back, I can't really focus on a specific thought that comes out of those conversations. It was a very general thing; it's because when we talked, we didn't talk about mathematics at the level where you see it in publications, with the revolving theme of first definition, then a theorem, then a proof. We didn't do that; we talked in very speculative terms. And I just found that I learned a great deal from this kind of conversation, and I'm really very deeply indebted to George for having told me these things—many, many things.

We went on having those conversations for the next two years, and then he went away to France for a year, and when he came back we started up again. Then I was away for two years, and we had to start again.

Finally, we used to talk after we were married and I and he both lived out toward the west end of Cambridge. We used to walk along Brattle Street, continuing the conversations of then, by this time, twenty years before.

And they were the same kinds of things. They were speculations about the nature of mathematics. They weren't theorems about mathematics; they were just speculations. And some of them worked out ultimately, some of them did not, and that's the way mathematics is. And I very much appreciate the fact that I learned a great deal from George and I went on from there, and eventually was able to become his colleague.

Thank you.

Andrew Gleason

almost no women mathematicians of stature. Therefore, on a statistical basis it is unlikely that a particular woman will be one." Of course such a view ignores all the complicated historical and cultural factors which explain why this might be so; nevertheless, the fact was hard to dispute. But what remains in my memory is that Mackey was always open-minded and unprejudiced, willing to take on-board new insights or experiences and accept new people on their merits, exactly as they came along.

Mackey stood for the highest standards. He lived his life by precise rules, but he enjoyed it to the fullest. Within his mathematics he found a fulfilment to which few can aspire. The spartan simplicity and mild disorder of his office contrasted sharply with the comfortable elegance created by Alice in their Cambridge home. Her wonderful old-world dinner parties were memorable occasions at which it was a privilege to be a guest. Mackey was sometimes disarmingly open about his family life, but through it all shone human warmth and love: their strictly scheduled but vastly important time reading aloud in the evenings, his pride in their daughter, Ann.

Mackey had the habit of writing lengthy letters about his latest discoveries. Long after retirement, indeed right up to a couple of years before his death, he continued working on various projects which between them seemed to involve nothing less than unravelling the entire mathematical history of the twentieth century. Subjects expanded to include statistical mechanics, number theory, complex analysis, probability, and more. He explained that group representations encompassed more or less everything, given that starting from quantum theory one obviously had to include chemistry and thus also biology. One might argue that things are a little more complicated; indeed I am sure with a twinkle in his eye he would agree. What is certain is that his ability to strip things down to their essential mathematical structure put a hugely influential stamp on generations of mathematicians and physicists. He was a man whose unique qualities, insights, and enthusiasms touched us all.

References

[1] R. M. Belinskaya, Partitions of Lebesgue space in trajectories defined by ergodic auto-morphisms, *Funktsional. Analiz i Ego Prilozen* **2**, No. 3 (1968), 4–16 (Russian).

[2] H. A. Dye, On a group of measure-preserving transformations, I, II, *Amer. J. Math.* **81** (1959), 119–159.

[3] P. Forrest, Virtual subgroups of $\mathbb{R}^n$ and $\mathbb{Z}^n$, *Adv. Math.* **3** (1974), 187–207.

[4] W. Kreiger, On ergodic flows and the isomorphism of factors, *Math. Ann.* **223** (1976), 19–70.

[5] G. Mackey, Ergodic theory and virtual groups, *Math. Ann.* **166** (1966), 187–207.

[6] ———, Effort reporting and cost sharing of federal research, *Science* **153** (Sept. 1966), 1057.

[7] ———, *The Theory of Unitary Group Representations*, Univ. of Chicago Press, 1976.

[8] ———, *Unitary Group Representations in Physics, Probability and Number Theory*, Benjamin, 1978.

[9] R. J. Zimmer, Hyperfinite factors and amenable actions, *Invent. Math.* **41** (1977), 23–31.

V. S. Varadarajan

I first met George Mackey in the summer of 1961 when he visited the University of Washington at Seattle, WA, as the Walker-Ames professor to give a few lectures on unitary representations and on quantum mechanics. The lectures were a great revelation to me, as they revealed a great master at work, touching a huge number of themes and emphasizing the conceptual unity of diverse topics. I had the opportunity to meet at leisure with him and talk about things, and his advice was invaluable to me. I was just getting started in representation theory, and his suggestion that I should start trying to understand Harish-Chandra's vast theory (based on a "terrifying technique of Lie algebras" as he put it) was one that gave my research career the direction and boost it needed.

In representation theory Mackey's goal was to erect a theory of unitary representations in the category of *all* second countable locally compact groups. This was decades ahead of his time, considering that all the emphasis on doing representation theory and harmonic analysis on p-adic and adelic groups would be ten to fifteen years in the future. In the aftermath of the fusion of number theory and representation theory, the original goal of Mackey seems to have fallen by the wayside; I feel this is unfortunate and that this is still a fertile program for young people to get into. It may also reveal hidden features of the p-adic theories that have escaped detection because of overspecialization.

I should mention his work on induced representations of finite groups. Even though this is a very classical subject, he brought fresh viewpoints that were extraordinarily stimulating for future research. A basic question in the theory is to compute the dimension of the space of intertwining operators between two induced representations of a finite group G, induction being from two possibly different subgroups $H_i (i = 1, 2)$. Mackey found a formula for this as a sum over the double coset space $H_1 \backslash G / H_2$

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of local (so to speak) intertwining numbers. The method on the surface does not seem to apply when G is infinite, for instance, when G is a Lie group. However, François Bruhat, then a student at Paris and interacting with Henri Cartan and Laurent Schwartz, realized that in order to make Mackey's method work one has to represent (following a famous theorem of Laurent Schwartz) the intertwining operators by suitable *distributions* on G that have a given behavior under the action of $H_1 \times H_2$ (from the left and right) and obtained a formula remarkably similar to Mackey's, at least when the double coset space was finite (as it is when G is semisimple and $H_1 = H_2$ is minimal parabolic). The Mackey-Bruhat theory has had a profound influence on the subject, as can be seen from Bruhat's own work on induced representations of p-adic groups and the later work of Harish-Chandra on the representations induced from an arbitrary parabolic and, later still, his work on the Whittaker representations of a semisimple Lie group.

The lectures he gave on quantum mechanics at Seattle were an eye-opener for me. He was the first person who fully understood the points of view of von Neumann and Hermann Weyl, made them his own, and then took them to even greater heights. His group-theoretic analysis of the fundamental aspects of quantum kinematics and dynamics was very beautiful, and he adumbrated this in a number of expositions. But it was his analysis of the foundations that was very original. The basic question, one that von Neumann first discussed in his book *Grundlagen der Quantenmechanik*, is the following: Is it possible to derive the statistical results of quantum theory by averaging a more precise theory involving several *hidden variables*? In his analysis von Neumann introduced the model-independent *Expectation functional* E on the space $\mathbb{O}$ of all bounded observables and showed that if $\mathbb{O} = B_{\mathbb{R}}(\mathcal{H})$, the space of bounded self-adjoint operators on the Hilbert space $\mathcal{H}$ (the model for quantum theory), then E is necessarily of the form $E(A) = \mathrm{Tr}(UA) = \mathrm{Tr}(U^{1/2}AU^{1/2})$ for all $A \in B_{\mathbb{R}}(\mathcal{H})$, for some positive operator U of trace 1. The states, which are identified with the Expectation functionals, form a convex set, and its *extreme points* are, by the above result of von Neumann, the one-dimensional projections $U = P_\phi$, the ϕ being unit vectors in the quantum Hilbert space $\mathcal{H}$. If there were hidden variables, the states defined by the P_ϕ would be convex combinations of the (idealized states) defined by giving specific values to the hidden variables, a contradiction.

The basic assumption that von Neumann made about the functionals E was their *unrestricted additivity*, namely, that $E(A + B) = E(A) + E(B)$ for *any two* $A, B \in B_{\mathbb{R}}(\mathcal{H})$. If A and B commute, they represent simultaneously measurable observables, and so they are random variables on the same probability space, thus presenting no obstacle to the assumption of the additivity of the expectation values. But if A and B *do not commute*, there is no single probability space on which they both can be regarded as random variables, and so in this case the assumption of additivity is less convincing. Mackey saw that to have the most forceful answer to the hidden variables question, the additivity can be assumed only for *commuting* observables. If E is assumed to be additive only for commuting observables, its restriction to the lattice $\mathcal{L}(\mathcal{H})$ of projections in $\mathcal{H}$ would be a *measure*, i.e., additive over orthogonal projections. Conversely, any such measure would define an expectation value that has all the properties that von Neumann demanded, except that additivity will be valid only for commuting observables. Andrew Gleason then showed, after Mackey brought his attention to the question of determining all the measures on the orthocomplemented lattice $\mathcal{L}(\mathcal{H})$, that the only countably additive measures are of the form $P \longmapsto \mathrm{Tr}(UP) = \mathrm{Tr}(U^{1/2}PU^{1/2})$ (when $\dim(\mathcal{H}) \geq 3$); from this point on, the argument is the same as von Neumann's. One can use the Gleason result to show also that there are no two-valued *finitely additive* measures on the lattice $\mathcal{L}(\mathcal{H})$ if $3 \leq \dim(\mathcal{H}) \leq \infty$, thus showing that there are no dispersion-free states. This analysis of hidden variables à la Mackey is a significant sharpening of von Neumann's analysis and reveals the depth of Mackey's understanding of the mathematical and phenomenological issues connected to this question.

In his view of quantum kinematics, Mackey formulated the covariance of a quantum system with a manifold M as its configuration space as the giving of a pair (U, P) where U is a unitary representation of a group G acting on M and P is a projection-valued measure. For any Borel set $E \subset M$, $P(E)$ is the observable that is 1 or 0 according to whether the system falls in E or not, and G is the given symmetry group or at least a central extension of it (the latter is necessary, as the symmetries act as automorphisms of the lattice of projections and so are given by unitary operators defined only up to a phase factor). Covariance is then given by the relations $U(g)P(E)U(g)^{-1} = P(g[E])$. This is exactly what Mackey had called a *system of imprimitivity for* G in his pioneering work on the extension of the theory of Frobenius (of induced representations) to the full category of all separable locally compact groups, and he was thus able to subsume the fundamental aspects of quantum kinematics under his own work. The story, as told to me by him in Seattle, of how he came upon this formulation of quantum kinematics is quite interesting.

Irving Segal, who had gone to attend a conference, sent him (Mackey) a postcard saying that Wightman had in his lectures at the conference used Mackey's work to discuss kinematic covariance in quantum mechanics, and Mackey then deduced his entire formulation with no further help other than this cryptic postcard! Of course there is more to covariance than a system of imprimitivity—indeed, even in ordinary quantum mechanics, this formulation does not prevent position observables from being defined for the relativistic photon, as Laurent Schwartz discovered, although we know that there is no frame where the photon is at rest, and so position operators cannot be defined for it. Much work thus remains to be done in giving shape to Mackey's dreams of a group-theoretic universe.

In recent years, when attention has been given to quantum systems arising from models of space-time based on non-Archimedean geometry, or super geometry, the Mackey formulation has offered the surest guide to progress. As an example one may mention the classification of superparticles carried out in the 1970s by physicists whose rigorous formulation needs an extension of Mackey's imprimitivity theorem to the context of homogeneous spaces for the super Lie groups, such as the super Poincaré groups.

In all my encounters with him he was always considerate, full of humor, and never condescending. He was aware that his strength was more in ideas than in technique (although his best work reveals technical mastery in functional analysis of a high order) and repeatedly told me that as one gets older, technique will disappear and so one has to pay more attention to ideas. His view of mathematics and its role in the physical world was a mature one, full of understanding and admiration for the physicists' struggles to create a coherent world picture, yet aware of the important but perhaps not decisive role of mathematics in its creation. In his own way he achieved a beautiful synthesis of mathematics and physics that will be the standard for many years to come.

Ann Mackey

Eulogy for My Father, George Mackey*

Before I lose my composure, I want to offer thanks. My mother and I thank my father for everything he was to us, and we thank everyone here today for coming to share in this memorial service, especially those who have spoken and captured my father's essence so beautifully.

My father had a wonderful life and knew it. Having started out feeling like a misfit who couldn't begin to live up to the material and social expectations set for him by his parents, he felt extraordinarily fortunate to have found his way to a world in which he could do what he loved best in such a rarified atmosphere. The world opened up for him, literally and figuratively, when he discovered mathematics, and he never looked back. He devoted all the time he could to his work, spending most of his days in his third-floor study, emerging only for meals. If I came upstairs to look for him, I could count on seeing him slumped in his chair with clipboard in hand, lost in thought and often chewing on one of the buttons on his shirt. That clipboard traveled with him around the world, and my mother and I left him working on countless park benches while we pursued separate adventures.

Photo courtesy of Ann Mackey.

Mackey with daughter Ann in Zurich, 1971.

My father was notoriously eccentric and proud of it. Having found a clothing style that suited him early in life, gold pocket watch included, he resisted straying any further from that than absolutely required. No matter how hot it got, he could rarely be persuaded to remove his jacket and tie, even at the beach (and we have the pictures to prove it here today). I will leave to your imaginations the discussions he had with my mother on the subject of his attire.

He disclaimed any formal interest in people, but his conversations were filled with news of those he had encountered during his day. Although he resisted any event that might interfere with his work time, he actively enjoyed socializing. Bedtime was sacred, though, so he was often the first to leave a party.

The visual arts left him unmoved; instead, he saw great beauty in mathematics. New insights thrilled him, and he would emerge from his study giddy with excitement about a new idea.

He was not musical, but enjoyed classical music in modest doses and had a great fondness for Gilbert and Sullivan tunes. He would often burst into song spontaneously, generally off-key. He taught himself to play the piano by creating his own numeric notational system, with pluses for sharps and minus signs for flats. He called it the "touch typewriter method" and built up quite a repertoire of his favorite tunes. He took a similar approach to foreign language study.

He was more sentimental than he would ever admit, often choking up as he read certain passages aloud.

**Remarks at the memorial service, Harvard Chapel, April 29, 2006.*

Many people have already touched on my father's honesty and adherence to principle, so I'm going try to avoid redundancy. However, I did want to stress that as much as he enjoyed a good argument and as much as his honesty could sometimes come at the expense of tact, he never wished to be unkind. He often agonized about how to deliver his message without giving serious offense. He could be absolutely infuriating, and there was sometimes an element of mischief and contrariness in his arguments, but his words truly bore no malice.

Photo courtesy of Robert Doran.

Mackey with his famous clipboard, 1988.

He rarely signed on to any idea or behavior before he had thoroughly researched the subject in question and had reached his own conclusions. He was not a quick study, and this could be infuriating when something seemed obvious on its face. We joked that despite his physical caution, his aversion to taking orders might someday cause him to walk straight off a precipice if he wasn't given clear, provable evidence that the precipice existed.

I loved my father dearly. Although he was fond of asserting to anyone who would listen that he'd never wanted a family, it was clear to everyone that once he stumbled into marriage and fatherhood, he relished and cherished it, even as he struggled to adapt to the compromises it asked of him.

His marriage to my mother, his opposite in so many ways, had its share of memorably dramatic moments, but at its core was love and respect. They lived much of their daily lives independently, but were together for most meals, especially their nightly cocktails and candlelit dinners, where they shared news of their days, followed by my father reading aloud to my mother as I drifted off to asleep upstairs. They enriched each other's lives in ways neither expected and particularly enjoyed their travels together and the friends they made around the globe. Despite their different outlooks on many things, each was the other's best and most trusted friend.

As serious as my father was about his work, he was a child at heart. He was a wonderful, playful father to me when I was young, reading to me, drawing me pictures, crawling around on all fours, and patiently playing endless games of Monopoly, so long as we kept the latter to morning play times, lest the competitive stress of the game interfere with his sleep. He was a thoughtful, concerned—albeit somewhat befuddled—advocate for me as I navigated the tricky landscape of adolescence. He was a refuge when I was sad or anxious. He was patient.

Photo courtesy of Ann Mackey.

George Mackey.

And although mystified that anyone, including myself, would not choose a career in the sciences, he believed that one should follow one's heart and always supported the choices I made, regardless of whether he fully understood them.

He was a dedicated letter writer, sending long, affectionate, newsy updates to us when he traveled, and for me, scientific and mathematical expositions, including letters that would end, and I quote, "Q.E.D. Love, Daddy." In his later years he eagerly embraced email as a way to communicate with me. At my request, he sent me a serialized account of his life, filled with all the stories he'd told me of his childhood and continuing partway through graduate school. A year or so ago, although he had lost the ability to put more than a few words on paper, he narrated further accounts aloud for my mother to transcribe. We have all these words to hold on to, and I am deeply grateful for that.

Please forgive me if I take this moment to encourage everyone here to make the time to write to those they love.

My father was a realist about death. Conscious of being an older parent, he had, to some extent, been preparing me for his eventual demise virtually since the day I was born. But it was very hard to watch the man we knew and loved slip away from us over these past few years. We are fortunate that in many fundamental ways he did retain much of his old self, but it was a sad journey.

Certainly we appreciate that death is part of the natural cycle of life and that we should rejoice that he lived so fully for so long. Those thoughts, and the memories he left, and those shared by so many people in their letters and phone calls do help immensely. I am glad that his grandchildren were at least able to spend time with him, if not know him as he once was. But standing right here, I am conscious mostly of what we have lost. My mother and I miss him terribly, and it is very hard to say goodbye.

Do Loops Explain Consciousness? Review of *I Am a Strange Loop*

Martin Gardner

I Am a Strange Loop
Douglas Hofstadter
2007, Basic Books, New York
US$26.95, 412 pages
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ISBN-10: 0-465-03078-5

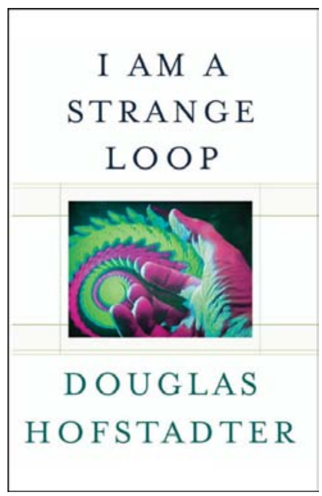
Barmaid: "Would you like some wine?"
Descartes: "I think not."
Then he vanishes.

—*Anonymous joke*

Our brain is a small lump of organic molecules. It contains some hundred billion neurons, each more complex than a galaxy. They are connected in over a million billion ways. By what incredible hocus-pocus does this tangle of twisted filaments become aware of itself as a living thing, capable of of love and hate, of writing novels and symphonies, feeling pleasure and pain, with a will free to do good and evil?

David Chalmers, an Australian philosopher, has called the problem of explaining consciousness the "hard problem". The easy problem is understanding unconscious behavior, such as breathing, digestion, walking, perceiving, and a thousand other things. Grappling with the hard problem has become one of the hottest topics facing philosophers, psychologists, and neuroscientists. According to philosopher John Searle, reviewing Nicholas Humphrey's *Red: A Study of Consciousness* (*New York Review of Books*, November 2005), Amazon lists 3,865 books on consciousness. The most recent, published this year by Basic, is Douglas Hofstadter's *I Am a Strange Loop*.

Martin Gardner wrote Scientific American*'s Mathematical Games column for 25 years. His most recent books are* The Annotated Hunting of the Snark *and* Are Universes Thicker Than Blackberries?



Hofstadter, a professor of cognitive science at Indiana University, is best known for his Pulitzer prize-winning *Gödel, Escher, Bach*, or *GEB* as he likes to call it. His new book, as brilliant and provocative as earlier ones, is a colorful mix of speculations with passages of autobiography. An entire chapter is devoted to a terrible tragedy that Hofstadter is still trying to cope with. His wife Carol, at age 42, died suddenly of a brain tumor. The preceding chapter links his love for Carol to a fantasy he once conceived about a mythical land he called Twinwirld. Its inhabitants are identical twins, so nearly alike that they think and act like single individuals.

I suspect Hofstadter will be surprised to know that L. Frank Baum, in his non-Oz fantasy *The Enchanted Island of Yew* (you?) imagined a similar land he called Twi. Everything in Twi is duplicated, like seeing the world through glasses that produce double images. Residents of Twi, like those of Twinwirld, are identical twins. The rulers of Twi are two beautiful girls who think and speak as a single entity.

In his heart-rending chapter on Carol, Hofstadter makes clear why he preceded it with a description of Twinwirld. He and Carol were so much alike they they resembled a pair of Twinwirlders. Unable to find consolation in hope for an afterlife, Hofstadter's only solace is knowing that for at least a time Carol will in a way live on in the memories of those who knew and loved her.

I Am a Strange Loop swarms with happy memories. One vivid recollection, not so happy, concerns a time when Hofstadter was fifteen and asked to select two guinea-pigs to be killed for a laboratory experiment. Faced with the task, he fainted. This aversion to animal killing led to his becoming a vegetarian. For a while he allowed himself eggs and fish, but later became a vegan, avoiding all food of animal origin. He refuses to buy leather shoes and belts. Like Baum's Tin Woodman, to whom the Wizard gave a fine velvet heart, Hofstadter has twinges of guilt when he swats a fly. One of his heroes is Albert Schweitzer, who whenever possible avoided killing an insect.

Many pages in *I Am a Strange Loop* express the author's great love of music. Hofstadter plays a classical piano. Bach, Chopin, and Prokofiev are among his favorite composers, Bartok among those he dislikes. Another passion is for poetry. He has translated from the Russian Pushkin's great poem *Eugene Onegin*, as well as the work of other foreign bards.

On page 94 Hofstadter offers a clever six-stanza poem by a friend that commemorates an event he later considered symbolic. One day he grabbed a batch of empty envelopes and was puzzled by what seemed to be a marble wedged between them. The marble turned out to be a spot where a thickness of paper felt like a marble. In a similar way, he believes, we imagine a self wedged somewhere between the neurons of our brain.

The marble provides the central theme of *I Am a Strange Loop*. The soul, the self, the I, is an illusion. It is a strange loop generated by a myriad of lesser loops. It is a minute portion of the universe, a glob of dead matter within our skull, not only observing itself, but aware it is observing itself.

Hofstadter has long been fascinated by self-reference loops. He sees them everywhere. They are at the heart of Gödel's famous undecidability proof. They lurk within Russell and Whitehead's *Principia Mathematica*. They are modeled by such logic paradoxes as "This sentence is false." and by the card that says on one side "The sentence on the other side is true," and on the flip side says "The sentence on the other side is false." Similar loops are such lowly mechanisms as flywheels, thermostats, and flush toilets. He reproduces Escher's famous lithograph of two hands, each drawing the other, and suggests modifying it by having one hand *erase* the other.

Many photographs in the book depict recursive loops. One shows a carton closed by four flaps, A on top of B, B on top of C, C on D, and D on A. In another picture Doug and Carol are each touching the other's nose. An amusing photo shows a grinning Doug with nine friends, each sitting on the lap of a person behind.

In Chapter 21 Hofstadter introduces a disturbing thought experiment, involving human identity, that has been central in dozens of science-fiction tales. A man is teleported by a process made famous by Star Trek. Officers of the Enterprise are beamed down to a planet, later beamed up again. This is done by apparatus that scans a person molecule by molecule, then transmits the information to a distant spot where it creates an exact duplicate

Photograph by Pete Rimbey.

Carol and Doug Hofstadter touching one another's noses.

of the person. If this destroys the original body there is no philosophical difficulty. But suppose the original is not destroyed. The result is a pair of identical twins with identical memories. Is the teleported person the *same* person or someone else?

The dilemma goes back to Plutarch. He imagines a ship that is slowly replaced, piece by piece, until the entire ship is reconstituted. The original parts are then reassembled. Each ship can claim to be the original.

Baum introduces the same problem in his history of the Tin Woodman. As all Oz buffs know, a cruel witch enchants Nick Chopper's ax, causing it to slice off parts of Nick's meat body. Each part is replaced by Ku-Klip, a master tinsmith, until Nick is made entirely of tin. In *The Tin Woodman of Oz* the tin man visits Ku-Klip's workshop where he converses with his former head. Ku-Klip has preserved it in a cupboard. Who is the real Nick Chopper? The tin man or his former head?

Hofstadter has little interest in such conundrums. Another topic that infuriates him is free will. Unlike his good friend philosopher Daniel Dennet, Hofstadter denies that free will exists. It is another mirage, like the marble in the envelopes.

Other topics drive Hofstadter up a wall. One is the "inverted spectrum" paradox. How can we be certain that our sensation of, say, red is the same as that of another person? What we experience as red could be what she experiences as what we call blue.

Another topic Hofstadter considers frivolous is the concept of a zombie. Zombies are persons who think, talk, and behave exactly like ordinary people but are entirely lacking in all human feelings and emotions. The concept arises in relation to computerized robots. Baum's wind-up robot Tik-Tok, who Dorothy rescues in *Ozma of Oz*, has a metal plate on his back that says, "Thinks, Speaks, Acts, and Does Everything but Live." It is hard to believe, but entire books have been written about zombies

Consciousness for Hofstadter is an illusion, along with free will, although both are unavoidable, powerful mirages. We feel as if a self is hiding inside our skull, but it is an illusion made up of millions of little loops. In a footnote on page 374 he likens the soul to a "swarm of colored butterflies fluttering in an orchard."

Like his friend Dennet, who wrote a book brazenly titled *Consciousness Explained*, Hofstadter believes that he too has explained it. Alas, like Dennet, he has merely described it. It is easy to describe a rainbow. It is not so easy to explain a rainbow. It is easy to describe consciousness. It is not so easy to explain the magic by which a batch of molecules produce it. To quote a quip by Alfred North Whitehead, Hofstadter and Dennet "leave the darkness of the subject unobscured."

Let me spread my cards on the table. I belong to a small group of thinkers called the "mysterians". It includes such philosophers as Searle (he is the scoundrel of Hofstadter's book), Thomas Nagel, Colin McGinn, Jerry Fodor, also Noam Chomsky, Roger Penrose, and a few others.

We share a conviction that no philosopher or scientist living today has the foggiest notion of how consciousness, and its inseparable companion free will, emerge, as they surely do, from a material brain. It is impossible to imagine being aware we exist without having some free will, if only the ability to blink or to decide what to think about next. It is equally impossible to imagine having free will without being at least partly conscious.

In dreams one is dimly conscious but usually without free will. Vivid out-of-body dreams are exceptions. Many decades ago, when I was for a short time taking tranquilizers, I was fully aware in out-of-body dreams that I was dreaming, but could make genuine decisions. In one dream, when I was in a strange house, I wondered if I could produce a loud noise. I picked up a heavy object and flung it against a mirror. The glass shattered with a crash that woke me. In another OOB dream I lifted a burning cigar from an ashtray, and held it to my nose to see if I could smell it. I could.

We mysterians are persuaded that no computer of the sort we know how to build—that is, one made with wires and switches—will ever cross a threshold to become aware of what it is doing. No chess program, however advanced, will know it is playing chess anymore than a washing machine knows it is washing clothes. Today's most powerful computers differ from an abacus only in their power to obey more complicated algorithms, to twiddle ones and zeroes at incredible speeds.

A few mysterians believe that science, some glorious day, will discover the secret of consciousness. Penrose, for example, thinks the mystery may yield to a deeper understanding of quantum mechanics. I belong to a more radical wing. We believe it is the height of hubris to suppose that evolution has stopped improving brains. Although our DNA is almost identical to a chimpanzee's, there is no way to teach calculus to a chimp, or even to make it understand the square root of 2. Surely there are truths as far beyond our grasp as our grasp is beyond that of a cow.

Why is our universe mathematically structured? Why does it, as Hawking recently put it, bother to exist? Why is there something rather than nothing? How do the butterflies in our brain—or should I say bats in our belfry—manage to produce the strange loops of consciousness?

There may be advanced life forms in Andromeda who know the answers. I sure don't. Nor do Hofstadter and Dennet. And neither do you.

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Another topic Hofstadter considers frivolous is the concept of a zombie. Zombies are persons who think, talk, and behave exactly like ordinary people but are entirely lacking in all human feelings and emotions. The concept arises in relation to computerized robots. Baum's wind-up robot Tik-Tok, who Dorothy rescues in *Ozma of Oz*, has a metal plate on his back that says, "Thinks, Speaks, Acts, and Does Everything but Live." It is hard to believe, but entire books have been written about zombies

Consciousness for Hofstadter is an illusion, along with free will, although both are unavoidable, powerful mirages. We feel as if a self is hiding inside our skull, but it is an illusion made up of millions of little loops. In a footnote on page 374 he likens the soul to a "swarm of colored butterflies fluttering in an orchard."

Like his friend Dennet, who wrote a book brazenly titled *Consciousness Explained*, Hofstadter believes that he too has explained it. Alas, like Dennet, he has merely described it. It is easy to describe a rainbow. It is not so easy to explain a rainbow. It is easy to describe consciousness. It is not so easy to explain the magic by which a batch of molecules produce it. To quote a quip by Alfred North Whitehead, Hofstadter and Dennet "leave the darkness of the subject unobscured."

Let me spread my cards on the table. I belong to a small group of thinkers called the "mysterians". It includes such philosophers as Searle (he is the scoundrel of Hofstadter's book), Thomas Nagel, Colin McGinn, Jerry Fodor, also Noam Chomsky, Roger Penrose, and a few others.

We share a conviction that no philosopher or scientist living today has the foggiest notion of how consciousness, and its inseparable companion free will, emerge, as they surely do, from a material brain. It is impossible to imagine being aware we exist without having some free will, if only the ability to blink or to decide what to think about next. It is equally impossible to imagine having free will without being at least partly conscious.

In dreams one is dimly conscious but usually without free will. Vivid out-of-body dreams are exceptions. Many decades ago, when I was for a short time taking tranquilizers, I was fully aware in out-of-body dreams that I was dreaming, but could make genuine decisions. In one dream, when I was in a strange house, I wondered if I could produce a loud noise. I picked up a heavy object and flung it against a mirror. The glass shattered with a crash that woke me. In another OOB dream I lifted a burning cigar from an ashtray, and held it to my nose to see if I could smell it. I could.

We mysterians are persuaded that no computer of the sort we know how to build—that is, one made with wires and switches—will ever cross a threshold to become aware of what it is doing. No chess program, however advanced, will know it is playing chess anymore than a washing machine knows it is washing clothes. Today's most powerful computers differ from an abacus only in their power to obey more complicated algorithms, to twiddle ones and zeroes at incredible speeds.

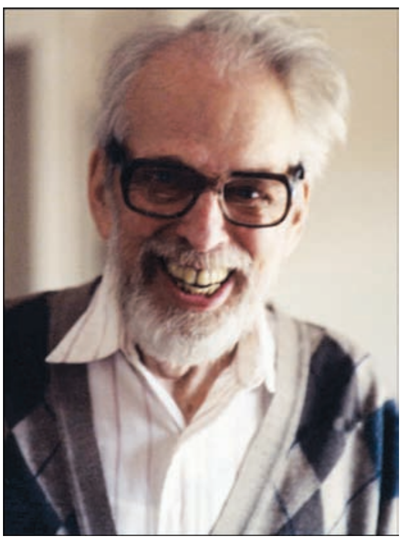
A few mysterians believe that science, some glorious day, will discover the secret of consciousness. Penrose, for example, thinks the mystery may yield to a deeper understanding of quantum mechanics. I belong to a more radical wing. We believe it is the height of hubris to suppose that evolution has stopped improving brains. Although our DNA is almost identical to a chimpanzee's, there is no way to teach calculus to a chimp, or even to make it understand the square root of 2. Surely there are truths as far beyond our grasp as our grasp is beyond that of a cow.

Why is our universe mathematically structured? Why does it, as Hawking recently put it, bother to exist? Why is there something rather than nothing? How do the butterflies in our brain—or should I say bats in our belfry—manage to produce the strange loops of consciousness?

There may be advanced life forms in Andromeda who know the answers. I sure don't. Nor do Hofstadter and Dennet. And neither do you.

Bers Library Finds a Home—and Resonance—at Charles University

Allyn Jackson



Photograph courtesy of Victor Bers.

Lipman Bers, 1991.

Lipman Bers died in 1993 after a long battle with Parkinson's disease. Not long after his death, his son and daughter, Victor Bers and Ruth Shapiro, had to start caring for their mother, so their father's study in the family home in New Rochelle, New York, remained basically in the state in which he had left it. When their mother passed away in early 2006, Ruth and Victor finally had to deal with the contents of their father's study. Victor is a professor of classics at Yale University—in other words, he is someone who lives and works through books. His sister, Ruth, is a retired professor of psychology at the City University of New York and a psychoanalyst, and she too felt that their father's mathematics books should not simply be discarded or sold off.

As they cast about for an idea of what to do, Ruth's husband, Bob Shapiro, decided to call the AMS for advice. Ruth and her brother knew of the AMS because their father had served as president of the Society from 1975 to 1977 and had been active in AMS affairs while they were growing up. But they did not know that the AMS has a book donation program and that many of the donated books have gone to Charles University in Prague, where the mathematics library was almost wiped out in the floods that devastated central Europe in 2002. "I'm not sure whether the person Bob spoke to realized that my father had his doctoral degree from Charles," said Victor. "It was the single most appropriate place on earth for the books to go."

When word came that the forty cartons had arrived in Prague in early 2007, "We couldn't have been happier," said Ruth. "We were overjoyed to be able to replace some of the books they had lost." With books in four languages that Lipman Bers knew well—English, French, German, and Russian—the collection symbolizes the life of a man who was deeply affected by the cataclysmic events of the early twentieth century but who remained true to his authentic calling in teaching, learning, and doing mathematics.

Mathematician, Teacher, Activist

By any standard, Lipman Bers led an eventful life. Sometime in the late 1980s, the AMS bought him a laptop computer so that he could write his memoirs. He worked on them intermittently, and when his illness advanced he was assisted by Janet Shapiro, a former graduate student of (but no relation to) his daughter, Ruth. Because of his failing health, Bers was unable to write a full-fledged autobiography. The resulting document, which he called "pages" from an autobiography, is a charming, fascinating, and sometimes harrowing 80-page account of his early life up to 1942. The penultimate event recounted in the memoir has him, his wife, and the six-month-old Ruth fleeing to the United States in 1940, shortly after the start of the Nazi occupation of Paris. As Bers recounted in his memoir, their passports were stamped by the French police, "pack your suitcase and get out."

Lipman Bers was born in Riga (now in Latvia, then part of Russia) in 1914. Although his father was trained as a mining engineer and his mother later became a psychoanalyst, they both worked as principals at progressive Yiddish-language schools in Riga. One summer when he was sixteen or seventeen years old, Bers traveled with his mother to

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Photographs of the library by Jaroslav Richter.

Photos of damage to books at the Charles University mathematics library, inflicted in the 2002 floods. Top: Books on the ground floor, where water rose to about 190 cm. Bottom: Destroyed books thrown from windows onto Sokolovska Street.

Prague, where they came upon a bookstore with many mathematics books. He was dazzled, for mathematics books were hard to come by in Riga. A short one on set theory caught his eye. Bers wrote in his memoir: "I opened it to the first page. Not only could I understand everything that I read, but the subject seemed familiar." The book included an open problem, Cantor's Continuum Hypothesis, which "would give me immortality if I could solve it." After returning to Riga, Bers decided to apply to the University of Zurich to study mathematics.

He spent one year in Zurich and then returned to Riga, where he became active in anti-Fascist youth movements. After a putsch by the Latvian prime minister, the situation became quite dangerous, with antigovernment groups being rounded up and sent to internment camps. Bers continued to be involved in the resistance movement, in particular helping to circulate a newspaper that was critical of the government. One day he called home and his mother told him she was "busy with visitors" and could not talk, a signal that the police had come to arrest him. He went into hiding and shortly thereafter fled Latvia, first going to Scandinavia and Poland and eventually making his way to Prague. There he enrolled in Charles University, where he earned a doctorate in mathematics in 1938. He wrote his thesis, *Ueber das harmonische Mass im Raume*, under the direction of Karel Löwner (who took the name Charles Loewner after emigrating to the United States). Löwner had also received his doctorate from Charles University, in 1917. Some of Bers's recollections of Prague are recounted in the excerpt from his memoirs that appears in this issue of the *Notices*.

After reaching the United States, Bers had a difficult time finding work. His son, Victor, explained that there was some fear that the many refugee mathematicians coming over from Europe might take jobs away from Americans, and there was also some anti-Semitism. On the other hand, many mathematics departments recognized the opportunity this wave of refugees offered for hiring outstanding researchers. Bers discussed this period in a lecture, "European Mathematicians' Migration to America", which he gave at the AMS centennial celebration in August 1988. In the lecture he recounted that when he came to the United States, he was advised to change his first name to Leslie and to join the Unitarian church. He also thanked the many American colleagues who welcomed so many refugees like him.

By 1942 Bers had landed a position at Brown University. In his memoir he recalled discussing the position with Brown mathematician William Praeger. Trying to test Bers's knowledge, Praeger explained in a superficial way what photo-elasticity is and then asked Bers, "You know the foundations of photo-elasticity, don't you?" Bers wrote: "I was pleased to realize that he knew not too much more than I, and I answered, 'the very foundations, yes.' Then he offered me a job to teach and do research in this fashionable discipline…I will always be grateful to him for not taking photo-elasticity too seriously."

After teaching at Brown for a few years, Bers moved to Syracuse University and then spent two years at the Institute for Advanced Study in Princeton. In 1951 he went to the Courant Institute at New York University and in 1964 moved to Columbia University, where he remained until his retirement in 1984.

Bers made deep and substantial contributions to several areas of mathematics, including quasiconformal mappings, Teichmüller theory, and Kleinian groups. An overview of his mathematical work may be found in the obituary by William Abikoff, which appeared in the January 1995 issue of the *Notices*. Abikoff not only describes Bers's mathematics but also fondly recalls the influence Bers had on his students and colleagues. "In his power as a mathematician, his dignity, his enthusiasm, and his caring for others, he set a standard for the people who knew him," Abikoff wrote. Bers and his wife, Mary, created in their home a warm and welcoming atmosphere for visitors, which included not only students and mathematicians but also dissidents expelled from the Soviet Union. Bers was active in many human rights efforts, and that part of his life is described in the *Notices* obituary by Carol Corillon and Irwin Kra.

Devastation Hits a Great Library

The Charles University mathematics library, called the Václav Hlavatý Library, was the largest mathematics library in the Czech Republic up to 2002, when catastrophic floods hit central Europe. The building housing the library is in the Karlin district of Prague, which was severely affected by the flooding. The library was on the ground floor with depositories in the cellar. At first it appeared that the ground floor would remain above the flood waters, so everything in the depositories was brought up to the ground floor. However, the official predictions about how high the waters would rise proved too optimistic. What is more, for security reasons the area was evacuated twenty hours before the flood's peak, making it impossible to move the library holdings higher once it was clear the high water predictions were wrong. By the time people were allowed back in the area, not only were the books and journals soaked, but mold had set in.

About 60 to 65 percent of the library's holdings were lost in the flood. These holdings included 400 journals (some of them, such as *Acta Mathematica*, in complete sets), more than 12,000 monographs, 6,500 sets of lecture notes, and 4,500 textbooks. In addition, the library had about 7,000 rare mathematical books, including many volumes of collected works of Cauchy, Weierstrass, and other important mathematicians. These rare books were entirely destroyed. According to Jiří Veselý of the Mathematical Institute at Charles University, a tally of what the library had spent on the holdings that were destroyed comes to about US$3 million. But this underestimates the actual loss, because, for example, the rare books had greatly increased in value since their acquisition. Some of the books were frozen and then dried, but in the end only about 15 percent of those could be saved. Veselý said the library plans to scan some of them, but it will be a long and costly procedure. "The annual budget of our math library is about twenty times smaller than what was lost, and many items we could not buy for any price," he said. "They are lost forever."

Over the past five years, many institutions and publishers all over the world have made donations to help rebuild the library. Veselý said that help from the AMS was especially important, because it included not only donated materials but also discounts for acquiring new materials. "Bers's collection was rather big and extremely useful," he said, with books in a broad range of areas—and all of the books were in excellent condition. The books in fluid dynamics are of particular interest to the Charles University group that works in mathematical modeling.

Nachlass Finds Its Best Home

When Ruth and her brother, Victor, finally sorted through their father's *Nachlass*, they found not only his mathematics library but also many letters and documents. Among these was a large collection of reprints of papers by Bers. Ruth and Victor plan to donate the reprints to the American Institute of Mathematics, which has an extensive reprint collection. And there was an even bigger treasure: a collection of letters from and to Paul Erdős, who was an old friend of Bers from the time when they were on the faculty together at Syracuse University and who occasionally visited the Bers family home. The letters, some of which date from the 1940s, have been entrusted to Ronald Graham of the University of California, San Diego, who is the literary executor of the Erdős estate.

Lipman Bers was a man who cared deeply about those around him—his family, his students, and his colleagues, as well as many others on whose behalf he fought for human rights. "My father was not very interested in worldly goods, but he loved his mathematics library," Ruth noted. "It was clear that the books were something he treasured." That the books should go to Prague and arrive at a time when Charles University really needed them—that, said Victor, "would have really pleased him."

Further information on the AMS book donation program is available on the AMS website at `http://www.ams.org/employment/bookdonation.html`*. To make or request a donation, please send email to* `bookdonations@ams.org`*, or phone the AMS at 800-321-4267, ext. 4096 (in the U.S.), or 401-455-4096 (from outside the U.S.). Those interested in helping the Charles University mathematics library should contact Jiří Veselý, email* `jvesely@karlin.mff.cuni.cz`.

Memories of Prague

Lipman Bers

Before his death in 1993, Lipman Bers began writing a memoir that eventually grew to about eighty pages. The memoir, which has never been published, covers his early life up to his emigration to the United States in 1940. What follows is an excerpt from the chapter about Bers's life as a student at Charles University in Prague, where he received his doctorate in mathematics in 1938. He arrived in Prague after fleeing his native Latvia, where he was wanted by the secret police for his antigovernment political activities. This excerpt is published on the occasion of the donation of Bers's mathematics library to Charles University in Prague (see the related article in this issue of the Notices). *The* Notices *thanks Victor Bers and Ruth Shapiro for permission to publish this excerpt from the memoir.*

As before, I was struck by the beauty of the city. After a few days I went to the police station to register, and the clerk asked me whether I could prove that I came as a political refugee. At this point a story published in the Riga paper *Tonight*, that Bers was hiding from the Latvian police, proved useful. Next, I went over to the administrative office of the university. It was manned, if I remember correctly, by Czech civil servants, and they were favorably inclined to giving me, at once, a one-year permit to live in Prague, which would be enough time to complete two academic terms. When nearly all the formalities were completed, I was asked to produce a permit to live in Prague for the year. "We cannot complete your registration without the permit," I was told. "You can get the permit at the police station."

"No," the police told me, "you are mistaken; we may issue you a residence permit only when you are registered as a student at the university." "But that's what I'm telling you: to register, I need the permit to stay." "No, it is a simple formality. Once you are a student, you are permitted to stay, but we cannot issue a permit to stay without something justifying your stay."

This back and forth required repeated trolley trips between the two offices. At the time I did not know the name of Kafka, Prague's most famous author, and did not know the meaning of "kafkaesque", but I will never forget the feeling of complete frustration that I felt after a day of shuttling between the two offices. The most peculiar element in this game was the fact that all the officials were actually intelligent and benevolently inclined.

The next morning I remembered having been told that whenever refugees in Prague are in trouble, they visit the president of the Czechoslovakian senate, Dr. František Soukup. I followed that advice and was not disappointed. Soukup introduced me to the Assistant for Refugee Affairs, a young law student of about 22. Soukup presented my case

as a complex dilemma, but the assistant was not at all impressed. "It is clear what you have to do. Apply to the Foreign Ministry for permission to leave Czechoslovakia for another country. You will certainly get it, and the permission to leave brings with it permission to stay in Prague for one year. With this permission you can register as a student, and by showing your registration to the police, all your difficulties will disappear." Just as the assistant predicted, the Foreign Ministry issued me the famous pink document, the Czechoslovakian "Foreign Passport for Foreign Persons". I took this to the university, which issued me a study permit allowing me to register. I was fortunate enough to be able to use Soukup and the assistant's influence on two more occasions. When I told the story of my Czechoslovakian papers to the famous Jewish Polish mathematician Hugo Steinhaus, he remarked that it confirmed a rule he always followed: everybody ought to hold at least two false passports.

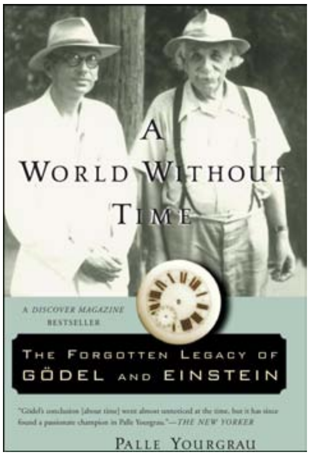
The German University in Prague, sometimes simply called "The University", was the oldest in [central] Europe…and was founded by the Holy Roman Emperor Charles IV. The university had a good mathematics faculty, including the exceptional mathematician Charles Loewner. Of course, we students were unaware of that. I discovered how good he was only after we met again in America. The students were mostly interested in teaching high school math; very few were doctoral candidates. The professors who were interested in research followed the tradition of German *lehr und lern*—teach and learn.

Courses that could be thought of as forerunners of modern logic were taught. I took a number of courses with the great logician Rudolf Carnap. The university took pride in having on its faculty one of the first physicists who did independent research in relativity theory. Einstein taught there briefly. As in most universities, students learned most from talking to each other. And this was not much to boast about. Still the seminar sessions were stimulating, particularly when they were directed by Loewner. I always imagined him to be a few inches taller than the average man, with a lionesque mane, as his name would suggest. He was actually a very shy and unassuming person. Such is the strong dependency a student feels for his teacher, especially when it comes to the thesis.

Loewner assigned me to report on a paper, and when I looked at it I saw that Lebesgue's integration was used everywhere. So I went to Loewner and confessed that I did not know it. He simply handed me a small book and said, "You will find it here." Indeed I did and never again had any trouble with what was for me, at the time, an advanced topic. The author of the paper Loewner wanted me to discuss was Kramer, a mathematical poet who was a very talented rhymester. I admired his style but unfortunately did not become too interested in the subject of my report. My interest switched to potential theory.…

On completing my degree, the Rerum Naturalium Doctor, I needed permission to change my passport to one issued to "Dr. Bers" and also to renew my permit to travel from Czechoslovakia to a foreign country. Through contacts with the French Socialist Party I was able to get a permit to go to France. I went to say goodbye to Soukup and to thank him for his help. The Munich Agreement, which resulted in the division of Czechoslovakia, had been signed, and Soukup was a broken man. "You are lucky that you're leaving this part of the world. It will be horrible." "Why don't you leave?" I asked. But Soukup was immovable: "You are a refugee who may someday return home. I cannot leave my country in its hour of greatest need." Many years later in America I met a gentleman who knew the Soukup family. As I feared, Soukup had been killed in a German camp.

Passport and identity papers of Lipman Bers, shown on this page, are courtesy of Victor Bers.



A World Without Time: The Forgotten Legacy of Gödel and Einstein

Reviewed by John Stachel

A World Without Time: The Forgotten Legacy of Gödel and Einstein
Palle Yourgrau
Hardcover, Basic Books, 2004,
US$24.00, 224 pages
ISBN-13: 9780465092932
Paperback, Perseus Publishing, 2006
US$15.00, 224 pages
ISBN-13: 9780465092949

The book's title suggests its three main themes:

1) "A World Without Time": Gödel's argument, based on his interpretation of the theories of relativity (both special and general), for the "unreality" of time. At a generous estimate, no more than forty of the book's 180-odd pages are devoted to this theme (essentially the last part of Chapter 6, and Chapter 7).

2) "Gödel and Einstein": An attempt to draw parallels between the lives and views of its two protagonists. An account of Gödel's life in Vienna (Chapters 3–5) includes a lengthy excursus into his seminal contributions to logic (Chapter 4). The account of the relationship between the two after Gödel's permanent move to the Institute for Advanced Study in 1940 (Chapters 1, 6, and 8; the last also discusses Gödel's final years) includes brief glimpses of Einstein's pre-Princeton years.

3) "The Forgotten Legacy": Yourgrau's polemic against what he sees as the neglect by the analytically-oriented American philosophical establishment of Gödel's significant contributions to metaphysics (the last part of Chapter 8 and Chapter 9). Insofar as Einstein is presumed to share Gödel's "German Bias for Metaphysics" (the title of Chapter 2), he is also portrayed as a victim of this "Conspiracy of Silence" (the title of Chapter 1).

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The Forgotten Legacy

Yourgrau, himself a philosopher, has been urging recognition of Gödel as "an important philosopher of mathematics and of space and time" (p. 181) for almost two decades. He regards "the dialectic of the formal and the intuitive" as "the leitmotif of Gödel's lifework" (p. 124), seeing both continuity and contrast in this work.

There is continuity in method: "Overarching much of his research in philosophy and logic was the 'Gödel program', the investigation of the limits of formal methods in capturing intuitive concepts" (p. 182; see also pp. 114, 127).

The contrast lies in the conclusions Gödel drew from the existence of these limits: In mathematics, he "concluded from the incompleteness of Hilbert's proof-theoretic system for arithmetic that the Platonic realm of numbers cannot be fully captured by the formal structures of logic. For Gödel, the devices of formal proof are too weak to capture all that is true in the world of numbers, not to say in mathematics as a whole." (p. 136)[1]. But in physics: "When it came to relativistic cosmology, however, he took the opposite tack…[R]elativity is just fine, whereas time in the intuitive sense is an illusion. Relativity…does not capture the essence

[1] *Feferman 2006 points out that: "The incompleteness theorems in and of themselves do not support mathematical Platonism," as Gödel admitted in 1951: "Of course I do not claim that the foregoing considerations amount to a real proof of this view of the nature of mathematics. The most I could assert would be to have disproved the nominalistic view, which considers mathematics to consist solely in syntactic conventions and their consequences" (Gödel 1995, pp. 304–23). Raatikainen 2005 discusses various philosophical interpretations of the incompleteness theorems.*

of intuitive time, because when it comes to time, our intuitions betray us" (pp. 136–137).

So far, so good: The argument seems clear enough. Yourgrau explains that "Gödel was at once a mathematical realist," who believed in the reality of "the Platonic realm of numbers", and "a temporal idealist" because "time in the intuitive sense is an illusion." He speaks of "the nonexistence of time in the actual world" (p. 139), presumably because it corresponds to nothing in the realm of Platonic ideas. Yourgrau's *World Without Time* is a world of "real, objective concepts" (p. 171) that does not include time.

How are we to square Yourgrau's words on pp. 136–139 with his account thirty pages later of Gödel's views on time and intuition? "Time, for example, in relation to being, Gödel considered one of the basic concepts [of metaphysics], but he believed that in the attempt to discover what is fundamental about our thinking about time we can receive no assistance from physics, which, he argued, combines concepts without analyzing them. Instead, we must reconstruct the original nature of our thinking…For this, he turned not to Einstein but to Husserl and phenomenology…Gödel saw phenomenology as an attempt to reconstruct our original use of basic ideas…on what we meant in the first place by our most fundamental acts of thought…[B]oth Gödel and Husserl (in his later period) were conceptual realists" (pp. 170–171).

It seems to follow from these quotations that, for Gödel, time *is* a basic metaphysical concept, one of "the fundamental concepts that underlie reality," about the nature of which "we can receive no help from physics."[2] Instead, one must use self-reflection to grasp this "real, objective concept".

Remember, the Yourgrau of pp. 136–139, also expounding Gödel, had assured us of "the nonexistence of time in the actual world." The disparity between the two Yourgraus left this reader unable to answer a basic question raised by the book: What is the Yourgrau-Gödelian concept of time, which must be grasped by self-reflection but is not based on an intuition of time that is illusory? In the final section of the review, I shall return to the question of what relativistic physics (*pace* the Yourgrau of pp. 170–171) *does* tell us about the nature of time and what is perhaps best left forgotten in Gödel's *Forgotten Legacy*.

The neglect of Gödel's philosophical views by analytic philosophers is mainly due to his affiliation with their *bête noir*: The metaphysical tradition associated with Plato, Leibniz, and the later Husserl, to name some of Gödel's favorites. "Concepts have an objective existence" Gödel wrote in a notebook entry on "My Philosophical Viewpoint" (quoted on p. 104), and his "conceptual realism" is more or less the same as what other philosophers call "objective idealism".[3]

Indeed, while having problems with the "Kantian philosophy, which is strong in epistemology but weak in ontology (weak that is for [conceptual–JS] realists like Gödel, Frege, and Husserl)" (p. 175), Gödel was an admirer of Hegel (see pp. 157, 182), and the method used in "the Gödel program" in logic has interesting parallels with Hegel's dialectical method of subverting a philosophical system from within.[4] Starting from the system's own premises, one demonstrates its inability to reach its own goals by exposing some contradiction between premises and goals. These contradictions are then "sublated"[5] by synthesis in some higher, more advanced system.

Hilbert's formalist program started from some set of axioms and syntactic rules of deduction with the goal of proving the completeness and consistency of arithmetic. Gödel subverted the program from within: using a newly developed formal technique (Gödel numbering), he proved the impossibility of reaching this goal. One might even say that he did so by "sublating" the syntactic concept of provability within a formal system in the semantic concept of truth in some model of that system (see the sidebar "Gödel's Theorems"). Yourgrau writes of "Gödel's dialectical dance with intuitive and formal time in the theory of relativity (p. 128)"; similarly there is a dialectical dance with semantics and syntax in his logic.

Gödel and Einstein

Both Gödel and Einstein are described in over-the-top superlatives: Gödel is "the greatest logician of all time, a beacon in the intellectual landscape of the last thousand years" (p. 1). Einstein is "the most famous scientist of all time" (p. 2), "the greatest scientist since Newton" (p. 31). "Together with another German-speaking theorist, Werner Heisenberg, they were the authors of the three most fundamental scientific results of the century. Each man's discovery, moreover, established a profound and disturbing *limitation*" (p. 2). Even limiting

[2] *On p. 105, Yourgrau cites Gödel's list of "the fundamental concepts that underlie reality," which includes "time".*

[3] *Terminological confusion abounds here since different philosophers attach opposing senses to the terms "real" and "realism," and "ideal" and "idealism". For advocates of "conceptual realism", the adjective "ideal" is pejorative: It implies that the noun it modifies does not have an objective conceptual counterpart.*

[4] *The similarity is in method, not motivation. Gödel's original intent was to contribute to Hilbert's program, and only years later did he realize that he had subverted it (see, e.g., Feferman 2006).*

[5] *"Sublation" is the best English equivalent for Hegel's "das Aufheben", which means simultaneously to preserve, destroy, and raise to a higher level (see the entry "Sublation" in Inwood 1992, pp. 283–285).*

oneself to limitations, one might well argue, for example, that Bell's theorem beats Heisenberg's uncertainty principle hands down.[6] But are such claims necessary? Isn't a sober statement of the results and their profound implications sufficient?

All is not rosy in Yourgrau's picture of Einstein: "After he arrived at the institute [for Advanced Study in 1933]…never again would he enjoy the intellectual camaraderie that had formed a cloak against all the ugliness that beset his years in Berlin" (p. 148). There is no mention of Walter Mayer, Peter Bergmann, Valentine Bargmann, Nathan Rosen, Leopold Infeld, Bruria Kaufman, Ernst Straus, all of them Einstein's scientific collaborators in Princeton; he remained close to many of them, both intellectually and personally, long after their collaborations ended. Nor is there mention of visits or longer stays at the institute by such scientific colleagues as Niels Bohr, Abraham Pais, Wolfgang Pauli, H. P. Robertson; nor of his close contact with fellow-expatriates such as the historian Erich Kahler and his wife Lily, the writer Hermann Broch; the philosopher Paul Oppenheim and his wife Gaby; art historian Erwin Panofsky and Princeton librarian Johanna Fantova; not to mention various romantic liaisons, such as that with Margarita Konenkova, a Russian woman recently accused of being a spy. Nor was he isolated at the institute: Batterson 2006 describes the important role Einstein played in its affairs from its formative years until his retirement.

Yourgrau's picture of Gödel as a social isolate in Princeton, with few friends except Einstein, and of his tragic descent into paranoia and death by self-starvation, is duly accurate. But to say "together they remained isolated and alone" at the institute (p. 4) is simply to overlook the profound difference between the personalities of the two.

Reliability of the Book

In contrast to his earlier book on the topic (Yourgrau 1999), "intended primarily for philosophers… this one [is] accessible to normal readers" (p. vii). Presumably, he means non-scholars, i.e., that the book is intended for a popular audience.[7] The writer of such a book has a particularly great responsibility, because its readers often take the author's word for factual and technical assertions not substantiated in the text. So if anything, popular books should be held to even higher standards of sobriety and accuracy than books addressed to other experts, capable of forming independent judgments on such matters. This book often falls short of such standards. I have already given some examples of lack of sobriety and, unfortunately, it is not hard to find examples of inaccuracy.

Contradictory assertions occur within a few pages: "Further separating Einstein from Gödel was the fact that Einstein never fully resolved his native suspicion of mathematics. …[T]he physicist remained forever wary of being led by the nose by mathematicians" (p. 15). "Einstein and Gödel, in turn, each in his own way, approached the world mathematically. For both, mathematics was a window onto ultimate reality, not, as for many of their scientific colleagues, a mere tool for intellectual bookkeeping." (p. 17).

Sometimes one of the two statements is so downright silly that it can only be ascribed to carelessness: On p. 44, Yourgrau speaks of "*rational numbers as infinite sequences of natural numbers*, and irrational numbers as infinite sequences of rational numbers [my emphasis–JS]." Three pages later he describes "irrational numbers [as] those that cannot be expressed as *ratios of two natural numbers* [my emphasis–JS]"—correctly implying that all positive rationals can be so defined. Yourgrau's comment on Einstein: "Never too concerned with consistency—unlike his logician companion [Gödel]" (p. 14) applies to many passages in this book!

Confusion even creeps into one of the best parts of the book: the account in Chapter 4 of Gödel's results in logic. Yourgrau's definition of ω-consistency (p. 67) is actually the definition of ω-incompleteness[8]. Conflating the two concepts is particularly unfortunate at this point, since the discussion concerns precisely Gödel's proof that ω-consistency implies ω-incompleteness.

The book also has its share of historical blunders. I cite just two related examples, the Schwarzschild and deSitter solutions of the Einstein equations, treated on pp. 116–117: "When Karl Schwarzschild …discovered in 1916 that if a star began an extreme gravitational collapse into itself, its mass would eventually reach a critical point after which space-time would be so severely curved that nothing inside (what is now known as) the 'event horizon', including light, would be able to escape, Einstein dismissed the 'Schwarzschild

[6] *For a discussion of Bell's theorem "that there is an upper limit to the correlation of distant events, if one just assumes the validity of the principle of local causes" (Peres 1993, p. 160), and the profound significance of its violation by quantum phenomena, see ibid, Chapter 6.*

[7] *But even scholarly readers, let alone "normal" ones, will often find it rough going: "The physicist's prophetic idea of describing a physical system by locating it in a logical framework in various dimensions of physical significance would have not only a profound effect on the future of quantum mechanics but on the Bible of the Schlick circle" (p. 38). That the physicist is Boltzmann and the Bible is Wittgenstein's Tractatus is clear from the context, but otherwise I can't make sense of the sentence, perhaps because I am not "normal".*

[8] *I thank Martin Davis for pointing this out to me (personal communication, December 25, 2005). Davis 2001 includes an excellent chapter on Gödel's contributions to logic.*

What Did Einstein Know and When Did He Know It?

Yourgrau is not alone in propagating the myth that Einstein was taken by surprise when presented with Gödel's results. Stephen Hawking states: "It was therefore a great shock to Einstein when, in 1949, Kurt Gödel…discovered a solution that represented a universe full of rotating matter, with closed time-like curves through every point" (Hawking 2002, p. 90).

Actually in 1914, almost as soon as Einstein realized the need to introduce a non-flat, dynamical space-time metrical structure, and well before he arrived at the final form of his field equations, he worried in print about the problem of closed time-like world-lines. Since his words seem little known, perhaps it is worthwhile to present here what Einstein wrote then:

"I shall now raise an even deeper-reaching question of fundamental significance, which I am not able to answer. In the ordinary [i.e., special–JS] theory of relativity, every line that can describe the motion of a material point, i.e., every line consisting only of time-like elements, is necessarily non-closed, for such a line never contains elements for which dx_4 vanishes. An analogous statement cannot be claimed for the theory developed here. Therefore a priori a point motion is conceivable, for which the four-dimensional path of the point would be an almost closed one. In this case *one and the same* material point could be present in an arbitrarily small space-time region in *several seemingly mutually independent exemplars*. This runs counter to my physical imagination most vividly. However, I am not able to demonstrate that the theory developed here excludes the occurrence of such paths" (I have modified the translation of Einstein 1914, p. 1079, given in Einstein 1997, pp. 77–78).

—*J. S.*

singularity' as a mathematical anomaly with no physical significance" (p. 116).

What Schwarzschild actually did soon before his untimely death in 1916 was to find the unique spherically-symmetric solution to the vacuum Einstein field equations (i.e., outside any source) and show that the solution is static in this region. No discussion of gravitational collapse of a spherically symmetric source beyond the Schwarzschild radius was published until the late 1930s, and the interpretation of this radius as an event horizon came even later (see below) [see for example Stachel 1995].

> Later in 1917, the Dutch Astronomer Wellem [sic!] de Sitter proposed a cosmological model for general relativity in which the universe was not static, as Einstein believed it to be, but rather expanding (p. 117).

De Sitter's original interpretation of his solution was similar to that of the Schwarzschild solution: a static model with a singularity. This interpretation was accepted by Einstein and others, and debate raged over the interpretation of both of these presumed singularities. It was not until 1922–23, when Lanczos found a singularity-free but non-static form of the de Sitter metric, that it began to be interpreted as an expanding universe (see for example Kerszberg 1989). In 1924, Eddington similarly found out how to remove the Schwarzschild singularity, but this did not become common knowledge among relativists until Finkelstein rediscovered it in 1959.

A World Without Time?

Yourgrau's views on the impact of relativity theory on the concept of time often clash directly with Einstein's. Following Gödel, Yourgrau identifies the concept of "time" with that of "global simultaneity" ("simultaneity, and thus time"). They proceed to reject the reality of time because there exist cosmological models (such as the Gödel universe), in which no such concept of cosmic or global time can be defined.

Einstein, on the other hand, in his *Autobiographical Notes* (in Schilpp 1949, the same volume as Gödel's article), lists "the insights of a definitive nature[9] that physics owes to the *special* theory of relativity [my emphasis–JS]." He gives pride of place to the insight:

> There is no such thing as simultaneity of distant events (*Es gibt keine Gleichzeitigkeit distanter Ereignisse*) (translation from Einstein 1979).

If this is Einstein's view of special relativity, Yourgrau's assertion is surely wrong that "the father of relativity was shocked" (p. 7) by Gödel's demonstration that there are cosmological models in *general* relativity, for which *no* global definition of distant simultaneity is even possible. Indeed, Einstein took this so much for granted that he does not even mention it in his comments on Gödel (Einstein 1949).

Since the exclusive identification of the concept of time with that of global simultaneity is the crux of Gödel's argument for the unreality of time, let us pause for further discussion of this point. Surely, we all have some intuitive concept of time. Does it embrace the concept of a unique cosmic or *global* time, marching forward in lock step throughout the entire universe? The only intuitive concept of time that *I* have is a purely *local* one, associated with *my* progress through the universe. And I seriously doubt that, without a good deal of education, anyone has an "intuition" that the march of his or her local time must coincide with the march of everyone else's local times, let alone the march of time on the sun, planets, and other stars—or even

[9] *I take his characterization of this insight as "definitive" to imply that it holds for general relativity as well.*

that such marches must exist. Ask a young child, just learning to handle the concept of time, what time it is on the sun![10]

This subjective concept of individual, local time has been objectified and incorporated in relativity theory—both special and general—as the concept of the proper time along any time-like world line. If Einstein wasn't shocked by the absence of a global time, was he shocked by Gödel's demonstration that there are models of general relativity containing *closed* time-like world lines? No: Einstein says, "The problem…disturbed me already at the time of the development of the general theory of relativity, without my having succeeded in clarifying it (Einstein 1949)."[11] He ends his reply to Gödel on a skeptical note: "It will be interesting to weigh whether these [solutions] are not to be excluded on physical grounds."[12]

Another conflict: Yourgrau writes, "Relativity had rendered time, the most elusive of beings [sic!], manageable and docile by transforming it into a fourth dimension of space, or rather of relativistic space-time. …the four-dimensional universe of space-time that he himself [i.e., Einstein–JS] had conjured into being."

Einstein writes, "It is a widespread error that the special theory of relativity is supposed to have… first discovered or, at any rate, newly introduced the four-dimensionality of the physical continuum. This, of course, is not the case. Classical mechanics too, is based on the four-dimensional continuum of space and time" (Einstein 1979, p. 55).

Lest Einstein is thought to be overmodest, I shall quote one sentence from Lagrange's 1797 *Mécanique analytique*: "Mechanics may be regarded as a four-dimensional geometry, and mechanical analysis [i.e., analytical mechanics] as an extension of geometrical analysis."

What about Yourgrau's claim that Einstein's accomplishment was "transforming [time] into a fourth dimension of space"? In a review of Emile Meyerson's book *La déduction relativiste*, Einstein praises the book for "rightly insist[ing] on the error of many expositions of relativity which refer to the 'spatialization of time'. Time and space are fused in one and the same continuum, but the continuum is not isotropic. The element of spatial distance and the element of duration remain distinct in nature…The tendency he denounces, although often latent, is nonetheless real and profound in the mind of the physicist, as is unequivocally shown by the extravagances of the popularizers and even of many scientists in their expositions of relativity" (Einstein 1928).

Gödel's Theorems

Young Gödel startled the symbolic logic community in the early 1930s by proving two metatheorems about the incompleteness—or better the incompletability—of any formal logical system based on a set of axioms strong enough to include ordinary arithmetic. A consistent axiomatic formal system is syntactically complete if, for every closed well-formed formula (sentence), either the formula or its negation can be proved from the axioms. Gödel constructed a well-formed formula that is not deducible from the axioms but that nevertheless can be seen to be true in the standard model of the formal system. Indeed, when interpreted semantically in the model, the sentence corresponding to the formula asserts precisely its own unprovability; so if it could be proved, the system would be inconsistent! If one attempts to complete the system by adding a finite number of such true but unprovable formulas to the list of axioms, then still other well-formed formulas will exist in the new system that have the same property. One could also add the negation of the unprovable formula to the axioms, resulting in an axiomatic system that would correspond to a valid statement in some nonstandard model. So "incompletability" seems more appropriate than "incompleteness" as a characterization of the situation.

—J. S.

Gödel and Einstein on Time

I shall devote this rest of this review to my own account of Gödel's and Einstein's views on time and to why I agree with John Earman's claim—which so horrifies Yourgrau—that the philosophers' neglect of Gödel's views is "benign" (p. 178).

Gödel 1949a offers two arguments based on relativity theory for "the unreality of change". Both are based on the premise that "change becomes possible only through the lapse of time," by which he means "an objective lapse of time". He explains that this "means (or at least is equivalent to the fact) that reality consists of an infinity of layers of 'now' which come into existence successively" (pp. 557, 558).

Gödel comes down hard on the side of endurance in the old debate between two views of temporal change: endurance versus perdurance:

> An object is said to endure just in case it exists at more than one time. …Objects perdure by having different

[10] *I find more attractive Thomas Sattig's thesis that there is no conflict between the viewpoint of one-dimensional "ordinary time" and of "four-dimensional spacetime": "I find it overwhelmingly plausible that all facts about ordinary time logically supervene on facts about spacetime; what goes on in spacetime fully determines what goes on in ordinary time" (Sattig 2006, p. 1). His treatment covers only Minkowski spacetime, but I believe it could be extended to general relativity.*

[11] *The sidebar "What Did Einstein Know and When Did He Know It?" shows that Einstein discussed this possibility in 1914.*

[12] *Similar skepticism is common in the relativity literature; see for example, Hawking and Ellis 1973, p. 170. Ignoring Einstein's comment, Yourgrau regards "Hawking's attempt to neutralize the Gödel universe" as "show[ing] how dangerous it is to break the conspiracy of silence that has shrouded the Gödel-Einstein connection" (p. 8).*

> temporal parts at different times with no part being present at more than one time. Perdurance implies that two hypersurfaces [in space-time] ...do not share enduring objects but rather harbor different parts of the same four-dimensional object (Wüthrich 2003, p. 1).

From the perdurance viewpoint, process is primary. The spatial and temporal aspects of a process—its many possible "heres" and "nows"—are just different "perspectival" effects of "viewing" the same process from different spatio-temporal reference frames.

Yourgrau opts for endurance without even mentioning, let alone discussing, the opposing viewpoint. At least Gödel presents an argument against the relative, perdurance view of time, but one based on a particularly ill-chosen analogy: "A lapse of time, however, which is not a lapse in some definite way seems to me as absurd as a colored object which has no definite color" (Gödel 1949a, p. 558, footnote 5).

There is an objective process, on which everyone can agree: The physical composition of the light rays falling on the eye of the subject, both from some object of perception and its surroundings. But the perceived color of that object—and color is nothing but a perception—is a "perspectival" effect, depending on the conditions of illumination of the object, the contrast with its surroundings, and the properties of the eyes and nervous system of the subject (ask a color-blind and a normal-sighted person whether all objects have a definite color!). So if one accepts Gödel's analogy, which we are under no obligation to do, it argues against rather than for his case.

While the debate between endurance and perdurance views arose long before relativity theory and endures—or perdures—to this day, relativity certainly has changed the terms of the debate. This brings us finally to Gödel's two arguments for "the unreality of change" based on relativity. The first is based on the special theory: "The very starting point of special relativity theory consists in the discovery of a new and very astonishing property of time, namely the relativity of simultaneity, which to a large extent implies that of succession." Gödel immediately qualifies this in footnote 2, p. 557, noting that although there is no longer "a complete linear ordering of all point events," "[t]here exists an absolute partial ordering." And I would add that, as Robb realized as early as 1914, this causal ordering is all that is needed for physics.

Gödel omits mention of the central point about simultaneity that Einstein emphasized from 1905 on: Any characterization of the simultaneity of distant events involves a convention or stipulation; so that there can be no right or wrong of the matter, only a question of the merits and drawbacks of the convention adopted. This would present a grave problem for the objectivity of physics if the nature of any physical process depended on the convention adopted, but it is easily seen that no physical result does. Indeed it is possible to formulate all the results of the special theory without adopting *any* simultaneity convention (see, e.g., the delightful exposition of his *K*-calculus in Bondi 1964). So the relativity of simultaneity is not the addition of "a new and very astonishing feature of time"; rather, it amounts to the *removal* from the concept of time in physics of an old, hitherto accepted feature: absolute simultaneity.

The most important new feature of time to emerge from the special theory of relativity is that the local or proper time between two events (discussed in the previous section), as measured for example by an ideal clock traveling between the two events, depends on the history of the clock, i.e., its path through space-time. We are quite familiar with the similar dependence of spatial distance on path: The reading of a pedometer worn by someone walking from one place to another depends on the path taken. The most important thing that special relativity has taught us about time is that clocks are a lot more like pedometers than assumed in pre-relativistic kinematics. Put in mathematical terms, it had long been a commonplace that the spatial differential $d\sigma$ between two neighboring points is not a perfect differential. But it had been assumed in Galilei-Newtonian kinematics that the temporal differential dt between two events is a perfect differential, which integrates to the absolute time $t_2 - t_1$ between the two events. Consequently, it was not so important to distinguish between the local time, as measured by a clock transported along some path, and the global time, stipulated to be equal to the absolute time: they always agreed.

Even before the advent of special relativity, a few careful analysts of the foundations of kinematics, notably Henri Poincaré and James Thomson (brother of William Thomson, Lord Kelvin), realized that the introduction of the concepts of distant simultaneity and global time always involves a definitional element, even if the definition using the absolute time seemed entirely unproblematic at the time.

In special-relativistic kinematics, the differential $d\tau$ of proper time is not a perfect differential but depends on the path in space-time between two events. Of course, there is still a big difference between space and time: The straightest path in space is the shortest distance between two points, while the straightest time-like path in space-time is the longest time interval between two events. This is the essence of the twin paradox.

Appropriately modified, these results of special relativity still hold in the general theory: Again, the proper time interval between two events depends on the time-like path and is a local maximum for any time-like geodesic path between them (assuming one exists). This is the truly revolutionary new feature of time that emerges from the two theories of relativity. And perhaps it is worth emphasizing that this path-dependent proper time is *absolute*; that is, its value does not depend on the reference frame in which it is calculated.

Once one realizes that the temporal interval between two events is path dependent, the role of a global time coordinate t is diminished considerably. As emphasized above, even when it can be defined, this definition always involves some convention or stipulation. Moreover, even if a global time can be defined, the proper time $\tau = \int d\tau$ between two events—the only physically significant time—occurring at global times t_1 and t_2 is not independent of the path in between them; and so *cannot* equal $t_2 - t_1$—or indeed *any* function of the two. In fact, in general relativity, there is usually *no* path for which $\tau = t_2 - t_1$.

Even when global times *can* be defined, as in special relativity, it is not always advantageous to do so, for there exist time-like fibrations of Minkowski space-time that are not hypersurface-orthogonal. Hence there is no way for a family of observers traveling along these world lines to synchronize their clocks so that their proper times coincide with any global time. The simplest example is a family of observers in uniform rotational motion relative to some inertial frame. The realization that these observers could not synchronize their proper times played an important role in Einstein's transition from special to general relativity, since it helped to liberate him from the preconception that a coordinate system always must have an immediate physical significance (see Stachel 1980).

The existence of solutions to the Einstein field equations, for which no global time can be defined, such as those found by Gödel (1949b), is certainly interesting. However, their existence does not decisively alter the relativistic concept of time, which as seen above in Einstein's comments on Meyerson, is basically local. The philosophical moral I draw from this discussion is that process is primary and absolute, while its division into spatial states evolving over time is secondary and always relative to the choice of some frame of reference, local or global. Translated into the language of relativity theory, space-time takes precedence over space and time.

Gödel's second argument against the reality of change is based on general relativity, which brought about a much more profound physical revolution than the special theory, the effects of which are still being felt in theoretical physics to this day. Special relativity brought about a change in the metrical structure of space-time, the stage on which all the dramas of physics are enacted. But, while it replaced Galilei-Newtonian space-time with Minkowski space-time, this is still a *fixed* background space-time; so special relativity is still a theory with a kinematics that is independent of all dynamical processes. In general relativity, *all* space-time structures—chrono-geometrical as well as inertio-gravitational—are dynamical fields, interacting via the Einstein equations with all other physical entities: fields and particles. It is a background-independent theory: the general-relativistic stage becomes part of the play, and there is no kinematics prior to and independent of dynamics.

Einstein soon realized that space-times exist, for which no global time can be defined for topological reasons (see above). In general their existence has no bearing on the concept of local (proper) time along a time-like world line. However, he also realized that space-times exist with closed or nearly-closed time-like world lines, and their existence *does* have a bearing on the *local* concept. It provides an extreme example of the fact, mentioned above, that the proper time between two events depends on the path between them. In the case of a (nearly) closed time-like world line, one of the possible values is (almost) zero, and the other is some large number.

Similar paradoxical-seeming results can be formulated for spatial intervals in spatially closed but unbounded universes: In such a universe, by going straight ahead along a spatial geodesic it is possible to return to one's starting point. Einstein's original 1917 static cosmological model, being the topological product of a spacelike three-sphere and a timelike line (see, e.g., Hawking and Ellis 1973), is of this type. So, even restricting ourselves to geodesic paths, the spatial distance between two points is both zero and a positive number. I don't know if anyone has actually used this observation as an argument against the reality of space, but it would be fair to say that arguments like Gödel's against "the reality of time" can be matched by similar arguments against "the reality of space".

The real question is: What is the physical significance of such models? Every physical theory that we know has two properties:

1) There are physical phenomena that fall outside its scope, i.e., that cannot be modeled by the theory (it is not a "theory of everything").

2) There are "unphysical" models of the theory, which do not correspond to any physical phenomena. The class of all models must be restricted by some additional criteria, such as boundary conditions, not inherent in the theory, in order to fit some limited range of physical phenomena.

The smaller the number of phenomena in class 1), and smaller the number of models in class 2), the more we value a theory. But there is no reason to believe that general relativity is an exception to this rule. To use the existence of a class of models with closed time-like world lines as an argument against the concept of time, without a shred of evidence that such models apply to any physical phenomena, is an example of that fetishism of mathematics, to which some Platonists are so prone.

Acknowledgment

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References

[1] Steve Batterson, *Pursuit of Genius: Flexner, Einstein and the Early Faculty at The Institute for Advanced Study*, A. K. Peters, Wellesley, MA, 2006.

[2] Hermann Bondi, *Relativity and Common Sense, a New Approach to Einstein*, Anchor Books, Garden City, NY, 1964.

[3] Martin Davis, *Engines of Logic*, paperback edition, Norton, New York, NY, 2001. (Originally published as *The Universal Engine*, Norton, New York, NY, 2000.)

[4] Albert Einstein, "Die formale Grundlagen der allgemeinen Relativitätstheorie", *Königlich Preussische Akademie der Wissenschaften (Berlin). Sitzungsberichte* (1914), 1030–1085.

[5] ______, A propos de la déduction relativiste de M. Emile Meyerson, *Revue Philosophique* **105** (1928), 161–166 (translated as "Comment on Myerson's 'La Déduction Relativiste' ", in *The Concepts of Space and Time: Their Structure and Development*, Milič Čapek, ed., Reidel, Dordrecht/Boston, 1976, pp. 366–367).

[6] ______, Remarks to the essays appearing in the collective volume, in Schilpp, 1949, pp. 663–688.

[7] ______, *Autobiographical Notes: A Centennial Edition*, Open Court, LaSalle and Chicago, 1979.

[8] ______ , *The Collected Papers of Albert Einstein*, vol. 6. The Berlin Years: Writings 1914–1917, English Translation of Selected Texts, Princeton University Press, 1997.

[9] Solomon Feferman, Provenly unprovable, *London Review of Books* **9**, February 2006.

[10] Kurt Gödel (1949a), A remark about the relationship between relativity theory and idealistic philosophy, in Schilpp, 1949, pp. 555–562; reprinted in Gödel 1990, pp. 202–207.

[11] ______ , (1949b): An example of a new type of cosmological solutions of Einstein's field equations of gravitation, *Reviews of Modern Physics* **21** (1949), 447–450. Reprinted in Gödel 1990, pp. 190–198.

[12] ______ , (1990) *Kurt Gödel: Collected Works*, vol. 2, Solomon Feferman et al., eds., Oxford University Press, New York, 1990.

[13] ______ , (1995): ibid, vol. 3 (1995).

[14] Stephen W. Hawking, Chronological protection, in *The Future of Spacetime*, Stephen W. Hawking et al., Norton, New York/London, 2002, pp. 87–108.

[15] Stephen W. Hawking and George F. R. Ellis, *The Large Scale Structure of Space-time*, Cambridge University Press, 1973.

[16] Michael Inwood, *A Hegel Dictionary*, Blackwell, Oxford, 1992.

[17] Pierre Kerszberg, The Einstein-de Sitter controversy of 1916–1917 and the rise of relativistic cosmology, in *Einstein and the History of General Relativity*, Don Howard and John Stachel, eds., Birkhäuser, Boston/Basel/Berlin, 1989, pp. 325–366.

[18] Asher Peres, *Quantum Theory: Concepts and Methods*, Kluwer, Dordrecht/Boston/London, 1993.

[19] Panu Raatikainen, On the philosophical relevance of Gödel's incompleteness theorems, *Revue Internationale de Philosophie* 2005, no. 234, pp. 513–534.

[20] Thomas Sattig, *The Language and Reality of Time*, Clarendon Press, Oxford, 2006.

[21] Paul Aurthur Schilpp, ed., *Albert Einstein: Philosopher-Scientist*, Open Court, LaSalle, 1949.

[22] John Stachel, History of relativity, in *Twentieth Century Physics*, Laurie M. Brown, Abraham Pais, and Brian Pippard, eds., vol. 1, IOP Publishers, Bristol; AIP Press, Philadephia, 1995, pp. 249–356.

[23] John Stachel, Einstein and the rigidly rotating disc, in *General Relativity and Gravitation One Hundred Years After the Birth of Albert Einstein*, Alan Held, ed., Plenum Press, New York, 1980.

[24] Christian Wüthrich, Quantum gravity and the 3D vs. 4D controversy, `http://alccor.concordia.ca/~scol/seminars/conference/Wuthrich.pdf`.

[25] Palle Yourgrau, *Gödel Meets Einstein/Time Travel in the Gödel Universe*, Open Court, Chicago/LaSalle, 1999.

Affordable Textbooks Campaign

Can Online Texts Help?

Bernard Russo

High textbook prices have led many to wonder if there are alternatives. Indeed there are, in the form of online textbooks and in the form of a grassroots effort to reduce the price of textbooks. This article looks at one online math textbook that is now available and describes the campaign.

A First Course in Linear Algebra, by Robert Beezer

This is a free online book (`http://linear.ups.edu`) designed for a rigorous introductory course in linear algebra at the sophomore or junior level. The author goes beyond the usual government copyright by licensing the book to anyone under the terms of the GNU Free Documentation License (details of which are in an appendix). Most of the information given in the first part of this article was obtained from the above URL, the author's website, and the preface to the book.

According to the author, the book is not only free, it has **freedom**, that is, "it will never go 'out of print' nor will there ever be trivial updates designed only to frustrate the used book market." Implicit in the licensing agreement is the hope that users will contribute back any modifications they make for incorporation into the book. Suggestions for how to do this are given at the end of the preface.

The book came into being as a result of the author's frustration with new editions of textbooks coming out with little or no substantial content changes and with textbooks going out of print. Central to the notes on which the book is based was a collection of stock examples that would be used repeatedly to illustrate new concepts. These examples are called Archetypes and are included in an appendix to the book. This book is an attempt to carry over the model of creative endeavor implied by the open-source software movement to textbook publishing.

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A novelty of this book is that Chapters, Theorems, etc. are not numbered but instead referenced by acronyms. This means that as revisions are made (the current online version is the 29th in two and a half years), Theorem XYZ will always be Theorem XYZ, for example. This may seem confusing at first but is compensated for by other features, such as lists of theorems, examples, definitions, and notation in the front of the book, and a very extensive index. In the electronic version, all of the cross-references are hyperlinks, allowing you to click to a definition or example, and then use the back button to return. Depending on which browser you are using, you will need to download fonts or plugins, which however are free. This is explained at the URL noted above. For copies of the book that you have downloaded free and printed, you must rely on page numbers, which will change, depending on the version, margins, size of paper, etc. But you don't have to download it; physical copies of the book are available at `http://Lulu.com`, a print-on-demand service. A paperback copy (684 pages) costs US$24.50. There is also a two-volume set with coil bindings, which should be easier for students to work from, for just a few dollars more.

The book is globally divided into three parts: **Core, Topics, Applications**. The **Core** contains the basic ideas of a first exposure to linear algebra, with chapter titles of SLE (Systems of Linear Equations), V (Vectors), M (Matrices), VS (Vector Spaces), D (Determinants), E (Eigenvalues), LT (Linear Transformations), R (Representations). **Topics** is meant to contain those subjects that are important in linear algebra and that would make profitable detours from the Core for those interested in pursuing them. **Applications** should illustrate the power and widespread applicability of linear algebra to as many fields as possible. (As of the writing of this article, with the exception of three sections in the Topics part, the latter two parts have not yet been written.) The Archetypes (mentioned above) cover many of the computational aspects of systems of linear equations, matrices, and linear transformations. Each section ends with some exercises (288 total), including detailed solutions to two thirds of them.

The author (as well as his university) is to be commended for devoting the time and energy to creating this book and more importantly of unselfishly making it freely available to the mathematical community. This gesture represents a significant step in the campaign currently under way to alleviate the problem of the runaway cost of textbooks. This campaign is described in the rest of this article.

The Affordable Textbooks Campaign

Some of the issues raised by the author and mentioned above are key elements of an organized campaign started by students, faculty, and public interest research groups in the fall of 2003 to stem the tide of the rising cost of textbooks. An excellent summary of that effort up to the middle of 2006 is Allyn Jackson's article in the August 2006 *Notices*. In it she summarizes reports by the California Public Interest Research Group (CALPIRG) in 2004 (updated in 2005) and by the federal Government Accountability Office (GAO) in 2005, and describes the efforts by certain mathematics departments to alleviate the situation.

The CALPIRG report asserted that the average expense for University of California students for textbooks (and supplies) was in the neighborhood of US$900 per year, up about 40% since 1996, compared to a rise of 17% for the Consumer Price Index in that period. The GAO report, as well as two other reports, substantiated this number in other states. On the other hand, an estimate by the Association of American Publishers (AAP), puts the figure at $576, thus putting the two groups most closely involved with textbooks at loggerheads in the debate.

The primary points of contention in this debate concern (1) whether ancillary materials which came bundled with textbooks are really necessary, (2) why the same book can sell for less in some foreign markets, (3) the short revision cycle, and (4) full disclosure by publishers.

Although this sometimes heated debate cooled off a bit in the first half of 2006, it picked up some momentum in the rest of that year. More than a dozen state PIRGs together put out two reports: *Textbooks for the 21st Century—A Guide to Free and Low Cost Textbooks* (August) and *Required Reading—A Look at the Worst Publishing Tactics at Work* (October). A third report was released in February 2007: *Exposing the Textbook Industry—How Publishers' Pricing Tactics Drive Up the Cost of College Textbooks*.

The first report found that major publishers are failing to offer viable low-cost alternatives to expensive college textbooks and, as a result, other free and low-cost options are slowly emerging in the market. The report features some examples of free and very low-cost textbooks (including the one described here) and offers an overview of what's been happening recently to lower textbook costs. The second report presents new case studies of how the college textbook publishing industry deliberately undermines the used book market and inflates prices. The latest report, based on a survey of 287 professors from a variety of disciplines at Massachusetts colleges, addressed points (1), (3), and (4) above.

The full text of each of these reports, as well as links to newspaper articles and other related documents can be found at `http://www.maketextbooksaffordable.com`. As was the case with the earlier PIRG reports, the AAP responded in kind and the debate is ongoing (see `http://www.textbookfacts.org`). An interested party that is following the issue is the National Association of College Stores (NACS), which put out a white paper in 2006 called "The Great Textbook Debate" (`http://www.nacs.org/whitepaper`).

In addition, 2006 saw a lot of textbook-related legislation and university policy. In June Connecticut passed a bill requiring publishers to disclose to professors what textbooks will cost so that professors can use price as one criterion in deciding whether to adopt the textbook for use. Several other states have passed or are considering bills that promote lower textbook costs by setting purchasing recommendations and addressing bundled books. Similarly, the Academic Senate of California State University recently passed a resolution advising faculty on how to lower textbook costs for their students. The Congressional Advisory Committee on Student Financial Assistance recently launched a one-year investigation on the rising costs of textbooks. It will make its recommendations on how to make textbooks more affordable during the summer of 2007. Also at the federal level, Senators Norm Coleman (R-MN) and Richard Durbin (D-IL), in March 2007, introduced the College Textbook Affordability Act of 2007, which was referred to the Committee on Health, Education, Labor, and Pensions.

With textbooks and price disclosure drawing so many decision-makers' attention, and with so many new alternatives to traditional publishing beginning to emerge, this is a busy time for anyone interested in this issue. Indeed, a Google search for "cost of textbooks" leads one to numerous other reports and media articles. Among them, I single out the following as particularly interesting or provocative.

- "Why Are Textbooks So Expensive?" (Henry L. Roediger III, Washington University, St. Louis, Association for Psychological Science *Observer*, January 2005).

  A well argued defense of the thesis: The high price of textbooks is the direct result of the used book market.

- "The High Cost of Textbooks: A Convergence of Academic Libraries, Campus Bookstores, Publishers?" (John H. Pollitz and Anne Christie, Oregon State University, *Electronic Journal of Academic and Special Librarianship*, Summer 2006).

  The university library can be part of the solution.

- "dotReader to Slash Cost of College Textbooks" (Press Release, May 30, 2006). (See also "Online college texts are free, but not free from ads", *Christian Science Monitor*, October 12, 2006.)

  The article discusses embedding of ads inside textbooks via dotReader, thereby reducing the cost by 60%.

- "High Cost of Textbooks Sparks Interest in Digital Alternatives" (Dan Gordon, Teaching Learning & Technology Center, University of California, 2005).

  Is the traditional college textbook on its way to becoming obsolete?

- "Viewpoint: The Economic Case for Creative Commons Textbooks" (Fred M. Beshears, UC Berkeley, October 2005)

  Inspired by MIT's OpenCourseWare, Rice University's Connexions, and the British Open University, an approach called OpenTextbook, still in the exploratory phase, is envisioned as a consortium of universities that would acquire and distribute high-quality Creative Commons content for use either as online courses, electronic textbooks, or customized printed textbooks.

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Mathematical Sciences in the FY 2008 Budget

Samuel M. Rankin III

Highlights

- Federal support for the mathematical sciences is slated to grow from an estimated US$417.24 million in FY 2007 to an estimated US$454.77 million in FY 2008, an increase of 8.9 percent.
- The National Science Foundation's (NSF) Division of Mathematical Sciences (DMS) would increase by 8.6 percent to US$223.47 million.
- The aggregate funding for the mathematical sciences in the Department of Defense (DOD) agencies, Air Force Office of Scientific Research (AFOSR), Army Research Office (ARO), Defense Advanced Research Project Agency (DARPA), National Security Agency (NSA), and Office of Naval Research (ONR) would increase by 8.7 percent. The majority of this increase comes from DARPA (50.0 percent).

Introduction

Research in the mathematical sciences is funded primarily through the National Science Foundation, the Department of Defense (including the National Security Agency), the Department of Energy (DOE), and the National Institutes of Health (NIH). As in previous years, the majority of federal support for the mathematical sciences in FY 2008 would come from the NSF, contributing approximately 49.1 percent of the federal total. The DOD accounts for around 20.8 percent of the total, with the NIH supplying 17.7 percent, and the DOE around 12.3 percent. The NSF currently accounts for almost 80.0 percent of the federal support for academic research in the mathematical sciences and is the only agency that supports mathematics research broadly across all fields. The DOD, DOE, and NIH support research in the mathematical sciences that contributes to the missions of these agencies.

The DOD supports mathematical sciences research and related activities in several programs: the Directorates of Mathematics, Information, and Life Sciences and Physics and Electronics, within the AFOSR; the Mathematical and Information Sciences Division within the ARO; the Mathematics, Computers, and Information Sciences Research division within the ONR; the Defense Sciences Program and the Microsystems Technology Office within DARPA; and the Mathematical Sciences Program within the NSA.

The DOE funds mathematics through its Applied Mathematics program within the DOE Mathematical, Information and Computational Sciences subprogram. The National Institutes of Health funds mathematical sciences research primarily through the National Institute of General Medical Sciences (NIGMS) and through the National Institute of Biomedical Imaging and Bioengineering (NIBIB).

Trends in Federal Support for the Mathematical Sciences

The FY 2008 estimated aggregate spending for mathematical sciences research and related activities would be US$454.77 million, a potential increase of 8.9 percent over FY 2007 estimated spending. The NSF Division of Mathematical Sciences budget would increase by 8.6 percent in FY 2008, while the DOD agencies would increase by 8.7 percent for FY 2008. DARPA increases its mathematical sciences spending by 50.0 percent, while the ARO mathematics budget decreases by 14.3 percent. The remaining DOD agencies would essentially have little or no growth in FY 2008. The DOE mathematical sciences budget increases by 15.9 percent, while the NIH funding increases by 5.7 percent.

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This article is a slightly revised version of a chapter about federal funding in the mathematical sciences in AAAS Report XXXI, Research & Development FY 2008, *published by the American Association for the Advancement of Science. The report is available on the Web at* `http://www.aaas.org/spp.rd/`.

The mathematical sciences make major contributions to the country's intellectual capacity, and the need for results from the mathematical sciences in scientific discovery and technological innovation is on an accelerating pace. Many disciplines depend on discoveries in the mathematical sciences to open up new frontiers. Even so, many mathematical scientists who are performing excellent research and who submit grant proposals deemed of very high quality are consistently either not funded or are underfunded. According to the *Science and Engineering Indicators*, 2006 Edition, in FY 2003 only 31.0 percent of full-time mathematical sciences faculty, having doctoral degrees, received federal research support. This is much lower than most other fields of science.

National Science Foundation (NSF)

The Division of Mathematical Sciences (DMS), http://www.nsf.gov/div/index.jsp?div=DMS, is housed in the NSF Directorate of the Mathematical and Physical Sciences (MPS). This directorate also contains the Divisions of Astronomical Sciences, Chemistry, Materials Research, Physics, and Multidisciplinary Activities. The DMS supports advances in the intellectual frontiers of the mathematical sciences, activities contributing to advancing knowledge in other scientific and engineering fields, and research that is critical to national competitiveness.

The DMS has essentially two modes of support: research and education grants, and institutes. Grants include individual-investigator awards, awards for multidisciplinary groups of researchers, and educational and training awards aimed at increasing the number of U.S. students choosing careers in the mathematical sciences. The DMS provides core support for five mathematical sciences research institutes as well as major support for three other institutes. These institutes, funded on a competitive basis, serve to develop new ideas and directions in the mathematical sciences as well as to promote interaction with other disciplines.

The DMS is slated to receive a budget of US$223.47 million in FY 2008, an increase of US$17.73

Table 1: Federal Funding for the Mathematical Sciences (millions of dollars)†

	FY 06 Actual	**FY 07** Estimate	**FY 08** Request	**Change** 2007–08 Amount	**Change** 2007–08 Percent
National Science Foundation					
DMS	199.52	205.74	223.47	17.73	8.6%
Department of Defense					
AFOSR	32.1	36.0	37.6	1.6	2.8
ARO	14.0	14.0	12.0	-2.0	-14.3
DARPA	16.0	18.0	27.0	9.0	50.0
NSA*	4.0	4.0	4.0	0.0	0.0
ONR	13.0	15.0	14.0	-1.0	-0.7
Total DOD	79.1	87.0	94.6	7.6	8.7
Department of Energy**					
Applied Mathematics	32.0	29.5	36.9	7.4	25.1
SciDAC	2.7	10.0	10.0	0.0	0.0
SAPs	1.0	7.6	7.9	0.3	3.9
OSG	.8	1.3	1.3	0.0	0.0
Total DOE	36.5	48.4	56.1	7.7	15.9
National Institutes of Health					
NIGMS	38.0	38.0	42.0	4.0	10.5
NIBIB	38.7	38.1	38.4	0.3	0.8
Total NIH	76.7	76.1	80.4	4.3	5.7
Total All Agencies	391.82	417.24	454.77	37.33	8.9

†Budget information is derived from agency documents and conversations with agency program managers and representatives.

**Estimates based on previous budgets.*

***Scientific Discovery through Advanced Computing (SciDAC); Scientific Applications Partnerships (SAPs); Open Science Grid (OSG).*

million or 8.6 percent over the FY 2007 budget. The US$17.73 million is broken down as follows: US$7.30 million for core programs; US$5.20 million for Cyber-enabled Discovery and Innovation (CDI), an NSF-wide initiative; US$1.50 million for Science Beyond Moore's Law, an MPS initiative; US$1.0 million for discovery-based undergraduate experiences; and US$2.73 million for mathematical sciences institutes and networks.

The mathematical sciences designation as an NSF priority area ended in the FY 2007 budget. The FY 2008 MPS budget reflects spending of US$6.62 million for continuing priority area awards made in prior years. Other components of the priority area investment will return to core programs for continued support.

For FY 2008 the DMS has several priorities. Core support for the mathematical sciences includes individual investigator awards, support for graduate and postdoctoral students within individual awards, and investments in formal interdisciplinary partnerships. The objective of CDI is to broaden the nation's capability for innovation through the development of a new generation of computationally based discovery concepts and tools that can deal with complex, data-rich systems. Areas of emphasis for the mathematical sciences include algorithm development and computational tools for large-scale problems of scientific importance, modeling of phenomena that occur over a large range of spatial and temporal scales, and finding patterns in the structure of large data sets. Going beyond Moore's law will require algorithms that increase the speed of basic computations exponentially in concert with hardware improvements. Emphasis will include algorithm design, analysis, and implementation; scalability in space and time; quantification of errors and uncertainty in visualization of large data sets. Broadening participation in the mathematical sciences will support interactions and research networks among a diverse population, including students and researchers at a wide array of institutions. Education and training activities include research experiences and mentoring activities aimed at increasing the number of U.S. students choosing careers in the mathematical sciences.

Air Force Office of Scientific Research (AFOSR)

Funding for the mathematical sciences at AFOSR is found in the Directorates of Mathematics, Information, and Life Sciences and Physics and Electronics. The AFOSR mathematics program includes specific portfolios in dynamics and control, physical mathematics and applied analysis, computational mathematics, optimization and discrete mathematics, electromagnetics, and signals communication and surveillance. Current areas of interest include cooperative/collaborative control of a team of unmanned aerial vehicles conducting operations; improved mathematical methods and algorithms that exploit advanced computational capabilities in support of Air Force computing interest; the development of accurate models of physical phenomena that enhance the fidelity of simulation; and the development of resilient algorithms for data representation in fewer bits, image reconstruction/enhancement, and spectral/frequency estimation in the presence of external corrupting factors. See the website http://www.afosr.af.mil. The AFOSR FY 2008 budget for the mathematical sciences would increase 2.8 percent over FY 2007.

Army Research Office (ARO)

The Mathematics Program, housed in the Mathematical and Information Sciences Division, http://www.arl.army.mil/main/main/default.cfm?Action=29&Page=194, manages the following programs: modeling of complex systems; computational mathematics; discrete mathematics and computer science; probability and statistics and stochastic analysis; and cooperative systems. The Mathematical Sciences Division plays an essential role in the modeling, analysis, and control of complex phenomena and large-scale systems which are of critical interest to the Army. The areas of application include wireless communication networks, image analysis, visualization and synthetic environments, pattern recognition, test and evaluation of new systems, sensor networks, network science, robotics, and autonomous systems. The division also works closely with the computer and Information Sciences Division of ARO to develop mathematical theory for systems control, information processing, information assurance, and data fusion. The FY 2008 budget for the Mathematical Sciences Division is US$12 million. The ARO budget would decrease by 14.3 percent from FY 2007.

Defense Advanced Research Projects Agency (DARPA)

The Defense Sciences Office (DSO) inside DARPA has a mathematics program encompassing both Applied and Computational Mathematics and Fundamental Mathematics, http://www.darpa.mil/dso/thrust/math/math.htm. The thrusts of DSO's programs are structured around focused initiative areas in interdisciplinary and core mathematics. Current program areas include: Discovery and Exploitation of Structure in Algorithms, Femtosecond Adaptive Spectroscopy Techniques for Remote Agent Detection, Geospatial Representation and Analysis, Integrated Sensing and Processing, Mathematical Time Reversal, Predicting Real Optimized Materials, Protein Design Processes, Robust Uncertainty Management, Stochastic and Perturbation Methods in PDE Systems, and Waveforms for Active Sensing, as well as Focus Areas in Theoretical Mathematics, Fundamental Laws of

Biology, Sensor Topology and Minimal Planning, and Topological Data Analysis. The Microsystems Technology Office has several programs where mathematical algorithms play a central role in the optimization, control, and exploitation of microelectronic and optical systems, http://www.darpa.mil/MTO/personnel/healy_d.html. These include the following programs: Analog-to-Information, Cognitively Augmented Design for Quantum Technology, Multiple Optical Non-redundant Aperture Generalized Sensors, Non-Linear Mixed Signal Microsystems, and Space-Time Adaptive Processing. The DARPA mathematics budget would increase by 50.0 percent over FY 2007.

Department of Energy (DOE)

Mathematics at DOE is funded through the Advanced Scientific Computing Research Program (ASCR) under its subprogram, Mathematical, Information, and Computational Sciences Division (MICS), http://www.science.doe.gov/ascr/mics. Funding for the mathematical sciences is found in the Applied Mathematics activity, the Scientific Discovery through Advanced Computing (SciDAC) activity, the Scientific Applications Partnerships activity, and the Open Science Grid. The Applied Mathematics activity supports research on the underlying mathematical understanding of physical, chemical, and biological systems and advanced numerical algorithms that enable effective description, modeling, and simulation of such systems on high-end computing systems. Research in applied mathematics supported by MICS underpins computational science throughout the DOE. Applied Mathematics supports work in a wide variety of areas of mathematics, including: ordinary and partial differential equations, numerical linear algebra, fluid dynamics, optimization, mathematical physics, control theory, accurate treatment of shock waves, mixed elliptic-hyperbolic systems, and dynamical systems. The FY 2008 Applied Mathematics activity budget includes increased support for mathematical research issues relevant to petascale science (+ US$2 million), research in optimization control and risk analysis in complex systems (+ US$1.9 million), support for multiscale mathematics (+ US$2.5 million), and funding for the Computational Science Graduate Fellowship Program (+ US$1.0 million). Support for multiscale mathematics is US$11 million in FY 2008. Around US$16.5 million of the US$46.9 million supporting the mathematical sciences in the Applied Mathematics and SciDAC programs goes to academic research, with the remainder supporting research at DOE labs. The DOE FY 2008 budget for the mathematical sciences will increase by 15.9 percent over FY 2007.

National Institutes of Health (NIH)

The NIH funds mathematical sciences research through the National Institute of General Medical Sciences (NIGMS) and the National Institute of Biomedical Imaging and Bioengineering (NIBIB). Mathematical sciences areas of interest are those that support the missions of NIGMS and NIBIB. Currently NIGMS is supporting a biomathematics initiative at around US$12 million per year in cooperation with the National Science Foundation, and NIBIB is participating in a joint initiative with the NSF and other NIH institutes, Collaborative Research in Computational Neuroscience. The aggregate budget for the mathematical sciences in NIBIB and NIGMS would decline by 5.7 percent in FY 2008.

National Security Agency (NSA)

The Mathematical Sciences Program of the NSA administers a Grants Program that supports fundamental research in the areas of algebra, number theory, discrete mathematics, probability, and statistics. The Grants Program also accepts proposals for conferences and workshops in these research areas. In addition to grants, the Mathematical Sciences Program supports an in-house faculty Sabbatical Program. The program administrators are especially interested in funding initiatives that encourage the participation of underrepresented groups in mathematics (such as women, African-Americans, and other minorities). NSA is the largest employer of mathematicians in the United States. As such, it has a vested interest in maintaining a healthy academic mathematics community in the United States. For more information see the website http://www.nsa.gov/msp/index.cfm. The NSA mathematics budget would remain unchanged for FY 2008.

Office of Naval Research (ONR)

The ONR Mathematics, Computers, and Information Research Division's scientific objective is to establish rigorous mathematical foundations and analytical and computational methods that enhance understanding of complex phenomena, and enable prediction and control for Naval applications in the future. Basic research in the mathematical sciences is focused on analysis and computation for multiphase, multimaterial, multiphysics problems; predictability of models for nonlinear dynamics; electromagnetic and acoustic wave propagation; signal and imaging processing; modeling pathological behaviors of large, dynamic complex networks and exploiting hybrid control to achieve reliability and security; optimization; and formal methods for verifiably correct software construction. For more information see the website http://www.onr.navy.mil/sci_tech/31/311/default.asp. The Mathematical, Computer, and Information Sciences Division's budget would decrease by 0.7 percent in FY 2008.

Note: Information gathered from agency documents and from agency representatives.

2006 Annual Survey of the Mathematical Sciences in the United States

(Second Report)

Updated Report on the 2005–2006 Doctoral Recipients
Starting Salary Survey of the 2005–2006 Doctoral Recipients

Polly Phipps, James W. Maxwell, and Colleen A. Rose

This Second Report of the 2006 Annual Survey gives an update of the 2005–2006 new doctoral recipients from the First Report, which appeared in the *Notices of the AMS* in February 2007, pages 277–97. The First Report gave salary data for faculty members in these same departments. It also had a section on new doctoral recipients in statistics that is not updated here.

The 2006 Annual Survey represents the fiftieth in an annual series begun in 1957 by the American Mathematical Society. The 2006 Survey is under the direction of the Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Institute of Mathematical Statistics, the Society of Industrial and Applied Mathematics, and the Mathematical Association of America. The current members of this committee are Richard Cleary, Amy Cohen-Corwin, Richard M. Dudley, John W. Hagood, Abbe H. Herzig, Donald R. King, David J. Lutzer, James W. Maxwell (ex officio), Bart Ng, Polly Phipps (chair), David E. Rohrlich, and Henry Schenck. The committee is assisted by AMS survey analyst Colleen A. Rose. Comments or suggestions regarding this Survey Report may be directed to the committee.

Update on the 2005–2006 Doctoral Recipients

Introduction

The Annual Survey of the Mathematical Sciences collects information each year about degree recipients, departments, faculties, and students in the mathematical sciences at four-year colleges and universities in the United States. Information about recipients of doctoral degrees awarded between July 1, 2005, and June 30, 2006, was collected from doctorate-granting departments beginning in late spring 2006. The "2006 Annual Survey First Report" (Notices, February 2007, pages 252–67) presented survey results about 1,245 new doctoral recipients based on the data provided by the departments. Here we update this information using data obtained from 660 new doctoral recipients who responded to a questionnaire, Employment Experiences of New Doctoral Recipients (EENDR), sent in early October 2006 to all new doctoral recipients. In addition, this report incorporates information on an additional 66 doctoral recipients from departments that responded too late to have the information included in the First Report. Finally, we present the starting salaries and other employment information from the new doctoral recipients that responded to the EENDR questionnaire.

The names and thesis titles of the 2005–2006 doctoral recipients reported on in the First Report were published in "Doctoral Degrees Conferred" (*Notices*, February 2007, pages 277–97). A supplemental listing of the 66 additional new doctoral recipients appears at the end of this report on pages 888–89.

Updated Employment Status of 2005–2006 Doctoral Recipients

The updated responses rates for the 2006 Survey of New Doctoral Recipients appear on the next page. The total number of departments responding in time for inclusion in this Second Report was 269, 24 more than were included in the 2006 First Report and 7 more than the number responding for

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

Highlights

There were 1,311 doctoral recipients from U.S. institutions for 2005–2006, up 89 (7%) from the previous year. This is the highest number of new Ph.D.'s ever reported.

The final unemployment rate for 2005–2006 doctoral recipients was 3.3%, the lowest percentage reported since 2002.

The number of new doctoral recipients who are not U.S. citizens is 759, up 33 over last year's number, and up 227 (43%) from 2001–2002.

The number of new doctoral recipients who are U.S. citizens is 552, up 56 (11%) from last year's number; this is the highest number of U.S. citizens reported since 1999–2000 when it was 566. The percentage of U.S. citizens among all doctoral recipients this year is 42%, up from 41% last year.

Females totaled 422 (32%) of all new doctoral recipients, up in number and percentage from 359 (29%) last year. Of the 552 U.S. citizen new doctoral recipients, 153 are female (28%), up in number and the same percent from last year. The highest percentage of females among the annual counts of doctoral recipients was 34%, reported for 1998–1999.

The number of doctoral recipients whose employment status is unknown is 163, up 13 from last year's number of 150.

Of the 1,148 new doctoral recipients whose employment status is known, 1,099 reported having employment in fall 2006 with 87% (958) finding employment in the U.S.; last year this percentage was 86%.

The number of new doctoral recipients taking positions in U.S. business/industry and government was 243 in fall 2006, a 38% increase from last year's number. The percentage of doctoral recipients employed in the U.S. taking positions in business/industry and government has increased to 25%, from 20% in fall 2005. This is the highest number and percentage reported since 2002 when it was 179 (24%).

The number of new doctoral recipients hired into U.S. academic positions in fall 2006 is 715. This is the highest such number reported over the past twenty-five years. Indeed, each of the numbers reported for the past three falls exceeds any number reported during the period from fall 1982 through fall 2003.

Non-U.S. citizens accounted for 58% of those employed in the U.S. (last year this percentage was 59%).

There were 660 new doctoral recipients responding to the EENDR survey; of the 563 who found employment in the U.S., 51% reported obtaining a permanent position (down from 56% in fall 2005).

The percentage of temporarily employed respondents who reported taking a postdoctoral position in the U.S. increased from 172 (74%) in fall 2005 to 209 (76%) in fall 2006.

Doctorates Granted Departmental Response Rates (updated April 2007)

Group I (Pu)[1]	25 of 25 including 0 with no degrees
Group I (Pr)	22 of 23 including 0 with no degrees
Group II	54 of 56 including 0 with no degrees
Group III	74 of 75 including 15 with no degrees
Group IV	73 of 87 including 14 with no degrees
Group Va	21 of 21 including 2 with no degrees

[1] For definitions of groups see page 887.

inclusion in the 2005 Second Report. Definitions of the various groups surveyed in the Annual Survey can be found on page 887 of this report.

Table 1A shows the fall and final counts of doctoral recipients in the mathematical sciences awarded by U.S. institutions in each year from 1996 through 2006. This year the total number of new doctoral recipients is 1,311, up from the previous year by 89. A detailed review of responding and non-responding departments indicates that the increase in doctoral recipients from 2005 to 2006 is not significantly influenced by differences in department response patterns.

Table 1A: Doctoral Recipients: Fall and Final Counts

Year	Fall	Final
1996–1997	1123	1130
1997–1998	1163	1176
1998–1999	1133	1135
1999–2000	1119	1127
2000–2001	1008	1065
2001–2002	948	960
2002–2003	1017	1037
2003–2004	1041	1081
2004–2005	1116	1222
2005–2006	1245	1311

Table 1B: Doctoral Recipients: Citizenship

Year	U.S.	Non-U.S.	**TOTAL**
2001–2002	428	532	**960**
2002–2003	499	538	**1037**
2003–2004	459	622	**1081**
2004–2005	496	726	**1222**
2005–2006	552	759	**1311**

Table 1C: Doctoral Recipients by Type of Degree-Granting Department

	Department Group[1]					
	I (Pu)	I (Pr)	II	III	IV	Va
Number	307	184	224	150	327	119
Percent	23%	14%	17%	11%	25%	9%

[1] For definitions of groups see page 887.

Table 2A: Fall 2006 Employment Status of 2005–2006 Doctoral Recipients: Field of Thesis (updated April 2007)

	FIELD OF THESIS												
TYPE OF EMPLOYER	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	TOTAL
Group I (Public)[1]	14	9	11	7	0	1	6	8	1	12	1	1	**71**
Group I (Private)	17	5	16	3	7	2	6	7	1	11	0	0	**75**
Group II	18	14	4	6	5	3	6	6	2	10	0	0	**74**
Group III	7	1	4	5	3	9	4	1	0	7	2	0	**43**
Group IV	0	0	0	0	7	63	1	1	0	0	1	0	**73**
Group Va	0	0	1	1	1	1	3	6	1	0	0	0	**14**
Master's	12	3	4	6	3	14	2	4	1	6	3	0	**58**
Bachelor's	38	12	21	12	7	11	10	7	2	15	5	0	**140**
Two-Year College	3	2	0	1	2	2	1	1	2	1	2	1	**18**
Other Academic Dept.[2]	3	5	3	7	2	52	23	4	1	9	1	3	**113**
Research Institute/ Other Nonprofit	8	0	3	3	1	12	5	1	0	3	0	0	**36**
Government	4	2	0	2	1	13	8	9	4	4	0	0	**47**
Business and Industry	8	7	5	11	19	108	17	9	5	6	0	1	**196**
Non-U.S. Academic	33	11	20	14	5	11	10	3	2	7	1	2	**119**
Non-U.S. Nonacademic	3	1	2	1	2	8	3	0	1	1	0	0	**22**
Not Seeking Employment	3	1	0	1	0	1	2	0	1	1	1	0	**11**
Still Seeking Employment	6	3	3	5	1	4	5	3	0	8	0	0	**38**
Unknown (U.S.)	7	3	5	2	3	18	17	3	1	4	1	0	**64**
Unknown (non-U.S.)[3]	6	3	6	2	1	39	21	11	1	7	0	2	**99**
TOTAL	**190**	**82**	**108**	**89**	**70**	**372**	**150**	**84**	**26**	**112**	**18**	**10**	**1311**
Column Subtotals Male	152	64	85	62	54	200	101	61	21	79	8	2	**889**
Column Subtotals Female	38	18	23	27	16	172	49	23	5	33	10	8	**422**

[1] For definitions of groups see page 887.
[2] These are departments outside the mathematical sciences.
[3] Includes those whose status is reported as "unknown" or "still seeking employment".

Table 2B: Fall 2006 Employment Status of 2005–2006 Doctoral Recipients: Type of Degree-Granting Department (updated April 2007)

	TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT							Row Subtotals	
TYPE OF EMPLOYER	Group I (Public)	Group I (Private)	Group II Math.	Group III Math.	Group IV Statistics	Group Va Applied Math.	TOTAL	Male	Female
Group I (Public)[1]	35	17	14	0	0	5	**71**	59	12
Group I (Private)	25	36	4	0	3	7	**75**	62	13
Group II	29	13	18	3	4	7	**74**	55	19
Group III	7	3	6	19	6	2	**43**	30	13
Group IV	3	0	1	2	65	2	**73**	42	31
Group Va	1	3	0	0	0	10	**14**	8	6
Master's	7	3	22	18	7	1	**58**	39	19
Bachelor's	41	14	42	30	7	6	**140**	101	39
Two-Year College	2	1	6	6	0	3	**18**	12	6
Other Academic Dept.[2]	14	11	9	15	52	12	**113**	71	42
Research Institute/ Other Nonprofit	7	8	6	0	11	4	**36**	17	19
Government	7	4	11	2	12	11	**47**	31	16
Business and Industry	34	17	21	13	92	19	**196**	120	76
Non-U.S. Academic	39	26	25	15	9	5	**119**	91	28
Non-U.S. Nonacademic	8	4	1	1	7	1	**22**	16	6
Not Seeking Employment	0	3	3	1	1	3	**11**	4	7
Still Seeking Employment	6	8	9	8	3	4	**38**	29	9
Unknown (U.S.)	19	3	12	8	17	5	**64**	46	18
Unknown (non-U.S.)[3]	23	10	14	9	31	12	**99**	56	43
TOTAL	**307**	**184**	**224**	**150**	**327**	**119**	**1311**	**889**	**422**
Column Subtotals Male	232	147	164	99	173	74	**889**		
Column Subtotals Female	75	37	60	51	154	45	**422**		

[1] For definitions of groups see page 887.
[2] These are departments outside the mathematical sciences.
[3] Includes those whose status is reported as "unknown" or "still seeking employment".

Table 2C: Field of Thesis of 2005–2006 Doctoral Recipients: by Type of Degree-Granting Department (updated April 2007)

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)[1]	84	25	42	22	26	10	28	16	4	44	3	3	**307**
Group I (Private)	51	11	31	20	12	4	30	7	1	17	0	0	**184**
Group II	36	34	22	18	9	10	35	22	11	23	3	1	**224**
Group III	18	11	11	21	3	29	15	14	1	14	11	2	**150**
Group IV	0	0	0	1	10	304	9	1	0	0	0	2	**327**
Group Va	1	1	2	7	10	15	33	24	9	14	1	2	**119**
TOTAL	**190**	**82**	**108**	**89**	**70**	**372**	**150**	**84**	**26**	**112**	**18**	**10**	**1311**

[1] For definitions of groups see page 887.

Table 2D: Percentage of Employed New Doctoral Recipients by Type of Employer

	Employed in U.S.		Not Employed in U.S.		NUMBER EMPLOYED
	Academic[1]	Nonacademic	Academic	Nonacademic	
Fall 2002	67%	22%	10%	1%	**829**
Fall 2003	70%	17%	12%	2%	**792**
Fall 2004	72%	15%	12%	1%	**910**
Fall 2005	69%	17%	12%	2%	**1018**
Fall 2006	65%	22%	11%	2%	**1099**

[1] Includes Research Institutes and other non-profits.

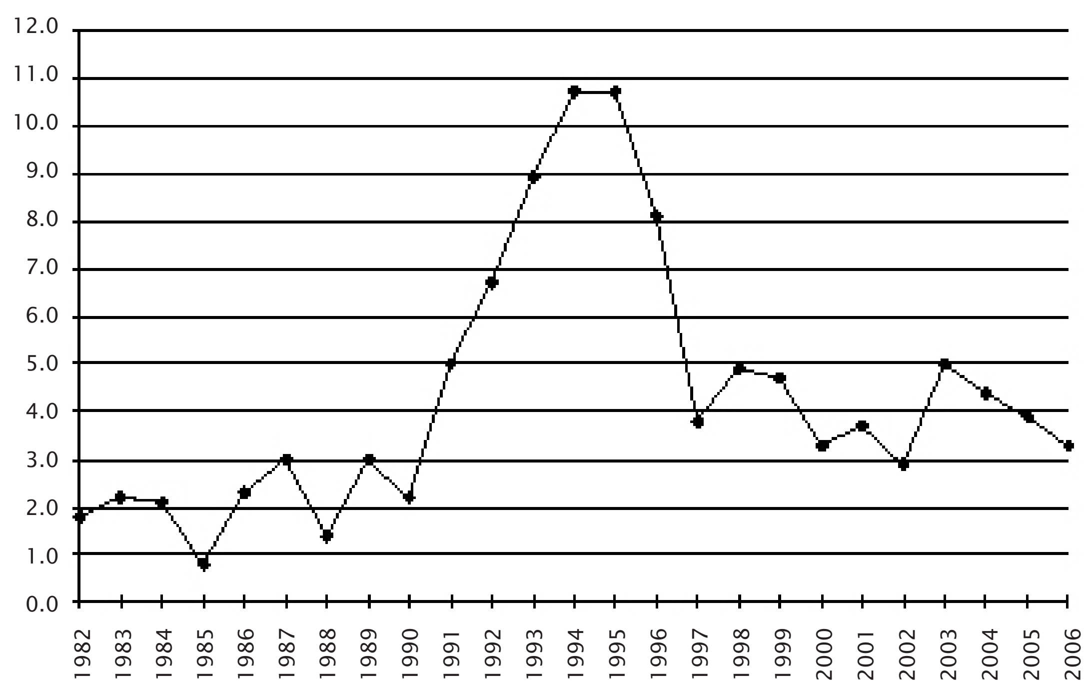
Table 1B shows trends in the number of new doctoral recipients for the past five years broken down by U.S. citizens and non-U.S. citizens. This year the number of new doctoral recipients who are U.S. citizens is 552, an increase of 56 (11%) over last year. The number of non-U.S. citizen new doctoral recipients rose to 759, a 5% increase over last year.

Table 1C gives a breakdown of the 1,311 doctoral degrees awarded in the mathematical sciences between July 1, 2005, and June 30, 2006, by type of degree-granting department.

Tables 2A, 2B, and 2C display updates of employment data, found in these same tables in the First Report, for the fall count of 2005–2006 doctoral recipients plus 66 additional doctoral recipients reported late. These tables are partitioned by field of thesis research, by the survey group of their degree-granting department, and by type of employer. New doctoral recipients are grouped by field of thesis using the *Mathematical Reviews* 2000 Mathematics Subject Classification list. A complete list of these groups is available on the AMS website at `www.ams.org/employment/Thesis_groupings.pdf`. At the time of this Second Report, the fall 2006

Figure 1: Percentage of New Doctoral Recipients Unemployed[1]

Year	Percentage
1982	1.8
1983	2.2
1984	2.1
1985	0.8
1986	2.3
1987	3.0
1988	1.4
1989	3.0
1990	2.2
1991	5.0
1992	6.7
1993	8.9
1994	10.7
1995	10.7
1996	8.1
1997	3.8
1998	4.9
1999	4.7
2000	3.3
2001	3.7
2002	2.9
2003	5.0
2004	4.4
2005	3.9
2006	3.3



[1] As reported in the respective Annual Survey Second Reports.

Table 3A: New Doctoral Recipients Employed in the U.S.

	Degree-Granting Department Group[1]													
	I (Pu)		I (Pr)		II		III		IV		Va		TOTAL	
	Academic[2]	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government	Academic	Business/ Industry & Government
Fall 2002	133	25	86	20	107	27	91	11	102	72	34	24	553	179
Fall 2003	123	24	90	16	118	13	61	10	119	54	40	14	551	131
Fall 2004	118	18	118	18	144	17	73	11	150	61	52	11	655	137
Fall 2005	152	21	104	17	152	23	97	18	149	79	45	18	699	176
Fall 2006	171	41	109	21	128	32	93	15	155	104	59	30	715	243

[1] For definitions of groups see page 887.
[2] Includes Research Institutes and other non-profits.

employment status of 1,148 of the 1,311 doctoral recipients was known.

The fall 2006 unemployment rate for new doctoral recipients, based on information gathered by the time of the Second Report, was 3.3%. Figure 1 presents the fall 1982 through fall 2006 trend in the final unemployment rate of new doctoral recipients. The counts on which these rates are determined do not include those new doctoral recipients whose fall employment status was unknown at the time of the Second Report. This year the number of recipients whose employment status was reported as unknown increased to 163 from 150 last year.

Of the 1,148 new doctoral recipients whose employment is known, 958 were employed in the U.S., 141 were employed outside the U.S., 38 were still seeking employment, and 11 were not seeking employment.

Table 2D presents the trend in the percentage of employed new doctoral recipients by type of employer for the last five years. Academic employment includes those employed by research institutes and other nonprofits. The percentage of the total employed new doctoral recipients that are in U.S. academic positions has dropped for the second consecutive year and concomitantly the percentage of the total employed in U.S. nonacademic positions (U.S. government, U.S. business and industry) has increased for the second consecutive year.

Among new doctoral recipients who are employed in the U.S., the percentage taking nonacademic employment varied significantly by field of thesis. For those whose field of thesis is in the first three columns in Table 2A, this percentage is the lowest at 10% (up from 7% last year), while the percentage for those with theses in probability or statistics is the highest at 40% (up from 36% last year).

Table 3A shows that the fall 2006 total number of doctoral recipients taking positions in business/industry and government is 243. This number reflects an increase of 38% over last year. All groups have shown an increase in the number of graduates finding employment in business/industry and government except Group III.

Table 3B: New Doctoral Recipients Employed in U.S. Academic Positions

	Hiring Department Group[1]					
	I–III	IV	Va	M&B	Other	**TOTAL**
Fall 2002	222	45	10	148	128	**553**
Fall 2003	216	39	9	158	129	**551**
Fall 2004	220	66	19	172	178	**655**
Fall 2005	249	53	12	212	173	**699**
Fall 2006	263	73	14	198	167	**715**

[1] For definitions of groups see page 887.

Table 3C: Females as a Percentage of New Doctoral Recipients

	Department Group[1]						
% Female	I (Pu)	I(Pr)	II	III	IV	Va	**TOTAL**
Produced	24%	20%	27%	34%	47%	38%	**32%**
Hired	17%	17%	26%	30%	42%	43%	**27%**

[1] For definitions of groups see page 887.

Table 3B shows that the number of new doctoral recipients taking U.S. academic positions has increased to 715, from 699 in 2005. Doctoral hires into U.S. academic positions are up in all groups except Groups M&B (down to 198 from 212 last year) and Other (down to 167 from 173 last year). The biggest percentage increase is in Group IV (38%). Doctoral hires into non-U.S. academic positions decreased by 6% to 119 from 127 last year.

Table 3C gives information about the production and hiring of female new doctoral recipients in the doctoral-granting departments of this survey. From Table 3C we see that the percentage of females hired ranges from a high of 43% in Group Va, followed by Group IV at 42% to a low of 17% in both Groups I (Pu) and 1 (Pr). The percentage of

Table 3D: Citizenship of 2005–2006 Male Doctoral Recipients by Fall 2006 Employment Status

TYPE OF EMPLOYER	CITIZENSHIP				TOTAL MALE DOCTORAL RECIPIENTS
	U.S. CITIZENS	NON-U.S. CITIZENS			
		Permanent Visa	Temporary Visa	Unknown Visa	
U.S. Employer	313	40	283	11	**647**
U.S. Academic	250	29	211	6	**496**
Groups[1] I, II, III, and Va	96	15	100	3	**214**
Group IV	17	6	19	0	**42**
Non-Ph.D. Department	128	7	85	3	**223**
Research Institute/Other Nonprofit	9	1	7	0	**17**
U.S. Nonacademic	63	11	72	5	**151**
Non-U.S. Employer	28	7	72	0	**107**
Non-U.S. Academic	28	6	57	0	**91**
Non-U.S. Nonacademic	0	1	15	0	**16**
Not Seeking Employment	3	0	1	0	**4**
Still Seeking Employment	18	1	10	0	**29**
Subtotal	362	48	366	11	**787**
Unknown (U.S.)	34	5	7	0	**46**
Unknown (non-U.S.)[2]	3	0	51	2	**56**
TOTAL	**399**	**53**	**424**	**13**	**889**

[1] For definitions of groups see page 887.
[2] Includes those whose status is reported as “unknown” or “still seeking employment”.

Table 3E: Citizenship of 2005–2006 Female Doctoral Recipients by Fall 2006 Employment Status

TYPE OF EMPLOYER	CITIZENSHIP				TOTAL FEMALE DOCTORAL RECIPIENTS
	U.S. CITIZENS	NON-U.S. CITIZENS			
		Permanent Visa	Temporary Visa	Unknown Visa	
U.S. Employer	124	33	145	9	**311**
U.S. Academic	93	24	97	5	**219**
Groups[1] I, II, III, and Va	23	9	31	0	**63**
Group IV	11	4	13	3	**31**
Non-Ph.D. Department	53	9	42	1	**106**
Research Institute/Other Nonprofit	6	2	10	1	**19**
U.S. Nonacademic	31	9	48	**4**	**92**
Non-U.S. Employer	8	3	22	0	**34**
Non-U.S. Academic	8	1	19	0	**28**
Non-U.S. Nonacademic	0	2	3	0	**6**
Not Seeking Employment	3	1	3	0	**7**
Still Seeking Employment	5	1	3	0	**9**
Subtotal	140	38	173	10	**361**
Unknown (U.S.)	13	2	3	0	**18**
Unknown (non-U.S.)[2]	0	0	42	1	**43**
TOTAL	**153**	**40**	**218**	**11**	**422**

[1] For definitions of groups see page 887.
[2] Includes those whose status is reported as “unknown” or “still seeking employment”.

female new doctoral recipients produced is highest in Group IV (47%). The total percentage of females produced and hired has increased from last year’s percentages of 29% and 26%, respectively, to this year’s 32% and 27%.

Updated Information about 2005–2006 Doctoral Recipients by Sex and Citizenship

Tables 3D and 3E show the sex and citizenship of the 1,311 new doctoral recipients and the fact that 958 new doctoral recipients found jobs in the U.S. this year. This is 83% of the 1,148 new doctoral recipients whose employment status was known and 87% of the 1,099 known to have jobs in fall 2006. respectively.

Sex and citizenship are known for all of the 1,311 new doctoral recipients. The final count of new doctoral recipients who are U.S. citizens is 552

Table 3F: Number of New Doctoral Recipients Employed in the U.S. by Citizenship and Type of Employer

U.S. EMPLOYER	CITIZENSHIP		TOTAL
	U.S.	Non-U.S.	
Academic: Groups I–Va	147	203	**350**
Academic: M&B, Other	196	169	**365**
Nonacademic	94	149	**243**
TOTAL	**437**	**521**	**958**

(42%) (up from 41% last year). Pages 235–8 of the First Report present further information related to the citizenship of the 2005–2006 new doctoral recipients.

Of the 552 U.S. citizen new doctoral recipients reported for 2005–2006, 153 are female and 399 are male. Females accounted for 27% of the U.S. citizen total (down from 28% last year). The number of female U.S. citizens has increased by 12 from last year's count of 141, and the number of male U.S. citizens increased by 44 over last year's count of 355.

Table 3F shows that U.S. citizens accounted for 46% of those employed in the U.S. (up from 42% last year). U.S. academic doctoral departments, Groups I through Va, hired 42% U.S. citizens, while groups M, B, and all other academic departments hired 54% U.S. citizens (last year these percentages were 40% and 53%, respectively). U.S. citizens represented 39% of those hired into nonacademic positions (last year 41%). Among all the 958 new 2005–2006 doctoral recipients employed in the U.S., 25% took nonacademic employment (government or business and industry.) This percentage is up from 20% in 2004–2005 and from 17% in 2003–2004.

New Information from the EENDR Survey

Of the 1,245 new doctoral recipients reported in the First Report, the 1,209 whose addresses were known were sent the Employment Experiences of New Doctoral Recipients (EENDR) survey in October 2006, and 660 (55%) responded. The response rates varied considerably among the various subgroups of new doctoral recipients defined by their employment status as reported by departments. Among those who were employed the highest response rate, 63%, was from those employed in the U.S. academic, while the lowest, 45%, was from those in non-U.S. academic.

The EENDR gathered details on employment experiences not available through departments. The remainder of this section presents additional information available on this subset of the 2005–2006 doctoral recipients.

Table 4A gives the numbers and percentages of EENDR respondents taking permanent and temporary positions in the U.S for fall 2002 through fall 2006.

This year we see that among the 563 employed in the U.S., 289 reported obtaining a permanent position and 274 a temporary position. While these numbers both reflect an increase, the percentage of individuals taking permanent positions in 2006 has decreased to 51% from 56% in 2005, and the percentage of those taking temporary positions has increased to 49% from 44% (the highest reported since 51% in 2004). Of the 274 in temporary positions, 98 (36%) reported taking temporary employment because a suitable permanent position was not available, and 209 (76%) classified their

Table 4A: Number (and Percentage) of Annual EENDR Respondents Employed in the U.S. by Job Status

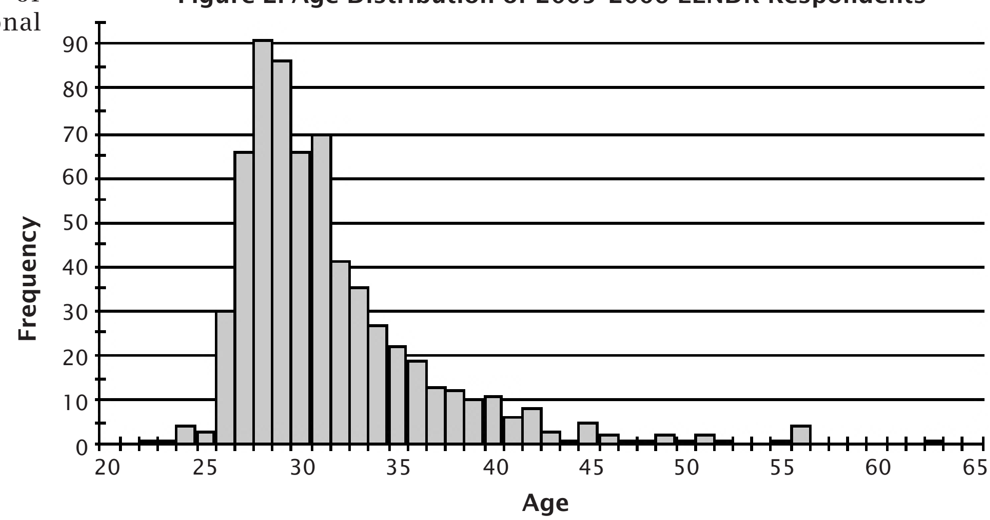
	Employed in U.S.					
	Permanent Total	Temporary Total	Temporary: Permanent not available	Temporary: Postdoctoral Total	Temporary: Postdoctoral Permanent not available	Unknown
Fall 2002	264(52%)	245(48%)	90(37%)	203(83%)	69(34%)	1
Fall 2003	253(54%)	216(46%)	87(40%)	164(76%)	53(32%)	--
Fall 2004	220(49%)	229(51%)	81(35%)	176(77%)	49(28%)	--
Fall 2005	291(56%)	232(44%)	92(40%)	172(74%)	55(32%)	--
Fall 2006	289(51%)	274(49%)	98(36%)	209(76%)	57(27%)	--

Table 4B: Percentage of Annual EENDR Respondents Employed in the U.S. by Employment Sector within Job Status

	Employed in U.S.					
	Permanent			Temporary		
	Academic[1]	Government	Business/ Industry	Academic	Government	Business/ Industry
Fall 2002	70%	6%	23%	93%	6%	1%
Fall 2003	76%	4%	20%	94%	3%	3%
Fall 2004	72%	5%	23%	97%	3%	--
Fall 2005	68%	5%	27%	96%	4%	--
Fall 2006	66%	4%	30%	93%	5%	2%

[1] Includes Research Institutes and other non-profits.

Figure 2: Age Distribution of 2005–2006 EENDR Respondents



position as postdoctoral. Of the 209 respondents taking positions they classified as postdoctoral, 57 (27%) reported that a suitable permanent position was not available.

Table 4B shows the employment trends of permanent and temporary positions broken down by sector for the last five years. Following last year's pattern the percentage of permanently employed EENDR respondents taking employment in academia and government has declined this year, and there was an offsetting increase in the proportion of permanently employed EENDR respondents taking positions in business and industry.

Among the 289 who reported obtaining a permanent position in the U.S. in fall 2006, 66% were employed in academia (including 1% in research institutes and other nonprofits), 4% in government, and 30% in business or industry. Women held 39% of the permanent positions.

Among the 274 individuals with temporary employment in the U.S. this year, 93% were employed in academia (including 9% in research institutes and other nonprofits), 5% in government, and 2% in business or industry.

Figure 2 gives the age distribution of the 647 new doctoral recipients who responded to this question. The median age of new doctoral recipients was 30 years, while the mean age was 32 years. The first and third quartiles were 28 and 33 years, respectively.

Previous Annual Survey Reports

The 2006 First Annual Survey Report was published in the *Notices* in the February 2007 issue. For the last full year of reports, the 2005 First, Second, and Third Annual Survey Reports were published in the *Notices* in the February, August, and December 2006 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`.

Starting Salary Survey of the 2005–2006 Doctoral Recipients

The starting salary figures for 2006 were compiled from information gathered on the EENDR questionnaires sent to individuals who received doctoral degrees in the mathematical sciences during the 2005-2006 academic year from universities in the United States (see previous section for more details).

The questionnaires were distributed to 1,209 recipients of degrees using addresses provided by the departments granting the degrees; 660 individuals responded between late October and April. Responses with insufficient data or from individuals who indicated they had part-time or non-U.S. employment were excluded. Numbers of usable responses for each salary category are reported in the following tables.

Readers should be warned that the data in this report are obtained from a self-selected sample, and inferences from them may not be representative of the population.

Key to Tables and Graphs. Salaries are those reported for the fall immediately following the survey cycle. Years listed denote the survey cycle in which the doctorate was received: for example: survey cycle July 1, 2005–June 30, 2006, is designated as 2006. Salaries reported as 9–10 months exclude stipends for summer grants or summer teaching or the equivalent. M and F are male and female respectively. Male and female figures are not provided when the number of salaries available for analysis in a particular category was five or fewer. All categories of "Teaching/Teaching and Research" and "Research Only" contain those recipients employed at academic institutions only.

Graphs. The graphs show standard boxplots summarizing salary distribution information for the years 1999 through 2006. Values plotted for 1999 through 2005 are converted to 2006 dollars using the implicit price deflator prepared annually by the Bureau of Economic Analysis, U.S. Department of Commerce. These categories are based on work activities reported in EENDR. Salaries of postdoctorates are shown separately. They are also included in other academic categories with matching work activities.

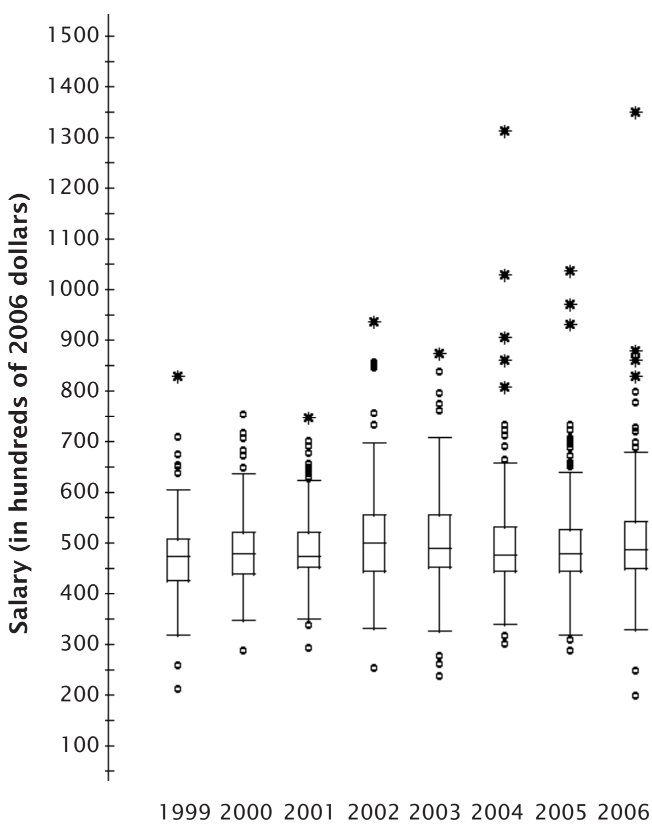
For each boxplot the box shows the first quartile (Q1), the median (M), and the third quartile (Q3). The interquartile range (IQR) is defined as Q3–Q1. Think of constructing invisible fences 1.5×IQR below Q1 and 1.5×IQR above Q3. Whiskers are drawn from Q3 to the largest observation that falls below the upper invisible fence and from Q1 to the smallest observation that falls above the lower invisible fence. Think of constructing two more invisible fences, each falling 1.5×IQR above or below the existing invisible fences. Any observation that falls between the fences on each end of the boxplots is called an outlier and is plotted as ∘ in the boxplots. Any observation that falls outside of both fences either above or below the box in the boxplot is called an extreme outlier and is marked as ∗ in the boxplot.

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

Academic Teaching/Teaching and Research 9–10-Month Starting Salaries* (in hundreds of dollars)

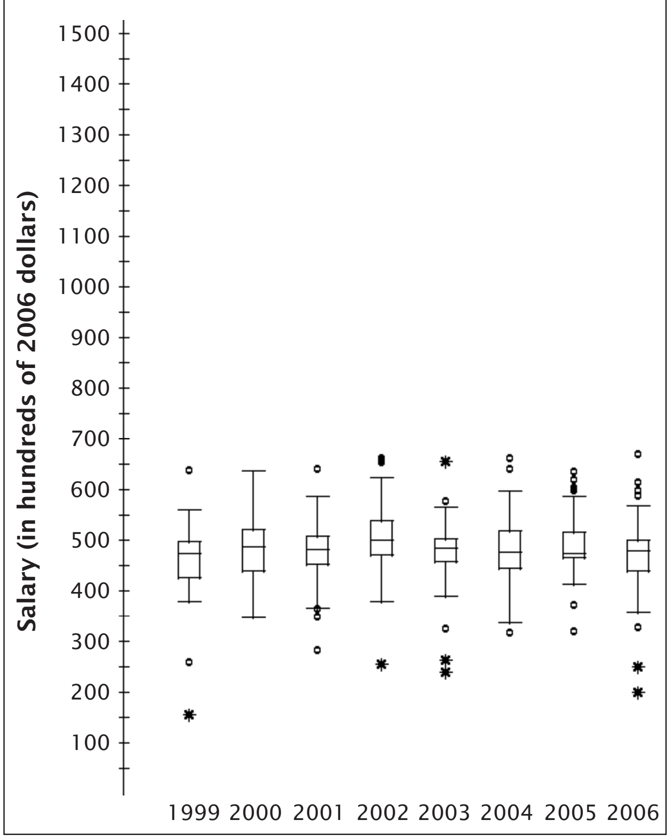
Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2006 $
1980	105	155	171	185	250	367
1985	170	230	250	270	380	416
1990	230	305	320	350	710	455
1995	220	320	350	382	640	441
1998*	140	340	370	410	700	445
1999	180	360	400	430	700	474
2000	250	380	415	450	650	482
2001	259	400	420	461	660	476
2002	230	400	450	500	840	501
2003	220	415	450	510	920	491
2004	285	420	450	500	1234	477
2005	280	430	465	506	1002	479
2006	200	450	490	550	1350	490
2002 M	230	420	450	500	840	
2002 F	300	400	441	498	610	
2003 M	220	420	450	509	855	
2003 F	359	414	444	512	920	
2004 M	285	420	450	490	850	
2004 F	300	421	450	500	1234	
2005 M	300	430	465	510	710	
2005 F	280	430	467	501	1002	
Total (193 male/78 female)						
2006 M	200	450	499	550	880	
2006 F	270	450	480	520	1350	
One year or less experience (167 male/64 female)						
2006 M	200	450	495	550	880	
2006 F	330	449	480	525	1350	



* Postdoctoral salaries are included from 1998 forward.

Academic Postdoctorates Only* 9–10-Month Starting Salaries (in hundreds of dollars)

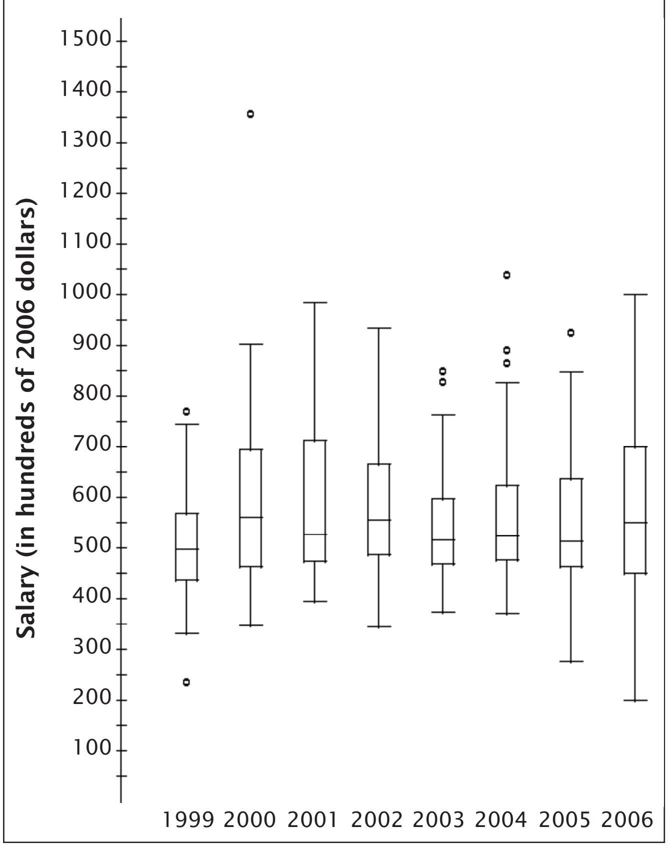
Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2006 $
1997	180	350	385	410	450	468
1998	290	350	390	420	500	469
1999	130	365	400	418	540	474
2000	300	385	420	450	550	487
2001	250	400	425	450	566	482
2002	230	425	450	487	595	501
2003	240	420	450	480	600	491
2004	300	420	450	490	625	477
2005	310	450	460	500	615	473
2006	200	441	480	500	670	480
2002 M	230	425	450	488	595	
2002 F	380	430	450	485	589	
2003 M	240	420	450	485	600	
2003 F	359	408	449	459	510	
2004 M	300	420	450	480	625	
2004 F	400	440	470	500	606	
2005 M	310	450	470	500	615	
2005 F	400	437	450	471	500	
Total (71 male/22 female)						
2006 M	200	450	483	523	670	
2006 F	330	413	464	500	590	
One year or less experience (67 male/20 female)						
2006 M	200	448	472	520	670	
2006 F	330	418	479	500	590	



* A postdoctoral appointment is a temporary position primarily intended to provide an opportunity to extend graduate training or to further research experience.

Academic Teaching/Teaching and Research
11–12-Month Starting Salaries*
(in hundreds of dollars)

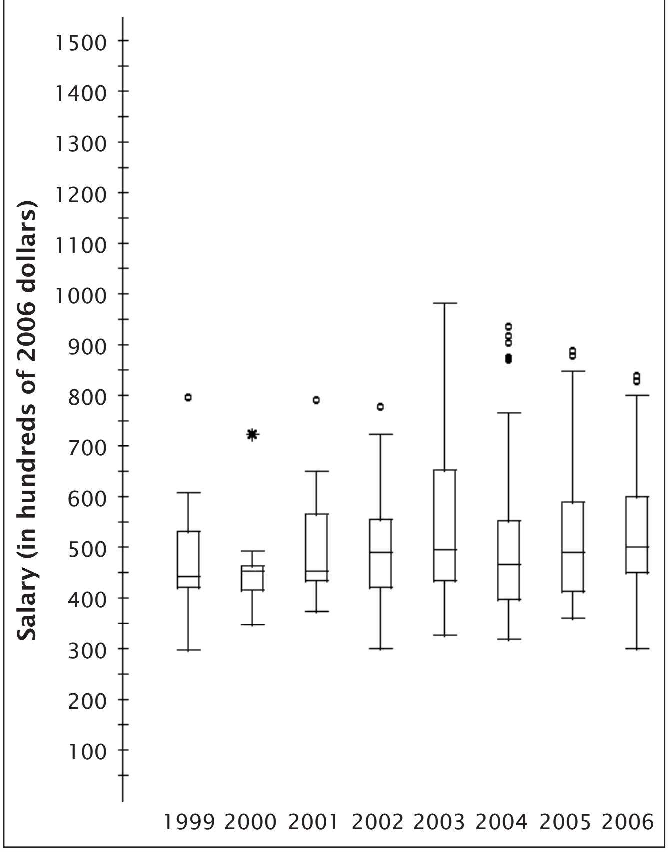
Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2006 $
1985	220	230	273	300	470	454
1990	225	318	365	404	670	519
1995	300	354	410	478	600	517
1998*	275	405	480	575	700	577
1999	200	374	420	469	650	498
2000	300	400	485	600	1170	563
2001	350	420	465	615	870	527
2002	310	439	500	597	840	557
2003	345	438	475	550	780	518
2004	350	450	495	583	980	525
2005	270	450	500	615	900	515
2006	200	450	550	700	1000	550
2002 M	310	420	485	595	840	
2002 F	400	453	500	558	700	
2003 M	397	440	490	555	780	
2003 F	345	400	440	513	620	
2004 M	350	448	487	533	980	
2004 F	380	465	545	605	650	
2005 M	270	455	490	549	900	
2005 F	420	450	570	753	824	
Total (44 male/13 female)						
2006 M	300	450	535	685	900	
2006 F	200	520	600	850	1000	
One year or less experience (39 male/12 female)						
2006 M	300	450	530	655	900	
2006 F	400	535	650	850	1000	



* Postdoctoral salaries are included from 1998 forward.

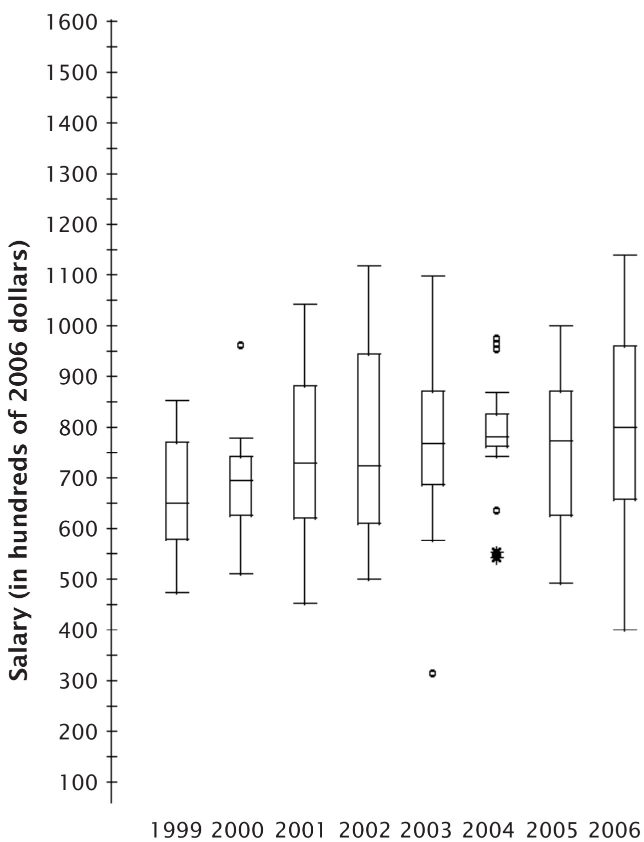
Academic Research Only
11–12-Month Starting Salaries
(in hundreds of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2006 $
1997	190	300	350	400	600	426
1998	200	333	360	428	617	433
1999	270	380	400	480	720	474
2000	300	365	400	529	1000	464
2001	300	350	400	575	796	453
2002	270	380	440	500	700	490
2003	300	405	455	600	900	496
2004	300	378	440	510	880	467
2005	350	400	475	570	860	489
2006	300	450	500	600	840	500
2002 M	270	384	440	495	650	
2002 F	310	350	440	505	700	
2003 M	300	410	440	505	820	
2003 F	310	390	480	650	900	
2004 M	300	380	440	560	880	
2004 F	350	378	430	493	820	
2005 M	350	420	480	580	860	
2005 F	350	400	475	529	850	
Total (30 male/15 female)						
2006 M	350	450	500	600	830	
2006 F	300	455	540	680	840	
One year or less experience (24 male/13 female)						
2006 M	360	465	500	575	830	
2006 F	300	445	510	600	840	



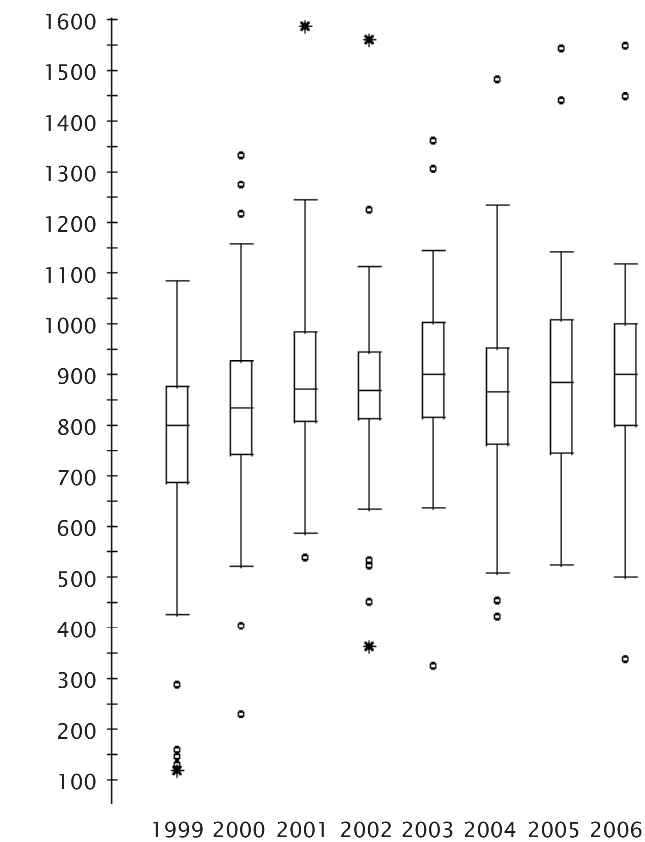
Government
11–12-Month Starting Salaries
(in hundreds of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2006 $
1985	263	294	325	381	440	541
1990	320	345	378	430	587	538
1995	370	440	494	507	650	622
1998	320	475	540	736	1250	650
1999	400	495	550	651	720	652
2000	440	540	600	640	830	696
2001	400	580	644	758	920	730
2002	450	551	650	775	1005	724
2003	290	668	705	763	1008	769
2004	510	720	738	780	920	783
2005	480	610	752	848	972	774
2006	400	678	800	961	1140	800
2002 M	450	551	642	725	1005	
2002 F	540	600	700	850	880	
2003 M	290	648	710	788	830	
2003 F	600	683	695	723	1008	
2004 M	520	700	730	740	910	
2004 F	510	733	749	790	920	
2005 M	500	668	790	902	955	
2005 F	480	540	750	770	972	
Total (18 male/8 female)						
2006 M	500	660	800	960	1000	
2006 F	400	775	790	1043	1140	
One year or less experience (16 male/8 female)						
2006 M	500	638	790	960	1000	
2006 F	400	775	790	1043	1140	



Business and Industry
11–12-Month Starting Salaries
(in hundreds of dollars)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 2006 $
1985	260	360	400	420	493	666
1990	320	438	495	533	700	704
1995	288	480	568	690	1250	716
1998	240	550	650	750	2250	782
1999	360	600	680	761	2450	806
2000	200	640	720	800	1500	835
2001	475	716	770	865	1850	873
2002	325	734	780	850	1400	869
2003	300	700	800	900	1250	872
2004	400	728	817	900	1800	866
2005	510	755	870	978	2000	895
2006	340	800	900	1000	1550	900
2002 M	325	378	782	858	1100	
2002 F	600	713	768	838	1400	
2003 M	550	725	840	920	1250	
2003 F	300	628	780	816	900	
2004 M	400	710	813	900	1800	
2004 F	480	789	850	900	1100	
2005 M	510	760	930	1005	2000	
2005 F	600	745	860	890	1100	
Total (52 male/33 female)						
2006 M	340	750	890	1000	1450	
2006 F	500	850	900	960	1550	
One year or less experience (43 male/26 female)						
2006 M	340	775	880	1000	1450	
2006 F	500	828	900	948	1550	



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 comprise 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 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 doctoral-granting departments with scores in the 3.00–5.00 range. Group I Public and Group I Private are Group I doctoral-granting departments at public institutions and private institutions respectively.

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

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

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

Group V contains U.S. doctoral-granting departments (or programs) of applied mathematics/applied science, operations research, and management science .

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

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

Group B or Bachelor's contains U.S. departments granting a baccalaureate degree only.

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

[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, *pages 257–67, and an analysis of the classifications was given in the June 1983* Notices, *pages 392–3.*

information needs of the professional organizations. Every year, college and university departments in the United States are invited to respond. The Annual Survey relies heavily on the conscientious efforts of the dedicated staff members of these departments for the quality of its information. On behalf of the Data Committee and the Annual Survey Staff, we thank the many secretarial and administrative staff members in the mathematical sciences departments for their cooperation and assistance in responding to the survey questionnaires.

Other Data Sources

American Association of University Professors, *Inequities Persist for Women and Non-Tenure-Track Faculty: The Annual Report on the Economic Status of the Profession 2004–2005*, Academe: Bull. AAUP (March/April 2005), Washington, DC.

American Statistical Association, *2006–2007 Salary Report of Academic Statisticians.* [`http://www.amstat.org/profession/salaryreport_acad2006-7.pdf`] (Published in *AMSTATNEWS*, December 2006, Issue #354.)

_____, *Salary Survey Results: Biostatistics and Other Biomedical Statistics Departments and Units*, AmStat News (February 2002207, Issue #356), Alexandria, VA.

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

_____, *Salaries of Scientists, Engineers, and Technicians: A Summary of Salary Surveys*, 21st ed., CPST (November 2005), Washington, DC.

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, 2002.

_____, *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 1995 CBMS Survey*, MAA Reports No. 2, 1997.

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

National Research Council, *Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States*, National Academy Press, Washington, DC, 2005.

_____, *Strengthening the Linkages between the Sciences and the Mathematical Sciences*, National Academy Press, Washington, DC, 2000.

_____, *U.S. Research Institutes in the Mathematical Sciences: Assessment and Perspectives*, National Academy Press, Washington, DC, 1999.

_____, *Research-Doctorate Programs in the United States: Continuity and Change*, National Academy Press, Washington, DC, 1995.

National Science Board, *Science and Engineering Indicators—2006.* Two Volumes (Volume 1, NSB 06–01; Volume 2, NSB 06–1A), National Science Foundation, Arlington, VA, 2006.

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

_____, *Graduate Students and Postdoctorates in Science and Engineering: Fall 2004* (NSF 06–235), Arlington, VA, 2006.

_____, *Science and Engineering Degrees: 1966–2001* (NSF 04–311), Detailed Statistical Tables, Arlington, VA, 2004.

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

_____, *Science and Engineering Doctorate Awards: 2004* (NSF 06–308), Detailed Statistical Tables, Arlington, VA, 2006.

_____, *Women, Minorities, and Persons with Disabilities in Science and Engineering Data Update* (March 2006). [http://www.nsf.gov/statistics/wmpd/pdf/march2006updates.pdf]

Doctoral Degrees Conferred 2005–2006

Supplementary List

The following list supplements the list of thesis titles published in the February 2007 *Notices*, pages 277–97.

CALIFORNIA

University of California, Davis (4)

STATISTICS

Kerr, Joshua, Signal extraction for seismic array data via partially linear least-squares.

Wu, Ping-Shi, Time-dynamic density estimation and functional discrimination for high-dimensional data.

Zhang, Ying, Time-varying functional regression models for time-to-event.

University of California, Irvine (4)

MATHEMATICS

Akhmedov, Anar, Smooth Structures on 4-manifolds with small Euler characteristics.

Beyaz, Ahmet, A new construction of spin smooth 6-manifolds.

Haessig, Douglas, On the symmetric power of the P-adic D-airy family.

Zhao, Rui, Computational studies of morphogen gradients.

University of California, Riverside (2)

STATISTICS

Kwon, Soonil, Spatial discrete choice models for multinomial respones.

Zainal, Mohammad, Skew-normal distribution with a cauchy skewing function.

IOWA

Iowa State University (4)

MATHEMATICS

Alm, Jeremy, Weak representation theory in the calculus of relations.

Kim, Joohyung, Classification of small class association schemes coming from certain combinatorial objects.

Meyer, Kristen, A new message authentication code based on the non-associativity of quasigroups.

Rajaram, Rajeev, Exact boundary controllability results for sandwich beam systems.

KENTUCKY

University of Kentucky (4)

STATISTICS

Bush, Heather, Khatri-Rao products and conditions for the uniqueness of PARAFAC solutions for 1xJxK arrays.

Chen, Min, Some contributions to the empirical likelihood method.

Tarima, Sergey, Consistency and generalization error bound of feed-forward neutral network trained with smoothing regularizer.

Liu, Chengan, Some sequential and two-stage procedures for selecting the best of treatments in clincial trials.

MARYLAND

University of Maryland, Baltimore County (6)

MATHEMATICS AND STATISTICS

Bebu, Ionut, Some statistical and probabilistic problems in Markov chains.

Gavrea, Bogdan, Simulation of rigid body system with joints, contact and friction.

Li, Cao, The assessment of multivariate bioequivalence.

Liu, Guohui, Sequential designs for logistic phase-I clinical trials.

Wu, Yanping, Topics in univariate bioequivalence testing.

Zhang, Lanju, Response-adaptive randomization in clinical trials with continuous and survival time outcomes.

MASSACHUSETTS

Tufts University (1)

MATHEMATICS

Finn, Lucas, A variational approach to vortex core identification.

MICHIGAN

Western Michigan University (2)

STATISTICS

Ratanaruamkarn, Sauwanit, New estimates of a circular median.

Scherzer, Rebecca, Testing procedures for group sequential clinical trials with multiple survial endpoints.

NEW JERSEY

Princeton University (8)

Program in Applied Computational Mathematics

Anthoine, Sandrine, Different wavelet-based approaches for the separation of noisy and blurred mixtures of components. Application to Astrophyical data.

Frierson, Dargan, Studies of the moist general circulation with a simplified moist GCM.

Gerber, Edwin, A dynamical and statistical understanding of the North Atlantic oscillation and annual modes.

Golden, Cliona, Spatio-temporal methods in the analysis of fMRI data in neuroscience.

Leslie, Nandi, Spatial stochastic models for landscape degrading and deforestation in Bolivia and Brazil.

Rustamov, Raif, On Heegard Floer homology of three-manifolds.

Sharp, Richard, Computational methods inspired by chemistry: multiscale modeling and mechanics of control.

Zou, Jing, Sublinear algorithms for the Fourier transform of signals with very few Fourier modes: theory, implementations, and applications.

NEW York

Cornell University (2)

Biometrics Unit

Denogean, Lisa Renee, Improved approximations of the density functions of estimators in population genetics.

Long, Yu, Bayesian Analysis of Levy processes with financial applications.

OHIO

Case Western Reserve University (6)

Epidemiology and Biostatistics

Campbell, Robert, Burden of disease amongst Carolina lupis patients: economic, humanistic, and clinical factors.

Davidson, Carrie, Efficiency, quality and costs in Ohio nursing homes.

Diggs, Jessica, The impact of medicaid outreach initiatives on the health and healthcare access of children in Ohio.

Mascha, Edward, Assessing individual treatment effect heterogeneity for binary outcomes.

Schumacher, Fredrick Ray, Relation between selenoprotein gene, selenium, and prostate cancer.

Wang, Tao, Extensions of Haseman-Elstron regression for linkage analysis.

SOUTH CAROLINA

University of South Carolina (3)

Statistics

Han, Jun, Parametric latent class joint model for longitudinal markers and recurrent events.

Parody, Robert, Simultaneous inference on the improvement in response surfaces.

Vera, Francisco, General convex stochastic orderings and related martingale-type structures.

VIRGINA

Virgina Tech (8)

Statistics

Chen, Younan, Bayesian hierarchical modeling on dual response surfaces.

Duan, Yuyan, A modified Bayesian power prior approach with applications in water quality evaluation.

Eisenbies, Penelop, Bayesian hierarchical methods and use of ecological thresholds and changepoints for habitat selection models.

Jensen, Willis, Profile monitoring for mixed model data.

Modarres-Mousavi, Shabnam, Monitoring Markov dependent binary observations with a log-likelihood ratio base CUSUM control chart.

Sego, Landon, Applications of control charts in medicine and epidemiology.

Yan, Mingjin, Methods of determining the number of clusters in a data set and a new clustering criterion.

Zhong, Xin, Efficient sampling plans for control charts when monitoring an autocorelated process.

WISCONSIN

University of Wisconsin, Madison (9)

Statistics

Monuz, Alendro, On approximate p-values for time series outlier detection.

Peng, Limin, Contributions to semi-completing risks data.

Song, Qinghua, Contributions to regression and classification tree methods.

Wang, Lin, Imputation methods for non-monotone non-ignorable missing data in logitudinal studies.

Xie, Xianhong, Smoothing in magnetic resource image analysis and a hybrid loss for support vector machine.

Yang, Hyuna, Model-based clustering of genomic observiations: generalizing the instability selection network model.

Yan, Ping, Bayesian cluster modeling for space-time disease counts.

Yue, Wei, Multi-resolution tree-structured spatial models.

Lu, Yuefeng, Contributions to functional data analysis with biological applications.

University of Wisconsin, Milwaukee (3)

Mathematical Sciences

Liu, Zhiyuan, Vortices in deformation background flow-A sensitivity source of the atmosphere.

Panayotova, Iordanka, Meridional asymmetrices in large-scale atmospheric dynamical phenomena.

Zhang, Weiqun, Numerical solutions for linear and nonlinear singular perturbation problems.

Mathematics People

Abouzaid, Galatius, and Maulik Named Clay Research Fellows

The Clay Mathematics Institute (CMI) has announced the appointment of three Research Fellows: Mohammed Abouzaid of the Massachusetts Institute of Technology, Soren Galatius of Stanford University, and Davesh Maulik of Princeton University. They were selected for their research achievements and their potential to make significant future contributions to the field.

Mohammed Abouzaid, born in 1981, received his Ph.D. in 2007 from the University of Chicago under the direction of Paul Seidel. In his thesis Abouzaid used techniques from tropical geometry to give a new approach to the homological mirror symmetry conjecture for toric varieties. He is interested in symplectic topology and its interactions with algebraic geometry and differential topology.

Soren Galatius, born in 1976, is a native of Denmark and received his Ph.D. from the University of Aarhus in 2004 under the direction of Ib Madsen. The focus of his research is in algebraic topology, especially the interplay between stable homotopy theory and geometry. A recent result involves automorphism groups of free groups; he proved that the stable rational homology is trivial.

Davesh Maulik is completing his Ph.D. at Princeton University under the direction of Rahul Pandharipande. His mathematical interests are algebraic geometry and its connections with symplectic geometry, mathematical physics, and combinatorics. His current research focus is in the area of Gromov-Witten theory and enumerative geometry.

Current Clay Research Fellows include Artur Avila, Daniel Biss, Maria Chudnovsky, Ben Green, Sergei Gukov, Bo'az Klartag, Ciprian Manolescu, Maryam Mirzakhani, Sophie Morel, Sam Payne, David Speyer, András Vasy, and Akshay Venkatesh.

—From a CMI announcement

American Academy Elections

Nine mathematical scientists have been elected to membership in the American Academy of Arts and Sciences for 2007. They are: F. Michael Christ, University of California, Berkeley; Robert L. Griess Jr., University of Michigan; Ehud Hrushovski, Hebrew University of Jerusalem; Victor Kac, Massachusetts Institute of Technology; Jon Kleinberg, Cornell University; Peter Wai-wong Li, University of California, Irvine; Tomasz Mrowka, Massachusetts Institute of Technology; Michael E. Taylor, University of North Carolina at Chapel Hill; and Robert J. Zimmer, University of Chicago.

The American Academy of Arts and Sciences was founded in 1780 to foster the development of knowledge as a means of promoting the public interest and social progress. The membership of the academy is elected and represents distinction and achievement in a range of intellectual disciplines: mathematical and physical sciences, biological sciences, social arts and sciences, and humanities and fine arts.

—From an AAAS announcement

National Academy of Sciences Elections

The National Academy of Sciences (NAS) has announced the election of seventy-two new members and eighteen foreign associates. The following mathematical scientists are among the newly elected members: Robert L. Bryant, Duke University; Richard Durrett, Cornell University; David Gottlieb, Brown University; Curtis T. McMullen, Harvard University; and Harold M. Stark, University of California, San Diego. Elected as foreign associates were Pierre Deligne, Institute for Advanced Study in Princeton, and John Kingman, Isaac Newton Institute for Mathematical Sciences, University of Cambridge.

—From an NAS announcement

Moody Mega Math Challenge Winners Announced

The winners of the 2007 Mega Math Challenge for high school students have been announced. A team from Manalapan High School, Manalapan, New Jersey, was awarded the Summa Cum Laude Team Prize of US$20,000 in scholarship money. The members of the team were Jason Kornblum, Dennis Kim, Caleb Tseng, Franklin Tong, and Naiim Ali. The coach of the team was Jessy Friedman, and the title of the team's project was "Pick Six Stocks". The Magna Cum Laude Team Prize of US$15,000 also went to a team from Manalapan High School. The members were Andy Liu, Dorothea Tsang, David Tretheway, Jonathan Newman, and Jesse Beyroutey. Their project was titled "Minimizing Risk…Maximizing Portfolio Profit". Their coach was Stephanie Pepper.

The Cum Laude Team Prize of US$10,000 in scholarship money was awarded to a team from Walt Whitman High School, Huntington Station, New York. The team members were John Lacara, Matthew Giambrone, Peter Werner, Julia Haigney, and Jessica Bloom. They were coached by Louis Crisci. Their team project was titled "Cracking the Code: A Mathematical Solution to the Stock Market".

A team from High Technology High School in Lincroft, New Jersey, won the Meritorious Team Prize of US$7,500 for their project "Portfolio Management: Maximizing Investment Return". The team members were Elizabeth Wendel, Raja Srinivas, and Yelizaveta Yermakova. Their coach was Ellen LeBlanc.

The Exemplary Team Prize of US$5,000 was awarded to a team from Great Neck North High School, Great Neck, New York, for their project "Constructing a Portfolio: Novel Mathematical Models for Profit Optimization". The team members were Ben Leibowicz, Sam Panzer, Barry Dynkin, David Rosengarten, and Scott Huang. Their coach was Linda Litvak.

The Mega Math Challenge invites teams of high school juniors and seniors to solve an open-ended, realistic, challenging modeling problem focused on real-world issues. The top five teams receive awards ranging from US$5,000 to US$20,000 in scholarship money. The competition is sponsored by the Moody's Foundation, a charitable foundation established by Moody's Corporation, and organized by the Society for Industrial and Applied Mathematics.

—Elaine Kehoe

USA Mathematical Olympiad

The thirty-sixth annual USA Mathematical Olympiad (USAMO) was held April 24 and 25, 2007. The students who participated in the Olympiad were selected on the basis of their performances on the American High School and American Invitational Mathematics Examinations. The twelve highest scorers in the USAMO, listed in alphabetical order, were: Sergei Bernstein, Belmont, Massachusetts; Sherry Gong, Exeter, New Hampshire; Adam Hesterberg, Seattle, Washington; Eric Larson, Eugene, Oregon; Brian Lawrence, Silver Spring, Maryland; Tedrick Leung, North Hollywood, California; Haitao Mao, Alexandria, Virginia; Delong Meng, Baton Rouge, Louisiana; Krishanu Sankar, Riverdale, New York; Jacob Steinhardt, Alexandria, Virginia; Arnav Tripathy, Chapel Hill, North Carolina; and Alex Zhai, Urbana, Illinois.

The twelve USAMO winners will attend the Mathematical Olympiad Summer Program (MOSP) from June 10 through June 30. Then six of the twelve students will be selected as the United States team to compete in the International Mathematical Olympiad (IMO) to be held in Hanoi, Vietnam, July 19 through 31, 2007.

—From an American Mathematics Competition announcement

Mathematics Opportunities

NSF Focused Research Groups

The Focused Research Groups (FRG) activity of the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) supports small groups of researchers in the mathematical sciences.

The DMS has announced deadline dates for the fiscal year 2007 competition for FRG grants. The deadline for receipt of the required letters of intent to submit FRG proposals is **August 17, 2007**. The deadline date for full proposals is **September 21, 2007**. The FRG solicitation may be found on the Web at `http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5671&org=DMS`.

—From an NSF announcement

NSF Mathematical Sciences Postdoctoral Research Fellowships

The Mathematical Sciences Postdoctoral Research Fellowship program of the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) awards fellowships each year for research in pure mathematics, applied mathematics and operations research, and statistics. The deadline for this year's applications is **October 17, 2007**. Applications must be submitted via FastLane on the World Wide Web. For more information see the website `http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5301&org=DMS`.

—From an NSF announcement

Travel Grants for ICME-11 in Monterrey, Mexico

Applications for travel grants are now available to attend the Eleventh International Congress on Mathematical Education (ICME-11), which will be held in Monterrey, Mexico, from July 6 to 13, 2008 (see `http://www.icme-11.dk/`). Contingent on the funding of a proposal pending at the National Science Foundation (NSF), grants will be available and awarded by the close of 2007. These grants will be available only to U.S. citizens and will support travel expenses to ICME-11 that include hotel accommodations, meal costs, and conference registration. They also can be used toward air transportation (on American carriers only). Travel grant awardees under this program may not use funds from other NSF programs to supplement their international travel (airfare to Mexico or subsistence at ICME-11).

The International Congresses are held every four years and offer a unique opportunity for mathematics educators from the United States to discuss issues related to mathematics education with international leaders from developed and developing countries. Grants will enable participants to listen to world-renowned scholars in mathematics and mathematics education and to take part in small, focused discussion groups on a wide range of topics, including a special emphasis on educating students from diverse cultures, mathematics education for second-language learners, the relationship between research and practice in mathematics education, the professional development of mathematics teachers, closing the achievement gap, and information and communication technology in mathematics education.

The National Science Foundation grants are available only to U.S. citizens and will support travel expenses to ICME-11 for K–12 mathematics teachers, mathematicians, graduate students, and mathematics teacher educators from the United States.

A selection committee will review applications and award the grants for ICME-11 travel. The committee will include representatives from the National Council of Teachers of Mathematics (NCTM), the Mathematical Association of America, the American Mathematical Association of Two-Year Colleges, the American Mathematical Society, and the U. S. National Commission on Mathematics Instruction.

Elementary, middle, and high school teachers and graduate students are strongly encouraged to apply. Questions can be directed to Gail Burrill, `burrill@msu.edu`. The travel grant application and selection criteria are available on the NCTM website at `http://www.nctm.org/icme.aspx` or from Margaret Iding, 116 North Kedzie, Division of Science and Mathematics Education, Michigan State University, East Lansing, MI 48824; telephone 517-355-1708, ext. 105; fax 517-432-9868; email: `idingm@msu.edu`. The application deadline is **September 30, 2007**. Notifications will be made by December 30, 2007.

—From an ICME-11 announcement

Wolfram Turing Machine Research Prize Established

Wolfram Research and Stephen Wolfram have announced the establishment of a US$25,000 prize for the first person or group to prove (or disprove) that a particular very simple Turing machine can act as a universal computer.

The prize is being announced on the fifth anniversary of the publication of Stephen Wolfram's influential book *A New Kind of Science* and is intended to help stimulate one of the lines of research opened up by the book.

Today's computers have CPUs with millions of components. But it is known in theory that much simpler systems are also capable of "universal computation", which means that with appropriate programming they can perform arbitrary computational tasks. The aim of the Wolfram 2,3 Turing Machine Research Prize is to determine the edge of where universal computation is possible.

The prize is open to all entrants, both amateur and professional. It has no closing date. The prize is being adjudicated by a distinguished committee consisting of Lenore Blum, Greg Chaitin, Martin Davis, Ron Graham, Yuri Matiyasevich, Marvin Minsky, Dana Scott, and Stephen Wolfram. Details of the prize are available at `http://www.wolframprize.org`.

—From a Wolfram Research news release

NSA Mathematical Sciences Program—Grants and Sabbaticals

As the nation's largest employer of mathematicians, the National Security Agency (NSA) is a strong supporter of the academic mathematics community in the United States. Through the Mathematical Sciences Program, the NSA provides research funding and sabbatical opportunities for eligible faculty members in the mathematical sciences.

Grants: The Mathematical Sciences Program (MSP) makes awards annually in support of self-directed, unclassified research in the following areas of mathematics: Algebra, Number Theory, Discrete Mathematics, Probability, and Statistics. Proposals for modest support of conferences and workshops in these five areas are also considered. The program does not entertain proposals that involve cryptology. Research grant support typically includes summer salary for faculty members, a modest amount for graduate student support, travel assistance, and other expenses typically associated with research in the mathematical sciences. Research and conference proposals that encourage the participation of women and other underrepresented groups in the mathematical sciences are particularly welcomed. Principal investigators, travelers, and all personnel supported by NSA grants must be U.S. citizens or permanent residents of the United States. Proposal submissions must be postmarked by **October 15** each year. Grants begin in the fall of the following year. Potential investigators are welcome to contact the MSP director prior to the submission date to discuss their proposal ideas: call 301-688-0400 or send email to `mdwagn4@nsa.gov`. For more detailed information on types of awards and proposal guidelines, see `http://www.nsa.gov/msp/msp00002.cfm`.

Sabbaticals: The NSA Mathematics Sabbatical Program provides support for mathematical scientists to work at the NSA for periods ranging from nine to twenty-four months. The NSA pays 50% of salary and benefits during academic months and 100% of salary and benefits during summer months of the sabbatical detail. A choice is offered between an allowance for moving expenses and a housing supplement. Applicants and their immediate family members (including parents and siblings) must be U.S. citizens. Target date for receipt of applications is **November 15** each year (to ensure ample time to complete the security clearance process). To apply, send a cover letter and curriculum vitae with list of publications. The cover letter should contain a description of research interests, description of programming experience and level of fluency, how the applicant hopes to contribute to NSA's mission, and how an NSA sabbatical would affect teaching and research upon returning to academia. On average, three sabbatical positions are available per year.

For additional information on these programs, see the Mathematical Sciences Program website (`http://www.nsa.gov/msp/index.cfm`), or contact the program staff: MSP Director, Michelle D. Wagner (`mdwagn4@nsa.gov`), MSP Program Administrator, Rosalie (Jackie) Smith (`rjsmit2@nsa.gov`). To obtain brochures or for questions, please call 301-688-0400 or write to: Mathematical Sciences Program, National Security Agency, Suite 6557, Fort Meade, MD 20755-6557.

—Mathematical Sciences Program announcement

For Your Information

News from MSRI

MSRI Receives Major Gift

James H. Simons, mathematician, philanthropist, and one of the world's most successful hedge fund managers, announced in May 2007 a US$10 million gift from the Simons Foundation to the Mathematical Sciences Research Institute (MSRI), the largest single cash pledge in the institute's twenty-five-year history. The new funding is also the largest gift of endowment made to a U.S.-based institute dedicated to mathematics.

The monies will create a US$5 million endowed chair, the "Eisenbud Professorship", named for David Eisenbud, director of MSRI, to support distinguished visiting professors at MSRI. The gift comes as Eisenbud nears the end of his term as MSRI director (from July 1997 to July 2007) and as MSRI prepares to celebrate its twenty-fifth anniversary in the late fall/winter 2007–08. "I'm particularly honored and gratified that Jim Simons has chosen to place a professorship in my name as part of his phenomenal generosity toward mathematics and MSRI," commented Eisenbud. An additional US$5 million will start a new campaign for an MSRI endowment by matching funds (1:1) raised for the institute's permanent endowment. "The institutions that do well over the long term, through good times and bad, are the ones that have substantial endowments. MSRI is of enormous importance to the mathematics community, so it gives me the greatest pleasure to see this first major step toward an endowment," stated Eisenbud.

MSRI's chair of the Board of Trustees, Charles Fefferman of Princeton University, remarked, "This wonderful gesture reflects Jim Simons's deep passion for mathematics. We hope this extraordinary gift will help bring forth at MSRI future breakthroughs of the stature of the Chern-Simons invariants. We are all deeply grateful."

Currently a trustee of MSRI, Simons has been a member of the institute's board since 1999 and is the founder of the New York City-based Math for America, a nonprofit organization with a mission to significantly improve math education in the nation's public schools. Together with his wife, Marilyn, Simons manages the Simons Foundation, a charitable organization devoted to scientific research. The Simonses live in Manhattan.

Simons is president of Renaissance Technologies Corporation, a private investment firm dedicated to the use of mathematical methods. Renaissance presently has over US$30 billion under management. Previously he was chairman of the mathematics department at the State University of New York at Stony Brook. Earlier in his career he was a cryptanalyst at the Institute of Defense Analyses in Princeton and taught mathematics at the Massachusetts Institute of Technology and Harvard University.

Simons holds a B.S. in mathematics from MIT and a Ph.D. in mathematics from the University of California, Berkeley. His scientific research was in the area of geometry and topology. He received the AMS Veblen Prize in Geometry in 1975 for work that involved a recasting of the subject of area-minimizing multidimensional surfaces. A consequence was the settling of two classical questions, the Bernstein Conjecture and the Plateau Problem. Simons's most influential research involved the discovery and application of certain measurements, now called the Chern-Simons invariants, that have wide use, particularly in theoretical physics. The Chern-Simons invariants were a product of his collaboration with Shiing-Shen Chern, MSRI's cofounder and first director.

New MSRI Director Named

In May 2007, MSRI announced the appointment of Robert L. Bryant as director. Bryant's five-year term at MSRI is effective August 1, 2007. He currently holds the Juanita M. Kreps Chair in Mathematics at Duke University. He succeeds David Eisenbud, who has served as MSRI director since 1997 and is also a tenured professor on the faculty at UC Berkeley. In August 2007 Eisenbud will leave MSRI to become a full-time member of the UC Berkeley Department of Mathematics.

—From MSRI news releases

Inside the AMS

AMS Congressional Fellow Chosen

The American Mathematical Society (AMS) is pleased to announce that Jeffry Phan has been chosen as the AMS Congressional Fellow for 2007–08.

The AMS will sponsor Jeffry's fellowship through the Congressional Fellowship program administered by the American Association for the Advancement of Science (AAAS). The fellowship is designed to provide a unique public policy learning experience, to demonstrate the value of science-government interaction, and to bring a technical background and external perspective to the decision-making process in Congress.

Fellows spend a year working on the staff of a member of Congress or a congressional committee, working as a special legislative assistant in legislative and policy areas requiring scientific and technical input. The fellowship program includes an orientation on congressional and executive branch operations, and a year-long seminar series on issues involving science, technology, and public policy.

Jeffry Phan was chosen from a field of outstanding candidates. He earned his Ph.D. in mathematics from Columbia University after completing his thesis on order properties of monomial ideals and their free resolutions. He was a teaching fellow with Columbia University's Science and Math Partnership and most recently worked as an assistant professor of mathematics at the University of Wisconsin–Whitewater.

—AMS Washington Office

Fan China Exchange Program Names Awardees

The Society's Fan China Exchange Program awards grants to support collaborations between Chinese and U.S. or Canadian researchers. Institutions in the United States or Canada apply for the funds to support a visitor from China or vice versa. This funding is made possible through a generous gift made to the AMS by Ky and Yu-Fen Fan in 1999. The awardees for 2007 follow.

Rutgers University was awarded a US$5,000 grant to support the visits of Zhi Lu of Fudan University and Hao Zheng of Zhongshan University; the University of Illinois, Chicago, received a grant of US$4,500 to support a visit from Yong Zhou of East China Normal University; and Harvard University received a grant of US$4,500 to support a visit from Jixiang Fu of Fudan University.

For information about the Fan China Exchange Program, visit the website `http://www.ams.org/outreach/chinaexchange.html`, or contact the AMS Membership and Programs Department, email: `prof-serv@ams.org`, telephone 401-455-4058 (within the U.S. call 800-321-4267, ext. 4058).

—Elaine Kehoe

AMS Names 2007 Mass Media Fellow

The AMS is pleased to announce that Adriana Salerno has been awarded its 2007 Mass Media Fellowship. Adriana is a Ph.D. student in mathematics at the University of Texas at Austin. She will be working at Voice of America for ten weeks over the summer under the sponsorship of the AMS.

The Mass Media Fellowship program is organized by the American Association for the Advancement of Science (AAAS) and is intended to strengthen the connections between science and the media, to improve public understanding of science, and to sharpen the ability of the fellows to communicate complex scientific issues to nonspecialists. The program is available to college or university students (in their senior year or in any graduate or postgraduate level) in the natural, physical, health, engineering, computer, social sciences, or mathematics who have outstanding written and oral communication skills and a strong interest in learning about the media. It is a highly competitive program, and the AMS wishes to congratulate Adriana Salerno on her accomplishment.

For a list of past AMS Media Fellows, see the website `http://www.ams.org/government/massmediafellowaward.html`.

—Anita L. Benjamin, AMS Washington Office

Math in Moscow Scholarships Awarded

The AMS has made awards to three mathematics students to attend the Math in Moscow program in the fall of 2007. The following are the undergraduate students and their institutions: Nate Bottman, University of Washington; Miranda Intrator, University of California, Santa Cruz; and Joan Pharr, Wake Forest University. Each student has been awarded a US$7,500 scholarship.

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

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

—Elaine Kehoe

Deaths of AMS Members

Deborah Tepper Haimo, retired, from the University of California, La Jolla, died on May 18, 2007. Born on July 1, 1921, she was a member of the AMS for 60 years.

Joseph P. Heisler, retired, from Notre Dame, IN, died on May 27, 2007. Born on August 9, 1934, he was a member of the Society for 21 years.

Emma Lehmer, from Berkeley, CA, died on May 8, 2007. She was born on November 6, 1906. The widow of D. H. Lehmer, she wrote around 60 papers on different aspects of number theory, about 20 of these being joint publications with her husband.

Alfred B. Willcox, retired executive director of the Mathematical Association of America, died on May 17, 2007. Born on September 18, 1925, he was a member of the Society for 58 years.

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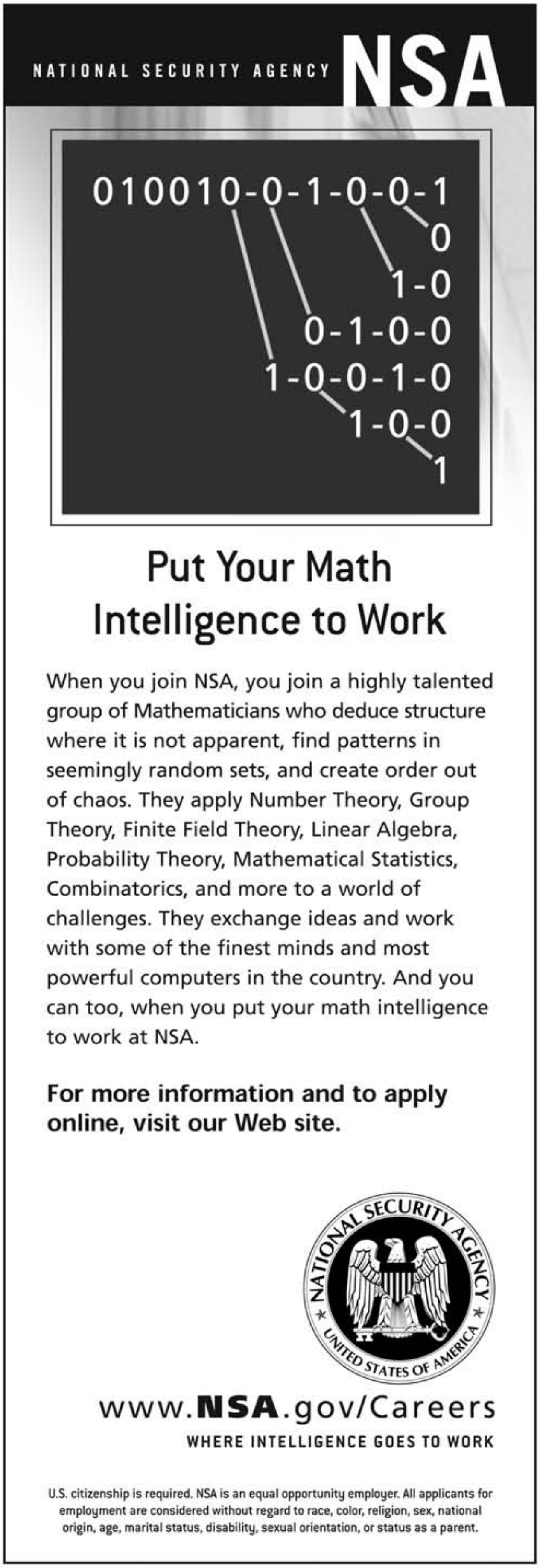

engineering, computer, social sciences, or mathematics who have outstanding written and oral communication skills and a strong interest in learning about the media. It is a highly competitive program, and the AMS wishes to congratulate Adriana Salerno on her accomplishment.

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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

July 19, 2007: Proposals for NSF CAREER program. See http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf05579.

July 31, 2007: Nominations for ICTP Ramanujan Prize. See http://news.ictp.it/php/linkout/o.php?out=http://www.ictp.trieste.it/%7Esci_info/awards/Ramanujan/Ramanujan.html.

August 15, 2007: Nominations for SASTRA Ramanujan Prize. See http://www.math.ufl.edu/sastra-prize/.

August 17, 2007: Letters of intent for NSF Focused Research Groups. See "Mathematics Opportunities" in this issue.

September 15, 2007: Nominations for Sloan Research Fellowships. See http://www.sloan.org/programs/fellowship_brochure.shtml.

September 21, 2007: Full proposals for NSF Focused Research Groups. See "Mathematics Opportunities" in this issue.

October 1, 2007: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone 703-934-0163; email: awm@math.umd.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

October 5, 2007: Full proposals for NSF IGERT competition. See http://www.nsf.gov/pubs/2007/nsf07540/nsf07540.htm.

October 15: Deadline for proposal submissions for NSA Mathematical Sciences Program grants for research. See "Mathematics Opportunities" in this issue.

October 15, 2007: Preferred deadline for January entrance in junior-year program at the Smith College Center for Women in Mathematics. See http://www.math.smith.edu/center.

Where to Find It

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

AMS Bylaws—*November 2005, p. 1239*

AMS Email Addresses—*February 2007, p. 271*

AMS Ethical Guidelines—*June/July 2006, p. 701*

AMS Officers 2006 and 2007 (Council, Executive Committee, Publications Committees, Board of Trustees)—*May 2007, p. 657*

AMS Officers and Committee Members—*October 2006, p. 1076*

Conference Board of the Mathematical Sciences—*September 2006, p. 911*

Information for *Notices* Authors—*June/July 2007, p. 765*

Mathematics Research Institutes Contact Information—*August 2007, p. 898*

National Science Board—*January 2007, p. 57*

New Journals for 2005, 2006—*June/July 2007, p. 767*

NRC Board on Mathematical Sciences and Their Applications—*March 2007, p. 426*

NRC Mathematical Sciences Education Board—*April 2007, p. 546*

NSF Mathematical and Physical Sciences Advisory Committee—*February 2007, p. 274*

Program Officers for Federal Funding Agencies—*October 2006, p. 1072 (DoD, DoE); December 2006, p. 1369 (NSF)*

Stipends for Study and Travel—*September 2006, p. 913*

October 17, 2007: Applications for NSF Mathematical Sciences Postdoctoral Research Fellowships. See "Mathematics Opportunities" in this issue.

October 17, 2007: Full proposals for NSF Computational Science Training for Undergraduates in the Mathematical Sciences (CSUMS). See http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf06559.

October 17, 2007: Proposals for NSF Postdoctoral Research Fellowships. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5301&org=DMS.

November 15: Target date for receipt of applications for NSA Mathematics Sabbatical Program. See "Mathematics Opportunities" in this issue.

January 5, 2008: Applications for IMA postdoctoral and New Directions program. See http://www/ima.umn.edu.

Contact Information for Mathematics Institutes

American Institute of Mathematics
360 Portage Avenue
Palo Alto, CA 94306-2244
Telephone: 650-845-2071
Fax: 650-845-2074
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Website: http://www.aimath.org

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Website: http://www.impan.gov.pl/BC

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Website: http://www.birs.ca

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Fax: 732-445-5932
email: admin@dimacs.rutgers.edu
Website: http://dimacs.rutgers.edu

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email: info@cscamm.umd.edu
Website: http://www.cscamm.umd.edu

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Website: http://www.maths.anu.edu.au/CMA/

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Website: http://www.cimat.mx

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Fax: 7 812 310-53-77
email: admin@euler.pdmi.ras.ru
Website: http://www.pdmi.ras.ru/EIMI/index.html

Fields Institute for Research in Mathematical Sciences
222 College Street, 2nd Floor
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Fax: 416-348-9714
email: geninfo@fields.utoronto.ca
Website: http://www.fields.utoronto.ca

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email: marcela.kraemer@fim.math.ethz.ch
Website: http://www.fim.math.ethz.ch

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Website: http://www.ihes.fr

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Website: http://www.ihp.jussieu.fr

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Website: http://www.math.ias.edu

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Fax: 55 21 2512 4115
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Website: http://www.impa.br

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Telephone: 39 040 2240111
Fax: 39 040 224163
email: sci_info@ictp.it
Website: http://www.ictp.it

International Centre for Mathematical Sciences (ICMS)
14 India Street
Edinburgh EH3 6EZ, United Kingdom
Telephone: 44 (0)131 220 1777
Fax: 44 (0)131 220 1053
email: enquiries@icms.org.uk
Website: http://www.icms.org.uk/index.php

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Website: http://www.kias.re.kr

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Fax: 614-247-6643
email: rebecca@mbi.osu.edu
Website: http://www.mbi.osu.edu

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17 Gauss Way
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Fax: 510-642-8609
email: msri-inquiries@msri.org
Website: http://www.msri.org

Mathematisches Forschungs-institut (Oberwolfach)
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D 77709 Oberwolfach Walke, Germany
Telephone: 49 7834 979 0
Fax: 49 7834 979 38
email: admin@mfo.de
Website: http://www.mfo.de

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P.O. Box 7280
D 53072 Bonn, Germany
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Fax: 49 228 402277
email: admin@mpim bonn.mpg.de
Website: http://www.mpim-bonn.mpg.de

Max-Planck-Institut für Mathematik in den Naturwissenschaften
Inselstrasse 22
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Research Institute for Mathematical Sciences (RIMS)
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Statistical and Applied Mathematical Sciences Institute (SAMSI)
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Research Triangle Park, NC 27709-4006
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email: info@samsi.info
Website: http://www.samsi.info

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Fax: 7-495-135-05-55
email: steklov@mi.ras.ru
Website: http://www.mi.ras.ru/index_e.html

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School of Mathematics
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Website: http://www.maths.warwick.ac.uk/mrc/index.html

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Book List

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

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

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

Analysis and Probability: Wavelets, Signals, Fractals, by Palle E. T. Jorgensen. Springer, September 2006. ISBN 0-387-29519-4.

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

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

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

Arthur Cayley: Mathematician Laureate of the Victorian Age, by Tony Crilly. Johns Hopkins University Press, December 2005. ISBN 0-801-88011-4.

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

A Beautiful Math: John Nash, Game Theory, and the Modern Quest for a Code of Nature, by Tom Siegfried. Joseph Henry Press, October 2006. ISBN 0-309-10192-1.

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

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

The Cat in Numberland, by Ivar Ekeland. Cricket Books, April 2006. ISBN-13: 978-0-812-62744-2.

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

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

Descartes: The Life and Times of a Genius, by A. C. Grayling. Walker & Company, November 2006. ISBN 0-8027-1501-X.

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

The Essential Turing, edited by B. Jack Copeland. Oxford University Press, September 2004. ISBN 0-198-25080-0. (Reviewed November 2006.)

Euclid in the Rainforest: Discovering Universal Truths in Logic and Math, by Joseph Mazur. Pi Press, October 2004. ISBN 0-131-47994-6.

Evolutionary Dynamics: Exploring the Equations of Life, by Martin Nowak. Belknap Press, September 2006. ISBN 0-674-02338-2.

The Fabulous Fibonacci Numbers, by Alfred S. Posamentier and Ingmar Lehmann. Prometheus Books, February 2007. ISBN 1-591-02475-7.

Fearless Symmetry: Exposing the Hidden Patterns of Numbers, by Avner Ash and Robert Gross. Princeton University Press, May 2006. ISBN 0-691-12492-2. (Reviewed January 2007.)

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

From Cosmos to Chaos: The Science of Unpredictability, by Peter Coles. Oxford University Press, August 2006. ISBN 0-198-56762-6.

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

Gödel's Theorem: An Incomplete Guide to Its Use and Abuse, by Torkel Franzen. A K Peters, May 2005. ISBN 1-568-81238-8. (Reviewed March 2007.)

Great Feuds in Mathematics: Ten of the Liveliest Disputes Ever, by Hal Hellman. Wiley, September 2006. ISBN 0-471-64877-9.

How Mathematics Happened, by Peter S. Rudman. Prometheus Books, October 2006. ISBN 1-591-02477-3.

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

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

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

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

King of Infinite Space: Donald Coxeter, the Man Who Saved Geometry, by Siobhan Roberts. Walker & Company, September 2006. ISBN 0-802-71499-4.

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

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

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

A Madman Dreams of Turing Machines, by Janna Levin. Knopf, August 2006. ISBN 1-400-04030-2.

The Man Who Knew Too Much: Alan Turing and the Invention of the Computer, by David Leavitt. Great Discoveries series, W. W. Norton, December 2005. ISBN 0-393-05236-2. (Reviewed November 2006.)

Mathematical Illustrations: A Manual of Geometry and PostScript, by Bill Casselman. Cambridge University Press, December 2004. ISBN 0-521-54788-1. (Reviewed January 2007.)

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

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

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

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

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

Musimathics: The Mathematical Foundations of Music, Volume 1, by Gareth Loy. MIT Press, September 2006. ISBN 0-262-12282-0.

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

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

Not Even Wrong: The Failure of String Theory and the Continuing Challenge to Unify the Laws of Physics, by Peter Woit. Jonathan Cape, April 2006. ISBN 0-224-07605-1.

Once upon Einstein, by Thibault D'Amour. A K Peters, March 2006. ISBN 1-568-81289-2.

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

The Pea and the Sun: A Mathematical Paradox, by Leonard M. Wapner. A K Peters, April 2005. ISBN 1-568-81213-2. (Reviewed October 2006.)

Piano Hinged Dissections: Time to Fold!, by Greg Frederickson. A K Peters, October 2006. ISBN 1-568-81299-X.

Piero della Francesca: A Mathematician's Art, by J. V. Field. Yale University Press, August 2005. ISBN 0-300-10342-5. (Reviewed March 2007.)

The Poincaré Conjecture: In Search of the Shape of the Universe, by Donal O'Shea. Walker, March 2007. ISBN-13: 978-08027-1532-6.

Prince of Mathematics: Carl Friedrich Gauss, by M. B. W. Tent. A K Peters, January 2006. ISBN 1-568-81261-2.

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

Pursuit of Genius: Flexner, Einstein, and the Early Faculty at the Institute for Advanced Study, by Steve Batterson. A K Peters, June 2006. ISBN 1-568-81259-0.

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

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

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

The Shoelace Book: A Mathematical Guide to the Best (and Worst) Ways to Lace Your Shoes, by Burkard Polster. AMS, June 2006. ISBN 0-8218-3933-0. (Reviewed December 2006.)

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

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

Stalking the Riemann Hypothesis: The Quest to Find the Hidden Law of Prime Numbers, by Dan Rockmore. Pantheon, April 2005. ISBN 0-375-42136-X. (Reviewed September 2006.)

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

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

The Three Body Problem, by Catherine Shaw. Allison and Busby, March 2005. ISBN 0-749-08347-6. (Reviewed October 2006.)

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

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

Unknown Quantity: A Real and Imaginary History of Algebra, by John Derbyshire. Joseph Henry Press, May 2006. ISBN 0-309-09657-X.

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

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

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

**You Failed Your Math Test, Comrade Einstein: Adventures and Misadventures of Young Mathematicians, or Test Your Skills in Almost Recreational Mathematics*, edited by M. Shifman. World Scientific, June 2005. ISBN-13: 978-9-812-56279-1.

From the AMS Secretary

Voting Information for 2007 AMS Election

ATTENTION ALL AMS MEMBERS

AMS members who have chosen to vote online will receive an **email message** on or shortly after August 20, 2007, **from the AMS Election Coordinator, Survey & Ballot Systems**.

The **From Line** will be "AMS Election Coordinator".

The **Sender email address** will be `amsvote@directvote.net`.

The **Subject Line** will be "AMS 2007 Election—login information below".

The body of the message will provide your unique voting login information and the address (URL) of the voting website. **If you use a spam filter, you may want to use the above address or subject information to configure your spam filter to ensure this email will be delivered to you.**

AMS members who have chosen to vote by paper should expect to receive their ballot by the middle of September. Unique voting login information will be printed on the ballot should you wish to vote online.

At midnight (U.S. Eastern Daylight Saving Time) on November 2, 2007, the website will stop accepting votes. Paper ballots received after this date will not be counted.

Additional information regarding the 2007 AMS Election is available on the AMS website, `http://www.ams.org/secretary/election-info.html`, or by contacting the AMS: `election@ams.org`, 800-321-4267 (U.S. & Canada), 401-455-4000 (worldwide).

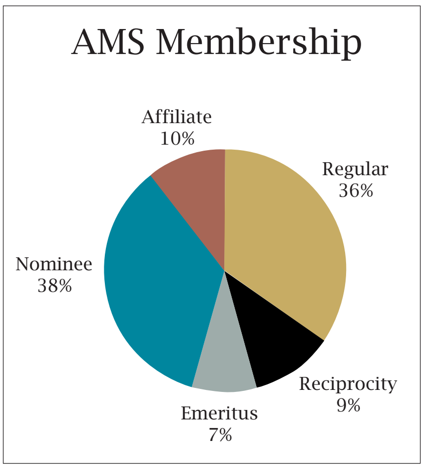
Thank you and please remember to vote.

—Robert J. Daverman

From the AMS Secretary

Report of the Executive Director, State of AMS, 2007

The AMS is a publisher. Often when people point this out, they mean it as an accusation—the AMS is a publisher and nothing more. That's not true. Looking back at past reports to the Council, I see that I often spend much of my time describing the *non*-publishing activities of the Society in order to make this point: The AMS is much more than a publisher. This year, however, I want to highlight our publishing program, not because it is more important than the rest (it's not), but because it is a part of the Society that we often take for granted.



I will begin by reminding you of all the *other* things the Society does.

Everything Else

The AMS is a moderately large society with an amazing diversity. It has more than 30,000 members, more than a third from outside North America. About a third of its members are students (mainly nominee members). Nearly 3,000 members are in developing countries (affiliate members). A similar and ever-increasing number are life, retired, or emeritus. AMS members come from every part of mathematics—pure and applied, academic and nonacademic, doctoral programs and four-year colleges.

As for almost all societies, meetings play a key role in the AMS. Our annual meeting, joint with the Mathematical Association of America (and others), has grown over time, and the recent meeting in New Orleans broke all records for attendance. The eight regional meetings each year attract many mathematicians, especially young ones, from across the country. And our joint international meetings—one or more each year—have become a regular occurrence and an effective way to reach out to the rest of the world mathematical community. For many years, the summer research conferences have been valuable to thousands of mathematicians, young and old, who attended them.

They produced dozens of first-rate books as well, spreading the benefit even more widely. While those conferences will cease after the current round in 2007, the Society and its partners take pride in the quarter-century legacy we leave behind. Meetings and conferences are fundamental to the AMS.

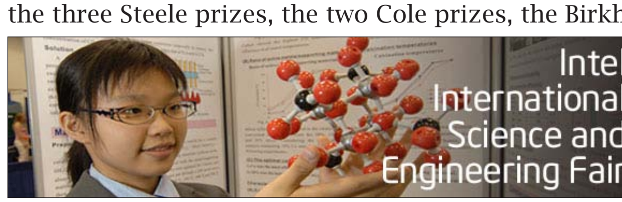
What else does the AMS do in support of mathematics? There is a long list of things, both large and small. Here is a sample, organized into categories.

The Society does many things related to employment, especially for young mathematicians.

- The annual survey covers over 1,500 mathematical sciences departments, and provides detailed information about employment and salary.
- The Conference Board on the Mathematical Sciences oversees a survey of educational issues in mathematics every five years, but the survey work itself is done by the AMS. Data extends back to 1965—a phenomenal collection.
- *Employment Information in the Mathematical Sciences* has been a standard location for advertising job postings for many years.
- The *Employment Center* takes place at each Joint Meeting, and contains not only the standard "registry" for scheduled appointments, but an increasingly popular self-scheduled section. This is jointly sponsored with the Mathematical Association of America.
- *MathJobs* is a new service provided by the AMS in cooperation with the mathematics department at Duke University. It allows departments, applicants, and reference writers to exchange information electronically in a secure environment.
- *Early Career Profiles* provide a central way to link to profiles of recent mathematics majors in a large group of departments, showing prospective majors what kinds of careers they might expect.

The Society awards prizes, grants, and fellowships of various kinds each year.

- The Society gives away prizes—lots of them, including the three Steele prizes, the two Cole prizes, the Birkhoff,



Bôcher, Conant, Doob, Eisenbud, Moore, Satter, Robbins, Veblen, and Whiteman prizes.

• The AMS awards *Centennial Fellowships* each year to one or two young mathematicians, giving them a full year to work on research without interruptions.

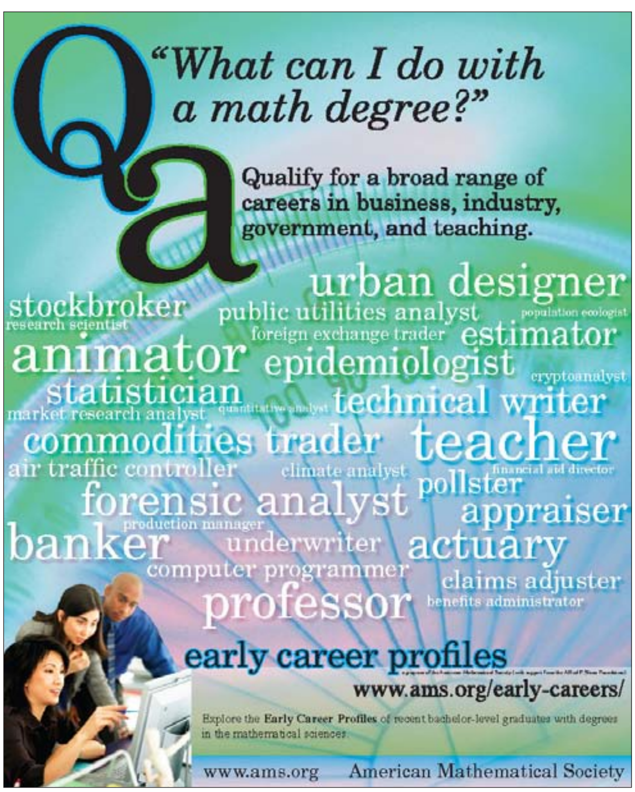
• The *Ky Fan Fund* makes awards each year to facilitate the exchange of mathematicians between North America and China, providing travel for brief visits.

• The *Trjitzinsky scholarships* are awarded to mathematics majors in departments of institutional members, rotating among them (there are nearly 500). About eight scholarships of US$3,000 each are awarded each year.

• The *Menger prizes* help to fund prizes and judging at the International Science and Engineering Fair each year, where the most talented high school students compete. Mathematics students are often among the most highly ranked.

• The Society provides monetary support for the annual meeting of the *Society for the Advancement of Native American and Chicano Students (SACNAS)*. This meeting hosts both undergraduate and graduate students.

• The *AMS Young Scholars program* provides approximately US$80,000 in grants to summer programs for talented high school students throughout North America.



(The Epsilon fund is being created to endow and expand this program in the future.)

• Recently, the AMS has added two new awards to recognize programs. One is the *Award for an Exemplary Program*, given to an outstanding mathematics department each year. The other is an award given by the Committee on the Profession to *Programs that Make a Difference*, which highlights the exceptional minority-serving programs, especially those that can be replicated.

The AMS has more than a third of its members outside North America, and many activities involve international outreach.

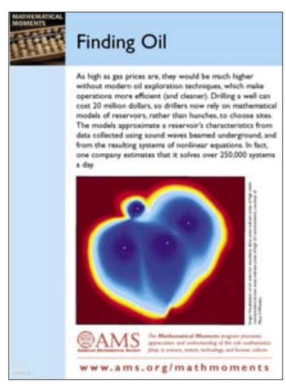
• The *AMS book and journal donation program* matches donors with recipient institutions, especially those in the developing world, and pays for the freight to send donations. This is funded by donations from the Stroock Family Foundation.

• For many years, the Society has collected donations from its members to the *Special Development Fund* of the International Mathematical Union. This money pays for young mathematicians in developing countries to attend the quadrennial International Congress of Mathematicians. Donations from the AMS constitute a major portion of the funding.

• Our affiliate memberships allow mathematicians in developing countries to join the Society for US$16 annual dues, which are often paid from the points earned by writing two reviews for *Mathematical Reviews*. This allows approximately 3,000 such mathematicians to receive the benefits of membership at nominal cost (to them).

In recent years, the AMS has devoted considerable effort and resources to public awareness. A small sample of activities includes:

• *Mathematical Moments* are one-page promotional pieces that have a common theme—mathematical research affects our everyday lives. There are more than fifty of these now, and some have been translated into multiple languages.



• The *Math in the Media* and *Feature Column* areas of our public awareness pages are spectacular examples of high-quality mathematical exposition, which reaches a broad spectrum of interested readers.

• The game show *Who Wants to Be a Mathematician* travels to approximately eight venues around the country each year. High school students compete for a US$2,000 grand prize—and often win.

• The *Arnold Ross Lecture*s bring a prominent mathematician to a science museum each year, to talk to groups of high school students and to inspire their interest in mathematics. The lecture is now coupled with a presentation of the game show, Who Wants to Be a Mathematician. These are supported through an endowment created by Paul Sally.

• *Headlines and Deadlines* is a monthly electronic newsletter that updates mathematicians about news and

CNSF
Coalition for National Science Funding

upcoming events. A new version was recently created for students.

The Society engages in advocacy for mathematics (and science more generally) in various ways.

• The Committee on Science Policy holds a *science policy forum* each year to exchange views between mathematicians and representatives of various other groups. The meeting attracts department chairs as well as members of the committee.

• A similar forum is held by the Committee on Education each fall, and again attracts many department chairs.

• Recently, the Committee on Science Policy has devoted part of its annual meeting to visiting congressional offices in order to promote mathematical research and the support of science.

• The Washington office of the AMS hosts a *congressional luncheon* each year in which a mathematician addresses a specific issue for twenty minutes, talking to an audience of congressional staff and, occasionally, members of Congress.

• The AMS now supports a *congressional fellow* each year. This person works full time in a congressional office, and while he or she doesn't work for the Society, fellows help to represent the mathematical scientific viewpoint.

• The Society has sponsored one or two *AAAS Mass Media Fellows* each summer for a number of years. These are usually mathematics graduate students who spend a summer working for a newspaper, magazine, or other media outlet.

• The Washington Office has played a key role in the *Coalition for National Science Funding* (Sam Rankin serves as chair), which brings together more than 100 organizations to support the National Science Foundation.

The Society provides services to other organizations, especially the agencies, in dealing with funding for mathematicians.

• For many years, the AMS has managed the panel that selects recipients of the National Science Foundation postdoctoral fellowships, a process that selects and brings together fifteen panelists to consider more than 150 applications and award about thirty fellowships each year.

• The Society manages a similar process for the National Security Agency, which selects a panel that considers over 200 applications for NSA awards.

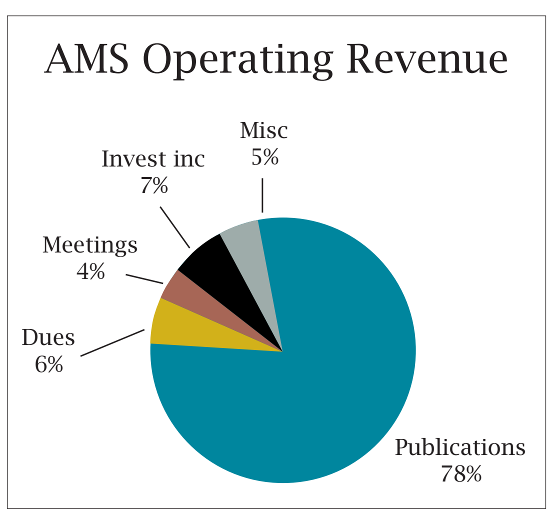
• Every four years, the AMS administers the NSF-funded travel grants to the International Congress of Mathematicians. For the 2006 congress, this involved almost 250 applications and approximately 120 awards totaling about US$250,000. Not only does the Society expend some of its own money in administering this program, but it also makes the program more effective by implicitly underwriting travel support in case more people than expected accept awards.

This is a sampling of "other" activities done by the AMS—that is, the things that have little to do with our publishing program.

Publishing at the AMS

Given this long list of activities, it may seem surprising that *most* of the "resources" of the Society are devoted to publishing. Most of the staff (about 160 of the 210 employees) work directly on publishing activities, and many of the rest work indirectly to support publishing. The AMS maintains its own printing plant and warehouse, with several presses, a bindery, a print-on-demand facility, and almost a million volumes on the warehouse shelves. We have our own graphic arts group, our own promotions and marketing departments, our own customer services operation, and multiple distribution channels throughout the world. Indeed, 56% of our publications sales are international (only 26% of our dues revenue is international). Among all other countries, Japan is number one in publication sales (although all of Europe has the largest sales); India and China are in seventh and eighth place.

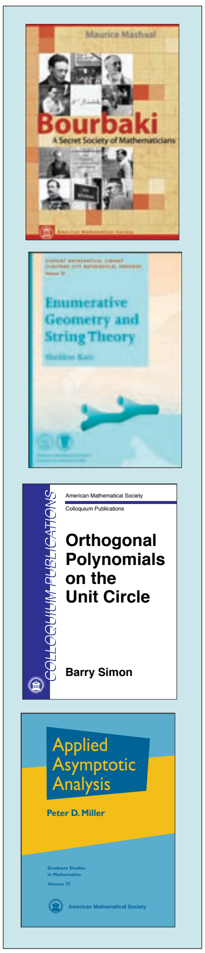
The AMS is a professional publishing company, not on a scale of the giant commercial publishers, but with many of their abilities. We compete with those commercial publishers in many areas, and indeed that competition is *part* of the reason for the AMS publishing program to exist—to put pressure on all publishers to serve the interests of mathematics, moderating prices, treating authors fairly, and implementing policies that serve the interests of the scientific community. The per page price of AMS journals is a fifth that of many commercial journals (which have moderated their price increases in recent years); the AMS forever-in-print policy for monographs attracts many authors, and has forced other publishers to be more careful about letting books go out of print too soon; the Society's "liberal" copyright policy, established in the early 1990s, gives authors and users great latitude in how they use published material, and has influenced the policies of many other publishers. Of course, the competition between *Mathematical Reviews* and *Zentralblatt* has benefited the entire mathematics community, as both products strive each year to improve their products and better serve their



users. Having a large publishing program makes it possible to influence the rest of mathematical publishing.

But the second reason for having a large publishing program is to generate revenue. The AMS would be able to carry out only a small fraction of the activities listed in the preceding section if it did not have a large and profitable publishing program. In 2006, publishing accounted for 78% of the Society's revenue! We structure our meetings program so that it "breaks even" (roughly); individual dues don't come close to covering member benefits, and in any case amount to only 6% of our revenue; almost *every* grant costs the Society money in the sense that the activity it sponsors costs more than the grant itself. Publishing and (more recently) investment income are the primary sources of revenue to fund the Society's programs.

Our publishing program is divided into three parts—books, journals, and the *Mathematical Reviews* database.



Books

The AMS book program is the newest part of our publishing. While the Society's *Colloquium* series has its roots in the famous 1893 lectures of Felix Klein, the AMS book program remained relatively small and narrowly defined throughout most of the twentieth century. Just twenty years ago, sales of indices (mainly for *Math Reviews*) were comparable to the sales of all books in series.

Early in the 1990s, the Society made a carefully reasoned decision to expand its book program. New series were created, including *Graduate Studies in Mathematics* and *The Student Mathematics Library*. The AMS collaborated with outside organizations to copublish more series; the emphasis shifted from proceedings to monographs; more acquisitions editors (always mathematicians) were added to aggressively pursue manuscripts from a variety of new sources. As a consequence, the book program has greatly expanded in recent years so that we are now publishing more than 100 new titles each year.

More importantly, the mixture of books has changed during this time. The emphasis is now on authored books rather than proceedings. The proceedings we *do* publish are high quality, in part because they are selected competitively. There are more books at a lower level, including some textbooks for undergraduates. The AMS has also published more books that address professional issues, and even books that are aimed at the general (scientifically minded) public.

Publishing slightly more than 100 books a year may not sound like a lot, but it is. Acquiring books is painstaking work—building relationships, reviewing manuscripts, negotiating contracts, nudging authors, and moving the submission through the production process (which, alas, is unique to each book). These are the parts of book publishing most mathematicians think about. But publishing books is far more complicated still. Few books are sold by standing order these days, and book sales have become ever more complicated. Books need to be promoted. Marketing arrangements with distributors and agents have to be managed. And every order has to be fulfilled, often one book at a time, and shipped out as quickly as possible. Book sales are among the most complicated sales arrangements, and creating a first-rate marketing system is a major factor in the success of any book program. The AMS has paid particularly close attention to this part of our program, and we continue to improve it year by year.

Perhaps the greatest strength of our book publishing program is its breadth. The Society has more than 3,000 titles in print (and, by the way, all 3,000 are searchable online through the Google book program, and soon will be through the comparable Microsoft book program as well). The AMS has this staggering number of titles because it pledges to keep every authored monograph in print—forever. We do not let authored books go out of print (but, of course, we *do* let proceedings go out of print). This is a policy that serves both our authors *and* the community well. Until recently, it was a difficult policy to administer because it meant printing small quantities of books that only sold a few copies each year. We now have a full-featured print-on-demand program, however, that allows us to produce *one* copy of a book, at moderate price and high quality. We will expand this program in the coming years.

Journals

While books are the newest part of our publication program, journals are the oldest. The *Bulletin* goes back to the very earliest days of the Society, and the *Transactions* was founded in 1900. Over the years, the journal program has grown, and the Society now has twelve journals that annually publish more than 20,000 pages combined. Those journals are distributed around the world, and indeed nearly 60% of the subscriptions are outside the United States.

The twelve AMS journals fall into four categories:

• Member journals: The *Bulletin* and the *Notices* have been rejuvenated over the past ten years. They are the most widely distributed (and read) high-level mathematics journals in the world. Each has its own special character, which evolves over time. In fact, that evolution is an important part of the "rejuvenation", which places a strong chief-editor in charge of each publication and encourages that individual to try out new things. These two journals are unusual in another respect as well: they are both *open* *access*—freely available online to everyone. This is unusual for member journals, and has been controversial because these journals are often considered our premier member benefit. On the other hand, precisely because they are open access, these journals have become the standard way to disseminate the most important mathematical news and information, and hence they provide a crucial service to all mathematicians—a service provided not only *to* but *by* our members.

• Primary Research Journals: The four primary research journals are (in order of their founding) the *Transactions of the AMS*, the *Proceedings of the AMS*, *Mathematics of Computation*, and the *Journal of the AMS.* The *Transactions* has a companion publication series, the *Memoirs*, which publishes twenty-four or more separate issues each year—lengthy articles in book form that serve an almost unique purpose in mathematics. Together, these journals published about 15,000 pages and nearly 1,000 articles in 2006. While this is only a fraction of the total mathematical research, the primary AMS journals set standards for other journals. The *Journal of the AMS* is consistently among the highest ranked mathematics journals. All four are high-quality journals with moderate prices, and help to moderate prices of other journals as well. In order to maintain that effect, the number of pages for the first three of these journals are being increased by 20% over the next two years, without passing along the increased costs to subscribers.

• Translation journals: Many people are unaware of the Society's four translation journals, *St. Petersburg Mathematical Journal, Sugaku Expositions, Theory of Probability and Mathematical Statistics,* and *Transactions of the Moscow Mathematical Society* (published jointly with the London Mathematical Society). *Sugaku* contains selected articles translated from the Japanese journal of the same name; the other three are all translated from Russian. The Society has a long tradition of publishing translation journals, and until twelve years ago published many other Russian translation journals as well. While many mathematicians in the rest of the world are writing papers in English, there is still an important need for translation journals.

• Electronic-only journals: The Society also publishes two e-only journals, *Conformal Geometry and Dynamics* and *Representation Theory*. These were originally thought of as the initial phase in a large program of electronic specialty journals, all published only in electronic format. While these journals have been a scientific success, they were less of a commercial success, even though they had a very small price. Access to these journals is now given to any subscriber of the primary AMS journals, and hence they have wide circulation.

All but one of these journals is online. (*Sugaku* publishes a single issue each year and remains in printed form only.) The primary journals went online in 1996, twelve years ago, and they were among the first mathematics journals online. Making older journals material available online has been a high priority for the AMS from the beginning. In order to make material available quickly, the Society joined the JSTOR project at its inception. JSTOR now makes hundreds of thousands of pages of AMS material available to a large number of institutions (well more than 2,000) around the world. We are currently digitizing the entire history of the *Bulletin* in a cooperative project with the Mathematical Sciences Research Institute, and the full *Bulletin* will be available online and searchable (for free) later in 2007.

The Society also was an early participant in *Portico*, a cousin of the JSTOR project, aimed at archiving electronic journals and making them available to libraries in case this becomes necessary.

Over the years, the AMS has led the community in formulating sensible policies that benefit both the Society as publisher and the mathematical community, which is meant to be the ultimate beneficiary of journals. Even before the Web existed, the Society adopted a forward-looking copyright policy that allows authors to post articles wherever they please. The AMS also adopted a policy of making its own journal material freely available after five years. And the AMS makes not only abstracts and bibliographic material freely available, but also the complete list of references. This means that mathematicians can frequently determine whether an article is useful (and perhaps write to the author), even without a subscription.

Mathematical Reviews

Mathematical Reviews is a phenomenal product—a huge database of more than 2.2 million items (more than 80,000 new items each year), combined with a sophisticated piece of software, *MathSciNet*, that puts this information at one's fingertips. In fact, the *MR* database is not one database but several. In addition to the collection of publications, *MR* maintains a database of authors, and another of journals, and more recently yet another of citations.

Here are some facts about these databases.

• There are more than 470,000 authors indexed, and almost all are uniquely identified by a team of specialists (a process that began in 1940).

• *MR* currently covers about 1,800 journals, sometimes choosing all articles from a journal, but often selecting only articles that are of interest to mathematicians. *MR* has constructed more than 800,000 links to original articles in those journals.

• *MR* also includes items about more than 85,000 monographs and 300,000 conference proceedings.

• The new citation database now contains more than 2.6 million items from reference lists, each matched to an item in the *MR* database. These refer to more than 142,000 authors, who were uniquely identified as described above, and to about 2,400 distinct journals.

The operation that assembles these databases is phenomenal as well. Creating the databases and updating the

THE MR PIPELINE

Each item passes repeatedly through five departments in a 16-step process, in addition to being sent out for review.

B = Bibliographic Services
E = Editors
P = Production
C= Copy Editors
R = Reviewer Services

PUBL→B→E→B→E→B→P→C→

R→E→R→P→C→E→E→C→P→MSN

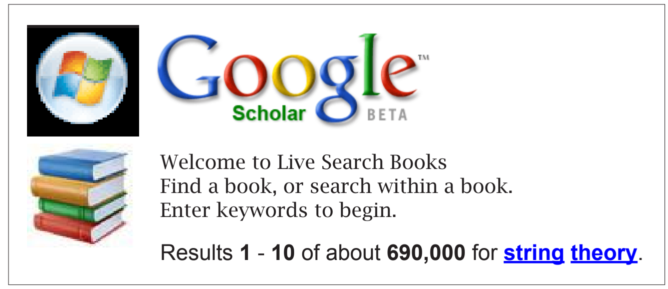
application each year requires more than seventy staff in the Ann Arbor office of the AMS. They sift through those 1,800 journals and many more books, considering well more than 110,000 items in order to find the approximately 85,000 items to include each year. Each selected item is classified, primary and secondary; each author is identified, often requiring detective work; each item is entered into the database in a standardized form, with painstaking checking; and each item is linked, whenever links can be made. All this takes place before the reviewing process has begun.

Reviews are carried out by the more than 12,000 *MR* reviewers, and their contribution is a key part of the *MR* operation. Reviewers have to be selected, however, and then occasionally nagged, and their reviews frequently have to be edited, adding references and checking them. Finally, for many journals, lists of references are entered in a standard format and then matched to *MR* items so that they are uniquely identified.

Of course, putting together the databases is only part of the job in making *Mathematical Reviews* available to the mathematics community. The big orange volumes continue to be printed, and a modest number of institutions still subscribe to the paper version of *MR*. The disc version is still used by a number of institutions as well. But the most popular way to search the database is through *MathSciNet*, the online version. Each year, the software underlying *MathSciNet* is updated and improved. The latest version was a major overhaul, designed to highlight the multiple databases of *MR*. Other improvements are made behind the scenes each year in order to make the application run better or smarter, with work beginning many months in advance of the annual release.

In addition, the AMS markets *Mathematical Reviews* products in innovative ways, providing inexpensive access for smaller institutions (through consortia) as well as for institutions in developing countries (through the National Data Access Fee program). Even the normal pricing scheme is innovative, making one charge for the cost of assembling the database and another for each individual product. While these marketing efforts require a substantial amount of staff time in our Providence offices, they have profoundly expanded the reach of *Mathematical Reviews*: In the past ten years, the number of institutions with access to *Math Reviews* has more than doubled.

Mathematical Reviews continues to grow and improve each year and promises to provide even more service in the future. The citation database already is a worthy competitor in mathematics to the Science Citation Index. The addition of many contributed items from digitization projects has helped to make *MathSciNet* into a gateway to much of the past literature, even that older than 1940. And *MR* has added substantially more of the literature in heavily applied areas in recent years in order to broaden its coverage.



The Society has invested heavily in *MR* over the past ten years. People sometimes ask whether *Mathematical Reviews* has a future—whether free services such as Google Scholar or the ability of mathematicians to find large amounts of information online will make *MR* obsolete. But that question answers itself: The ever-increasing quantity of information online promises to grow at a quickening pace in the next few years. As it grows, high-quality and carefully maintained databases such as *Mathematical Reviews* will provide a more and more valuable service, provided their services are tailored to the needs of the community. This means investing in *Mathematical Reviews* as the world changes, as we have in past, and as we will continue to do in the future.

Conclusion

Is the AMS a publisher disguised as a scientific society? Surely not. The AMS does many different things for many different groups—service, awards, awareness, policy, and advocacy. The list is long and varied. There is no need for a disguise.

But the Society is indeed a publisher, and it takes pride in that fact. As a publisher, it makes money, which it uses to fund its society-like activities. It also views publishing as part of its service to the mathematical community—for its authors, editors, and readers. And finally, it uses publishing to persuade other publishers to deal fairly with the mathematical community, by competing with them on price, policy, and service.

The fact that the AMS works hard at its publishing program, making it both profitable and first-rate, means that it is a successful program—one in which members of the AMS can take pride…for the program belongs to them.

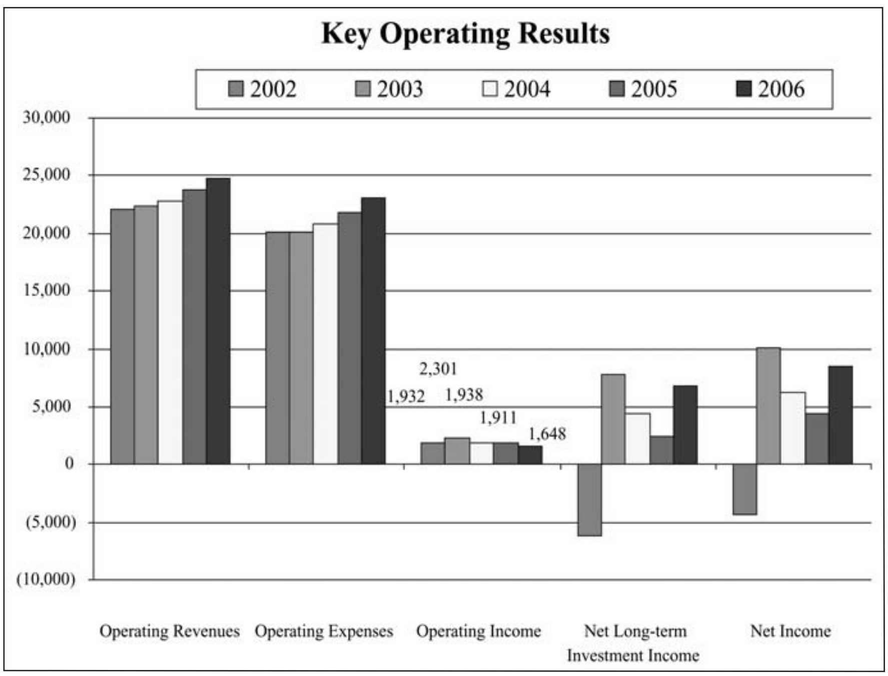
John Ewing

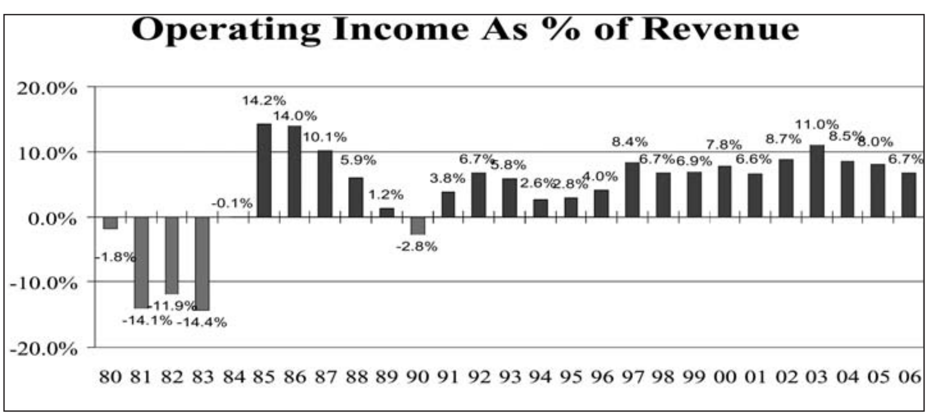
Report of the Treasurer (2006)

I. Introduction

One of the most important duties of the Treasurer is to lead the Board of Trustees in the oversight of financial activities of the Society. This is done through close contact with the executive staff of the Society, review of internally generated financial reports, review of audited financial statements, and direct contact with the Society's independent auditors. Through these and other means, the Trustees gain an understanding of the finances of the Society and the important issues surrounding its financial reporting. The Report of the Treasurer is presented annually and discusses the financial condition of the Society as of the immediately preceding fiscal year end, and the results of its operations for the year then ended. It contains summary information regarding the operating results and financial condition of the Society for 2006, a review of 2006 operations, containing more detailed information regarding the Society's operations, and a discussion of the assets and liabilities of the Society. Finally, in the last part of the Report, there are financial statements derived principally from the Society's audited financial statements, which present the balance sheet, statement of activities (akin to an income statement in a for-profit organization) and information regarding the Society's invested funds.

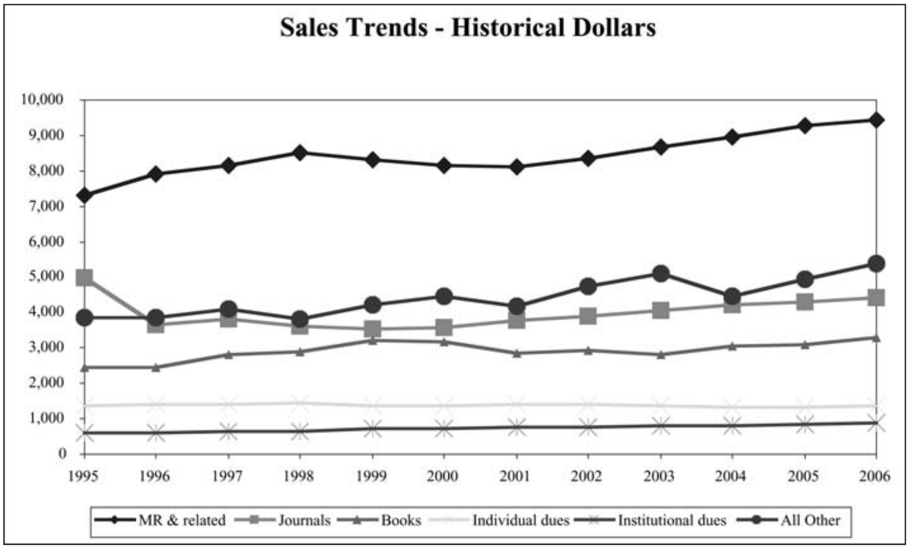
The Society segregates its net assets, and the activities that increase or decrease net assets, into three types. Unrestricted net assets are those that have no requirements as to their use placed on them by donors outside the Society. A substantial majority of the Society's net assets and activities are in this category. Temporarily restricted net assets are those with donor-imposed restrictions or conditions that will lapse upon the passage of time or the accomplishment of a specified purpose. Examples of the Society's temporarily restricted net assets and related activities include grant awards and the spendable income from prize and other income-restricted endowment funds. Permanently restricted net assets are those that must be invested in perpetuity and are commonly referred to as endowment funds. The accompanying financial information principally relates to the unrestricted net assets, as this category includes the operating activities of the Society.

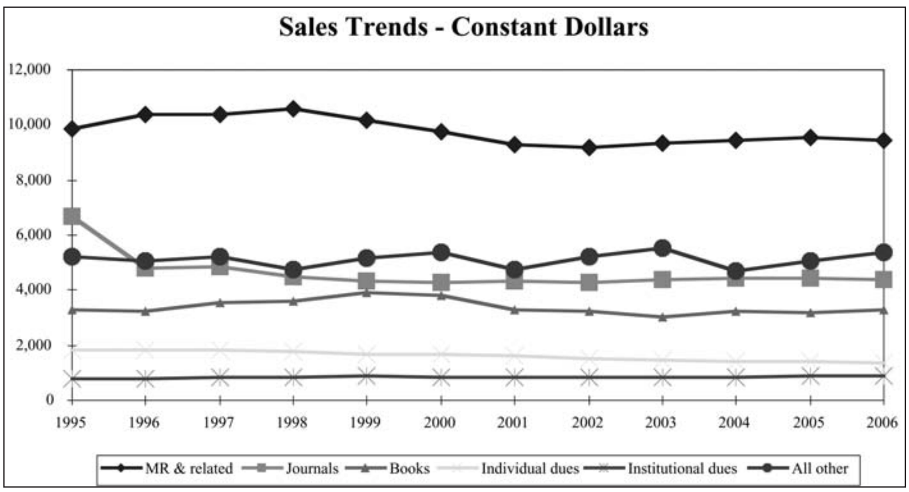




Unrestricted revenues in excess of unrestricted expenses for the year ended December 31, 2006, resulted in an increase in unrestricted net assets of approximately $8,528,000. Of this amount, net income on the unrestricted portion of the long-term investment portfolio totaled approximately $6,880,000 and net income from operations totaled approximately $1,648,000. The continuing bull market in the domestic and international equity markets in 2006 resulted in a return on the long-term portfolio of approximately 13.6%. These and other matters are discussed in more detail in the following Sections.

The Society's net assets totaled $73,940,000 at December 31, 2006. $3,677,000 is permanently restricted, consisting of the original amount of donor restricted gifts and bequests received by the Society. $1,965,000 is temporarily restricted by donor-imposed limitations that will lapse upon the passage of time or the use of the asset for its intended purpose. $68,298,000 is unrestricted, of which $58,127,000 has been designated by the Board of Trustees as reserved for future expenditure in two distinct funds, the Economic Stabilization Fund (ESF, formerly known as the base portion of the ESF) and the Operations Support Fund (OSF, formerly known as the supplemental portion of the ESF). The ESF's purpose is to provide a source of cash in the event of a financial crisis. The Society's





Board of Trustees set the target at which to maintain the ESF at the sum of 75% of annual operating expenses plus the current estimate of the post-retirement health benefit obligation. The OSF is used to provide operating income to the Society via the use of a 5% spending rate. At year end December 31, 2006, the ESF and OSF were rebalanced and we will do this annually so that the ESF is at its target level. This change in policy resulted in a transfer of assets of approximately $13,032,000 from the ESF to the OSF at the end of 2006. The remaining unrestricted net assets consist of $3,735,000 invested in fixed assets and undesignated net assets of $6,436,000.

II. Review of 2006 Operations

As indicated in the graph below, the past five years have been very good years, financially, for the Society, apart from investment losses incurred in 2002.

Although the Society experienced investment losses from 2000–2002, all losses have been recouped to date. Further, in spite of these losses, long-term investments have generated good returns over a long period (an average annual return of 7.78% over the last 10 years), and that income has helped the endowment funds (and the income they produce) to keep pace with inflation.

Since 2002, the Board of Trustees has appropriated investment income from those endowment funds with income whose use is unrestricted and from the Operations Support Fund to support operations. The total amounts of such appropriations that have been included in operating revenue are $899,630 in 2006, $847,225 in 2005, $792,870 in 2004, $865,696 in 2003 and $760,811 in 2002.

This percentage relationship has shown much more stability in the last ten years compared to the first seventeen years, which is a positive financial indicator. However, with expenses rising at a faster pace than revenues in the most recent years, the percentage has entered a declining phase.

Sales Trends

The graphs on this page show sales trends from 1995 through 2006, first in historical dollars and second in constant dollars (using 2006 as the base year and adjusting other years for inflation).

The trends shown in historical dollars above are in general mildly upward, and this is partly due to pricing strategies that counter the effects of inflation and attrition. When shown in constant dollars below, most sources of revenue are fairly flat.

During the ten-year period from 1996 through 2006, the average annual inflation was 2.44% (1996 was selected as the base year as it was the first year after the loss of the four Russian translation journals). During this same period, the Society's average annual expense growth was 1.94%, indicating that the Society was able to keep its expense growth about 0.5% below the rate of inflation for each year in this time period. This is indicative of the productivity gains experienced by the Society. At the same time, the average annual growth in revenue was 2.23%. While the revenue growth did not keep up with inflation during this period, it was almost 30 basis points better than that of the expense growth rate. This positive differential was achieved during the same period of time when price increases on journals and *MR* products were lowered (the DAF had no price increase for one year), sectional meeting fees were held constant and individual dues were frozen for two years. If the Board had not appropriated investment income to support operations (commencing in 2002), there would have been a negative difference between the growth of expenses and revenues of 0.33% annually during this ten-year period (expenses rising faster than revenues).

Mathematical Reviews. Total revenue from *MR* in its various forms increased from 2005. This is due to price increases effective in 2006, net of attrition (which was

Major Expense Categories

	2004		2005		2006	
Personnel Costs	$13,881	66%	$14,608	66%	$15,471	67%
Building and equipment related	1,391	7%	1,389	6%	1,359	6%
Postage	799	4%	865	4%	904	4%
Outside printing, binding, and mailing	669	3%	806	4%	876	4%
Travel: staff, volunteers, grant support	796	4%	972	4%	1,131	5%
All other expenses	3,294	16%	3,557	16%	3,371	14%
TOTAL	$20,830	100%	$22,197	100%	$23,112	100%

minor). The Society continues to concentrate its marketing efforts on working with consortia, where costs can be spread over a larger number of institutions. This has the effect of providing the *MR* product line to a much wider audience than could afford it as individual institutions, as well as protecting the current revenue stream for future years. *MR* is currently financially healthy; however, it is probably unrealistic to expect significant increases in sales revenue from additional subscribers.

Journals. Journal revenues are doing well with improvement seen in the last four years, as attrition of subscribers has been less than expected. The financial solvency of subscription agents continues to be a worry to scholarly publishers. We experienced the bankruptcy of one subscription agent in 2003 and in 2004 a subscription agent with significant market share required the infusion of additional capital from investors in order to meet its obligations to subscribers and publishers. In early 2007, a Korean subscription agent went into bankruptcy; we are in the process of gathering information about our subscribers who used this agent. Ultimately, it is the choice of the subscriber to use a subscription agent, but the scholarly publishers pay the highest price should any further financial difficulties arise.

There continue to be financial pressures on libraries everywhere in the world, as their budgets lag behind the cost of obtaining scholarly journals and books. This has been the case for many years now, and is not likely to change. Accordingly, scholarly publishers are fighting over an ever dwindling slice of pie. The decline in the value of the dollar compared to many other currencies during the last five years has helped the Society's retention efforts with respect to non-U.S. subscribers. The domestic economy continues to be quite stagnant, insofar as it directly affects our major end users (scholarly libraries and individual mathematicians).

The drop in 1996 resulted from decisions made by those in control of four Russian journals (Izvestiya, Sbornik, Steklov, and Doklady) to use sources other than the AMS for translation into English and distribution of the resulting translation journals.

Books. Book revenues increased in 2006 in historical dollars and slightly in constant dollars, with the production of 101 new titles (versus a budget of 107). Sales of new and backlist titles remained strong throughout 2006. The

2006 Operating Revenue and Expenses by Major Activity, in Thousands of Dollars

	Revenue	Expense	Net
Publications:			
Mathematical Reviews	$ 9,445	$ 6,133	$ 3,312
Providence publications (books, journals, etc.)	8,229	4,472	3,757
Publications indirect (customer services, marketing, distribution and warehousing, etc.)		2,745	(2,745)
Total publications	17,674	13,350	4,324
Member and professional services:			
Services and outreach programs	1,344	3,539	(2,195)
Grants, prizes and awards	881	1,190	(309)
Meetings	893	916	(23)
Divisional indirect		442	(442)
Governance		417	(417)
Spendable income from investments	820		820
Dues	2,239		2,239
Total member and professional services	6,177	6,504	(327)
Other	909	143	766
General and administrative		3,115	(3,115)
Total	$24,760	$23,112	$ 1,648

Society continues to work with distributors and continues to improve marketing efforts in order to keep the book program as healthy as possible.

Dues. Dues, the sum of individual and institutional, have shown a slight upward slope on the historical dollars chart and a flat or slightly decreasing line in constant dollars. A flat constant dollar line is expected for institutional dues, as the number of members varies little from year to year and the dues rates have been set so that dues will increase at about the same level as inflation. There has been a slight decline in individual dues from their high in 1998.

Major Expense Categories

The preceding table shows the major expenses for 2004, 2005 and 2006, in thousands of dollars. There has not been much change from year to year in the types of expenses incurred by the Society.

Operating expenses can also be associated with the various activities of the Society, and this is how our audited financial statements are presented (see Section 4). The Society has accounting systems in place to capture the identifiable direct costs of its publishing and member and professional services activities, as well as indirect costs associated with these two major functions. General and administrative costs are those that cannot be directly associated with either of its two main functions or any activity therein. The following is a summary presentation that matches the revenue and costs of the major activities of the Society, derived directly from its audited financial statements.

Some points worth noting in the above presentation are that the *Mathematical Reviews* activities and the Providence publications produce about the same margin (in dollars) after identifiable direct costs associated with these products. The indirect costs associated with the overall publishing activities of the Society (taking orders, shipping and storing goods, marketing and sales efforts, etc.) reduces this margin by 39%. If general and administrative were allocated to the publishing activities, this margin would be reduced even further. But there would still be a margin from publications, available to spend on services and outreach activities.

The member and professional services activities use resources of the Society, which are then supported, or "paid for" by member dues, spendable income from reserve and endowment funds, and the margin from publishing activities. While the various activities in this functional area do have revenue streams, such as fees, grant support, prize fund spendable income, etc., the costs incurred by these activities are significantly greater than the revenues generated.

III. Assets and Liabilities

So far, this report has dealt with revenues and expenditures that affect unrestricted net assets. Another aspect of the Society's finances is what it owns and owes, or its assets and liabilities, which are reported below in the Balance Sheets. As discussed previously, the Society's net assets and activities that increase or decrease net assets are classified as unrestricted, temporarily restricted, or permanently restricted. A majority of the assets and liabilities detailed on the accompanying Balance Sheets constitute the unrestricted net assets. The permanently restricted net assets are supported by investments in the long-term investment portfolio and the temporarily restricted net assets are supported by investments in the long-term and short-term investment portfolios. The Market Value of Invested Funds shows the market value of each endowment and Board designated (quasi-endowment) fund, including any reinvested earnings.

The Society's fiscal year is the calendar year and thus coincides with the period covered by subscriptions and dues. Since dues and subscriptions are generally received in advance, the Society reports a large balance of cash and short-term investments on its financial statements at year-end. This amounted to approximately $18,614,000 and $16,820,000 at December 31, 2006, and 2005, respectively. The corresponding liability for the revenues received in advance was approximately $12,908,000 and $11,971,000 at December 31, 2006, and 2005, respectively.

The Society's property and equipment include land, buildings and improvements, office furniture and equipment, and software. The Society also owns a small amount of transportation equipment. The land, buildings, and improvements include the Society's Rhode Island headquarters, with buildings in Providence and Pawtucket, and the *Mathematical Reviews* offices in Ann Arbor. The largest part of the Society's office equipment is its investment in computer facilities. Generally accepted accounting principles require that investments in property, plant and equipment used for operations be stated at cost, less accumulated depreciation. It is likely that the value of the land and buildings owned by the Society is significantly greater than the net amount recorded as assets (approximately $3,342,000 at December 31, 2006).

An important feature to note on the Society's balance sheet is that the Society owes no debt to third parties, other than the normal liabilities incurred in operations such as those owed to employees, vendors, and the deferred revenue for payments received in advance from members, subscribers, and other customers. This means that the Society owns all of its assets free and clear of any encumbrances, liens or other types of impairments typically associated with debt.

The Society's endowment is managed under the "total return concept". Under this management policy, income in excess of a reasonable amount (set by the Board of Trustees) is reinvested and increases the value of the fund. This allows for growth in income over time. As discussed previously, in 2002 the Board of Trustees established a policy of annually appropriating investment income from those true endowment funds whose use of income is unrestricted and from the Operations Support Fund to support operations. The amount of such appropriations included in operating revenue is $899,630 and $847,225 in 2006 and 2005, respectively.

IV. Summary Financial Information

The following Balance Sheets and Statements of Activities are from the audited annual financial statements of the

Society, and the Statement of Invested Funds is from the internal financial records of the Society. Each year, the Audit Committee of the Board of Trustees meets with the Society's auditors to review the conduct of the audit, the Society's financial statements, and the auditors' report on the financial statements. Pursuant to the recommendation of the Audit Committee, the Board of Trustees has accepted the audited financial statements. A copy of the Society's audited financial statements, as submitted to the Trustees and the Council, will be sent from the Providence Office to any member who requests it from the Treasurer. The Treasurer will be happy to answer any questions members may have regarding the financial affairs of the Society.

—Respectfully submitted,

John M. Franks
Treasurer

BALANCE SHEETS
December 31, 2006, and 2005

Assets	2006	2005
Cash and cash equivalents	$ 1,518,285	$ 674,624
Short-term investments	17,095,580	16,145,544
Receivables, less allowances of $250,000 and $230,000 respectively	1,607,714	1,135,742
Deferred prepublication costs	580,769	609,877
Completed books	1,060,636	972,114
Prepaid expenses and deposits	1,172,409	1,079,528
Land, bldgs., and equipment, less accumulated depreciation	3,734,674	3,828,156
Long-term investments	68,461,186	60,258,660
Total assets	**$95,231,253**	**$84,704,245**

Liabilities and Net Assets		
Liabilities:		
Accounts payable	$ 1,534,995	$ 1,545,820
Accrued expenses:		
Severance and study leave pay	1,147,066	1,058,971
Payroll, benefits, and other	994,608	1,092,225
Deferred revenue	12,907,692	11,971,021
Postretirement benefit obligation	4,706,688	3,998,645
Total liabilities	**21,291,049**	**19,666,682**
Net assets:		
Unrestricted	68,297,387	59,769,368
Temporarily restricted	1,965,378	1,794,484
Permanently restricted	3,677,439	3,473,711
Total net assets	**73,940,204**	**65,037,563**
Total liabilities and net assets	**$95,231,253**	**$84,704,245**

STATEMENTS OF ACTIVITIES
Years Ended December 31, 2006, and 2005

Changes in unrestricted net assets:

Operating Revenue	2006	2005
Publication:		
Mathematical Reviews and related activities	$ 9,444,936	$ 9,294,428
Journals (excluding MR)	4,407,455	4,288,978
Books	3,293,020	3,081,012
Sale of services	385,855	379,114
Other	142,632	135,675
Total publication revenue	17,673,898	17,179,207
Membership and professional services:		
Dues, services, and outreach	3,583,116	3,431,224
Grants, prizes, and awards	881,496	977,253
Investment earnings available for spending	819,630	727,225
Meetings	893,202	822,188
Total membership and professional services revenue	6,177,444	5,957,890
Short-term investment income	756,686	503,262
Other	152,355	137,844
Total operating revenue	**$24,760,383**	**$23,778,203**

Operating Expenses		
Publication:		
Mathematical Reviews and related activities	$ 6,133,098	$ 5,919,533
Journals (excluding MR)	1,293,764	1,276,304
Books	2,926,057	2,604,319
Publication–divisional indirect	805,909	666,448
Warehousing and distribution	857,274	791,142
Customer services	848,861	776,448
Marketing and sales	232,922	219,230
Sale of services	251,747	325,231
Total publication expense	13,349,632	12,578,655
Membership and professional services:		
Dues, services, and outreach	3,539,475	3,115,145
Grants, prizes, and awards	1,190,011	1,278,042
Meetings	916,111	735,513
Governance	417,497	419,659
Divisional indirect	441,759	500,038
Total membership and professional services expense	6,504,853	6,048,397
Other	142,711	97,118
General and administrative	3,114,916	3,142,371
Total operating expenses	**$23,112,112**	**$21,866,541**
Excess of operating revenue over operating expenses	$1,648,271	$1,911,662
Long-term investment return in excess of investment earnings available for spending	6,879,748	2,481,812
Change in unrestricted net assets	**8,528,019**	**4,393,474**

	2006	2005
Changes in temporarily restricted net assets:		
Contributions and grants	52,971	153,455
Long-term investment income (loss)	420,472	191,766
Net assets released from restrictions	(302,549)	(344,848)
Change in temporarily restricted net assets	**170,894**	**373**
Change in permanently restricted net assets—Contributions	**203,728**	**187,353**
Change in net assets	8,902,641	4,581,200
Net assets, beginning of year	65,037,563	60,456,363
Net assets, end of year	**$73,940,204**	**$65,037,563**

STATEMENTS OF INVESTED FUNDS

As of December 31, 2006 and 2005

	Dec. 31, 2006		Dec. 31, 2005
	Original Gift(s)	**Market Value**	**Market Value**
Endowment Funds:			
Prize Funds:			
Steele	$145,009	$ 647,897	$ 593,039
Birkhoff	10,076	39,195	35,876
Veblen	2,000	13,237	12,116
Wiener	2,000	13,237	12,116
Bôcher	1,450	9,627	8,812
Conant	9,477	43,209	39,550
Cole	5,550	22,732	20,808
Satter	15,000	34,412	31,499
Morgan	25,000	47,022	43,041
Whiteman	63,468	71,111	50,493
Doob Book Prize	45,000	52,504	48,059
Robbins Prize	40,000	47,719	43,678
Eisenbud	40,000	43,476	
Arnold Ross Lectures	70,000	79,125	63,202
Trjitzinsky Scholarships	196,030	520,924	476,817
C. V. Newsom	100,000	242,410	221,885
Centennial Fellowship	56,100	124,292	113,768
Menger	9,250	12,164	11,134
Ky Fan (China)	366,757	383,173	366,757
Epsilon	910,371	1,030,659	812,237
Total Income Restricted Funds	**$2,112,538**	**$3,478,125**	**$3,004,887**

	Dec. 31, 2006		Dec. 31, 2005
	Original Gift(s)	**Market Value**	**Market Value**
Endowment	100,000	797,059	730,870
Morita	100,000	142,234	130,422
Henderson	548,223	4,272,703	3,917,891
Schoenfeld/Mitchell	573,447	801,601	735,034
Laha	189,309	270,358	247,907
Ritt	51,347	254,561	233,422
Moore	2,575	23,996	22,003
Total Income Unrestricted Funds	**1,564,901**	**6,562,512**	**6,017,549**
Total Endowment Funds	**$3,677,439**	**$10,040,637**	**$9,022,436**
Board-Restricted Funds:			
Journal Archive		599,289	487,181
Young Scholars		653,985	574,912
Economic Stabilization		21,302,648	30,182,936
Operations Support		35,571,266	19,608,088
Total Board-Restricted Funds		**58,127,188**	**50,853,117**
Total Funds		**$68,167,825**	**$59,875,553**

ASSOCIATE SECRETARY

Eastern Section

Position

The American Mathematical Society is seeking applications and nominations of candidates for the post of Associate Secretary of the Eastern Section. The section is loosely described as the states and provinces from the Atlantic Ocean as far West as Pennsylvania and Southeastern Ontario and as far south as Maryland and Delaware. Lesley Sibner, the current Associate Secretary there, wishes to step down at the end of her present term.

An Associate Secretary is an officer of the Society and is appointed by the Council to a two-year term, ordinarily beginning on 01 February. In this case the term should begin 01 February 2009 and end 31 January 2011. Reappointments are possible and desirable. All necessary expenses incurred by an Associate Secretary in performance of duties for the Society are reimbursed, including travel and communications.

Duties

The primary responsibility of an Associate Secretary is to oversee scientific meetings of the Society in the section. Once every four years an Associate Secretary has primary responsibility for the Society's program at the January Joint Mathematics Meeting. An Associate Secretary is a member of the Secretariat, a committee consisting of all Associate Secretaries and the Secretary, which approves all applications for membership in the Society and approves all sites and dates of meetings of the Society. Occasionally an Associate Secretary is in charge of an international joint meeting. Associate Secretaries are the principal contact between the Society and its members in the various sections. They are invited to all Council meetings and have a vote on the Council on a rotating basis.

Applications

An Associate Secretary is appointed by the Council upon recommendation by the Executive Committee and Board of Trustees. Applications should be sent to:

Robert J. Daverman, Secretary, American Mathematical Society,
312D Ayres Hall, University of Tennessee, Knoxville TN 37996-1330

email: daverman@math.utk.edu

Applications received by 30 September 2007
will be assured full consideration.

AMS
American Mathematical Society
www.ams.org

Mathematics Calendar

The most comprehensive and up-to-date Mathematics Calendar information is available on the AMS website at http://www.ams.org/mathcal/.

August 2007

* 6–8 **Workshop on Quantum Groups and Noncommutative Geometry**, Max Planck Institut für Mathematik, Bonn, Germany.
Organizers: Matilde Marcolli (Bonn), Deepak Parashar (Warwick/Bonn).
Information: email: qg@mpim-bonn.mpg.de; http://www.mpim-bonn.mpg.de/Events/This+Year+and+Prospect/Workshop+on+Quantum+Groups+and+.../.

* 17–19 **Young Mathematicians Conference 2007**, The Ohio State University, Columbus, Ohio.
Description: The conference provides an opportunity for undergraduate students around the country to present their research in mathematics in short talks and posters, and for mentors to exchange ideas.
Speakers: Ruth Charney (Brandeis University), Dennis DeTurck (University of Pennsylvania), and Amelia Taylor (Colorado College).
Information: Information and application forms can be found at: http://www.math.osu.edu/conferences/ymc/.

September 2007

* 3–7 **Some Trends in Algebra '07**, Czech University of Agriculture, Prague, Czech Republic.
Program: The topics include various aspects of module theory. The main focus is on category theoretic, homological, set theoretic and model theoretic methods.
Organizers: Department of Algebra, Charles University in Prague, Department of Mathematics, Czech Agricultural University.
Information: http://www.karlin.mff.cuni.cz/katedry/ka/sta07.htm.

* 23–26 **The 15th International Symposium on Graph Drawing**, Syndey, Australia.
Scope: The range of topics that are within the scope of the International Symposium on Graph Drawing includes (but is not limited to): • Visualization of networks, • Web maps, • software engineering diagrams, • database schemas, • chemical structures and molecules, • Graph Algorithms, • Geometric graph theory, • Geometric computing, • Software systems for graph visualization, • Topology and planarity, • Graph theory and optimization on graphs, • Interfaces for interacting with graphs, • Task analysis to guide graph drawing.
Invited Speakers: Brendan McKay (ANU, Australia), Norishige Chiba (Iwate University, Japan).
Contact Information: The organizing committee can be contacted at gd2007@cs.usyd.edu.au.

* 24–25 **DIMACS/DyDAn Workshop on Computational Methods for Dynamic Interaction Networks**, DIMACS Center, CoRE Building, Rutgers University, Piscataway, New Jersey.
Short Description: A substantial body of research in various sciences aims at understanding the dynamics and patterns of interactions within populations, in particular how social groups arise and evolve. As a result of the advances in communications and computing technology, extreme amounts of data are being accumulated representing the evolution of large scale communication networks, such as the WWW, chatrooms, Blogs, and networks of bluetooth enabled handheld devices. Moreover, as small sensors become largely available and affordable, new research areas are exploiting the social networks resulting from those sensor networks data. Finding patterns of social interaction within a population has been addressed in a wide range applications including: dis-

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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/.

ease modeling cultural and information transmission, intelligence and surveillance, business management, conservation biology and behavioral ecology.

Organizers: Tanya Berger-Wolf, University of Illinois at Chicago, tanyabw@uic.edu; Mark Goldberg, RPI, goldberg@cs.rpi.edu; Malik Magdon-Ismail, RPI, magdon@cs.rpi.edu; Fred Roberts, DIMACS, froberts@dimacs.rutgers.edu; William "Al" Wallace, RPI, wallaw@rpi.edu.

Information: http://dimacs.rutgers.edu/Workshops/Dynamic.

October 2007

* 22–26 **Numerical Tools and Fast Algorithms for Massive Data Mining, Search Engines and Applications**, UCLA, Los Angeles, California.

Topics: Deterministic and randomized algorithms for matrix approximation, Analysis of dense matrices, Fast algorithms for SVD solvers, Algorithms for l0 and l1 approximation, High precision randomized algorithms of linear algebra, Interior point methods, Relation of fast solvers to the Fast Multipole Method, Manifold approximation, Band-limited functions on data sets.

Organizing Committee: Yann LeCun, Chair (New York University), Ming Gu (University of California, Berkeley), Piotr Indyk (Massachusetts Institute of Technology), Vladimir Rokhlin (Yale University), Sam Roweis (University of Toronto), Andrew Zisserman (University of Oxford).

Application/Registration: An application/registration form is available at http://www.ipam.ucla.edu/programs/sews2/. The application part is for people requesting financial support to attend the workshop. If you don't intend to do this, you may simply register. Applications received by September 3, 2007, will receive fullest consideration.

November 2007

* 1–4 **Knotting Mathematics and Art: a Conference on Low Dimensional Topology and Mathematical Art**, University of South Florida, Tampa, Florida.

Organizers: J. Scott Carter, University of South Alabama; Mohamed Elhamdadi, University of South Florida; Natasa Jonoska, University of South Florida; Seiichi Kamada, Hiroshima University; Akio Kawauchi, Osaka City University; Masahico Saito, University of South Florida; John Sims, JohnSimsProjects.

Program: Lectures on knot theory, low dimensional topology and mathemtical art. Exhibition of mathematical art.

Information: Contact: saito@math.usf.edu (Masahico Saito), jonoska@math.usf.edu (Natasha Jonoska); http://knotart.cas.usf.edu.

January 2008

* 10–13 **First Announcement for Thirteenth Annual Conference and First International Conference of Gwalior Academy of Mathematical Sciences (GAMS) with Symposium on Mathematical Modeling in Engineering and Biosciences**, Anand Engineering College, Agra, U.P. India.

Workshop Topic: Mathematical Modeling in Engineering and Biosciences.

Organizers: Jointly organized by Gwalior Academy of Mathematical Sciences (GAMS): http://www.gamsinfo.com & Anand Engineering College, Keetham, AGRA-282007 (India).

Deadlines: Last date for Pre- Registration & Submission of Abstract: August 6, 2007. Communication of Acceptance: September 10, 2007. Last date for submission of full-length papers for publication in the Proceedings: October 1, 2007. Second Announcement: October, 2007.

Information: General Correspondence: Prof. V. P. Saxena, Anand Engineering College Keetham, Agra- Delhi Road (N.H. #2) Agra-282007, India; Mob. +91-94251-09044; email: saxena_vp@rediffmail.com. Submission of Abstracts and Papers: Prof. K. R. Pardasani, Department of Mathematics, Maulana Azad National Institute of Technology, Bhopal- 462007, India; Bhopal- 462007, India; Mob. +91-94253-58308; email: 13plus1gams@gmail.com; http://kamrajp@hotmail.com.

* 28–February 1 **Image Analysis Challenges in Molecular Microscopy**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

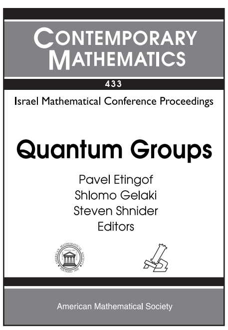
Description: Scientific Background: Understanding the hierarchical organization of molecules, multi-protein assemblies, organelles and networks within the interior of a eukaryotic cell is a challenge of fundamental interest in cell biology. A wide variety of microscopic and spectroscopic methods already exist for imaging intact cells and their components: modern fluorescence microscopic methods provide powerful tools for imaging at spatial resolutions in the micron range, while emerging methods in electron microscopy can be used to image the arrangement of protein assemblies at resolutions of 1 nm or better. To take advantage of these rapid advances in imaging technology, it is critical to develop and apply advanced computational strategies for image processing that can cope both with the volume and complexity of the data. This conference seeks to bring together leaders at this interdisciplinary interface of image processing and stimulate new partnerships to address computational problems at this exciting frontier of cell biology. The one-week meeting will bring together biologists, physicists, mathematicians and specialists in microscopy and image analysis.

Organizing Committee: Guillermo Sapiro, Chair (University of Minnesota, Twin Cities), Alberto Bartesaghi (National Institutes of Health (NIH)), Jacqueline Milne (National Institutes of Health (NIH)), Sriram Subramaniam (National Institutes of Health (NIH)).

Application/Registration: An application/registration form is available on http://www.ipam.ucla.edu/programs/imm2008/. The application part is for people requesting financial support to attend the workshop. If you don't intend to do this, you may simply register. We urge you to apply as early as possible. Applications received by December 17, 2007, will receive fullest consideration. Successful applicants will be notified as soon as funding decisions are made. We have funding to support the attendance of recent Ph.D.s, graduate students, and researchers in the early stages of their career; however, mathematicians and scientists at all levels who are interested in this area are encouraged to apply for funding. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.

New Publications Offered by the AMS

Algebra and Algebraic Geometry



Quantum Groups

Pavel Etingof, *Massachusetts Institute of Technology, Cambridge, MA*, **Shlomo Gelaki**, *Technion-Israel Institute of Technology, Haifa, Israel*, and **Steven Shnider**, *Bar-Ilan University, Ramat-Gan, Israel*, Editors

The papers in this volume are based on the talks given at the conference on quantum groups dedicated to the memory of Joseph Donin, which was held at the Technion Institute, Haifa, Israel in July 2004. A survey of Donin's distinguished mathematical career is included. Several articles, which were directly influenced by the research of Donin and his colleagues, deal with invariant quantization, dynamical R-matrices, Poisson homogeneous spaces, and reflection equation algebras. The topics of other articles include Hecke symmetries, orbifolds, set-theoretic solutions to the pentagon equations, representations of quantum current algebras, unipotent crystals, the Springer resolution, the Fourier transform on Hopf algebras, and, as a change of pace, the combinatorics of smoothly knotted surfaces.

The articles all contain important new contributions to their respective areas and will be of great interest to graduate students and research mathematicians interested in Hopf algebras, quantum groups, and applications.

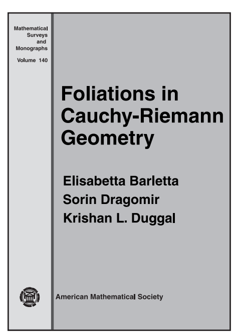
This book is copublished with Bar-Ilan University (Ramat-Gan, Israel).

Contents: **A. Mudrov** and **S. Shnider**, Joseph Donin's mathematical research, 1966–2003; **A. Berenstein** and **D. Kazhdan**, Geometric and unipotent crystals II: From unipotent bicrystals to crystal bases; **R. Bezrukavnikov** and **A. Lachowska**, The small quantum group and the Springer resolution; **A. Braverman**, **D. Gaitsgory**, and **M. Vybornov**, Relation between two geometrically defined bases in representations of GL_n; **M. Cohen** and **S. Westreich**, Fourier transforms for Hopf algebras; **B. Enriquez**, **P. Etingof**, and **I. Marshall**, Quantization of some Poisson-Lie dynamical r-matrices and Poisson homogeneous spaces; **B. Enriquez**, **S. Pakuliak**, and **V. Rubtsov**, Basic representations of quantum current algebras in higher genus; **G. Felder**, **R. Rimányi**, and **A. Varchenko**, Poincaré-Birkhoff-Witt expansions of the canonical elliptic differential form; **D. Gurevich** and **P. Saponov**, Geometry of non-commutative orbits related to Hecke symmetries; **V. Hinich**, Drinfeld double for orbifolds; **R. M. Kashaev** and **N. Reshetikhin**, Symmetrically factorizable groups and set-theoretical solutions of the pentagon equation; **P. P. Kulish** and **A. I. Mudrov**, Dynamical reflection equation; **G. Lancaster**, **R. Larson**, and **J. Towber**, On the combinatorics of Carter-Rieger-Saito movies in the theory of smoothly knotted surfaces in $\mathbb{R}^4$.

Contemporary Mathematics, Volume 433

August 2007, 336 pages, Softcover, ISBN: 978-0-8218-3713-9, LC 2007060761, 2000 *Mathematics Subject Classification:* 16W30, 81R50, 18D10, 17B37, **AMS members US$79**, List US$99, Order code CONM/433

Analysis



Foliations in Cauchy–Riemann Geometry

Elisabetta Barletta and **Sorin Dragomir**, *Università degli Studi della Basilicata, Potenza, Italy*, and **Krishan L. Duggal**, *University of Windsor, Ontario, Canada*

The authors study the relationship between foliation theory and differential geometry and analysis on Cauchy–Riemann (CR) manifolds. The main objects of study are transversally and tangentially CR foliations, Levi foliations of CR manifolds, solutions of the Yang–Mills equations, tangentially Monge–Ampére foliations, the transverse Beltrami equations, and CR orbifolds. The novelty of the authors' approach consists in the overall use of the methods of foliation theory and choice of specific applications. Examples of such applications are Rea's holomorphic extension of Levi foliations, Stanton's holomorphic degeneracy, Boas and

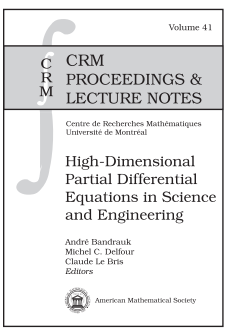
Straube's approximately commuting vector fields method for the study of global regularity of Neumann operators and Bergman projections in multi-dimensional complex analysis in several complex variables, as well as various applications to differential geometry. Many open problems proposed in the monograph may attract the mathematical community and lead to further applications of foliation theory in complex analysis and geometry of Cauchy–Riemann manifolds.

Contents: Review of foliation theory; Foliated CR manifolds; Levi foliations; Levi foliations of CR submanifolds in $\mathbb{C}P^N$; Tangentially CR foliations; Transversally CR foliations; $\mathcal{G}$-Lie foliations; Transverse Beltrami equations; Review of orbifold theory; Pseudo-differential operators on orbifolds; Cauchy-Riemann orbifolds; Holomorphic bisectional curvature; Partition of unity on orbifolds; Pseudo-differential operators on $\mathbb{R}^n$; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 140

July 2007, 256 pages, Hardcover, ISBN: 978-0-8218-4304-8, LC 2007060684, 2000 *Mathematics Subject Classification:* 53C12, 53C50, 53D10, 32T15, 32T27, 32V05, 32V15, 32V20, 32V30, 32V35, **AMS members US$60**, List US$75, Order code SURV/140

Differential Equations



High-Dimensional Partial Differential Equations in Science and Engineering

André Bandrauk, *Université de Sherbrooke, QC, Canada*, **Michel C. Delfour**, *Université de Montréal, QC, Canada*, and **Claude Le Bris**, *École Nationale des Ponts et Chaussés, Marne La Vallée, France, and INRIA Rocquencourt, Le Chesnay, France*, Editors

High-dimensional spatio-temporal partial differential equations are a major challenge to scientific computing of the future. Up to now deemed prohibitive, they have recently become manageable by combining recent developments in numerical techniques, appropriate computer implementations, and the use of computers with parallel and even massively parallel architectures. This opens new perspectives in many fields of applications. Kinetic plasma physics equations, the many body Schrödinger equation, Dirac and Maxwell equations for molecular electronic structures and nuclear dynamic computations, options pricing equations in mathematical finance, as well as Fokker–Planck and fluid dynamics equations for complex fluids, are examples of equations that can now be handled.

The objective of this volume is to bring together contributions by experts of international stature in that broad spectrum of areas to confront their approaches and possibly bring out common problem formulations and research directions in the numerical solutions of high-dimensional partial differential equations in various fields of science and engineering with special emphasis on chemistry and physics.

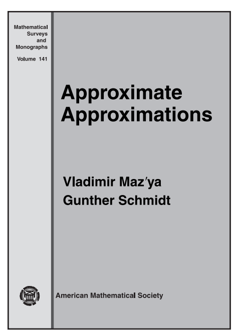
This item will also be of interest to those working in mathematical physics and applications.

Titles in this series are co-published with the Centre de Recherches Mathématiques.

Contents: A. D. Bandrauk and **H. Lu**, Singularity-free methods for the time-dependent Schrödinger equation for nonlinear molecules in intense laser fields—A non-perturbative approach; **E. Cancès**, **C. Le Bris**, **Y. Maday**, **N. C. Nguyen**, **A. T. Patera**, and **G. S. H. Pau**, Feasibility and competitiveness of a reduced basis approach for rapid electronic structure calculations in quantum chemistry; **G. Chen**, **Z. Ding**, **A. Perronnet**, **M. O. Scully**, **R. Xie**, and **Z. Zhang**, Some fundamental mathematical properties in atomic and molecular quantum mechanics; **P. Delaunay**, **A. Lozinski**, and **R. G. Owens**, Sparse tensor-product Fokker–Planck-based methods for nonlinear bead-spring chain models of dilute polymer solutions; **M. Escobar** and **L. Seco**, A partial differential equation for credit derivatives pricing; **M. J. Esteban**, A short review on computational issues arising in relativistic atomic and molecular physics; **P. Gori-Giorgi**, **J. Toulouse**, and **A. Savin**, Model Hamiltonians in density functional theory; **H. Kim** and **R. Kapral**, Simulation of quantum-classical dynamics by surface-hopping trajectories; **D. M. Koch**, **Q. K. Timerghazin**, and **G. H. Peslherbe**, Simulating realistic and nonadiabatic chemical dynamics: Application to photochemistry and electron transfer reactions; **E. Lorin**, **S. Chelkowski**, and **A. Bandrauk**, A Maxwell-Schrödinger model for non-perturbative laser-molecule interaction and some methods of numerical computation; **Y. Maday**, Parareal in time algorithm for kinetic systems based on model reduction.

CRM Proceedings & Lecture Notes, Volume 41

July 2007, 194 pages, Softcover, ISBN: 978-0-8218-3853-2, LC 2007060763, 2000 *Mathematics Subject Classification:* 65Mxx, 35Gxx; 76-XX, **AMS members US$63**, List US$79, Order code CRMP/41



Approximate Approximations

Vladimir Maz′ya, *University of Linköping, Sweden, and University of Liverpool, United Kingdom*, and **Gunther Schmidt**, *Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany*

In this book, a new approach to approximation procedures is developed. This new approach is characterized by the common feature that the procedures are accurate without being convergent as the mesh size tends to zero. This lack of convergence is compensated for by the flexibility in the choice of approximating functions, the simplicity of multi-dimensional generalizations, and the possibility of obtaining explicit formulas for the values of various integral and pseudodifferential operators applied to approximating functions.

The developed techniques allow the authors to design new classes of high-order quadrature formulas for integral and pseudodifferential operators, to introduce the concept of approximate wavelets, and to develop new efficient numerical and semi-numerical methods for solving boundary value problems of mathematical physics.

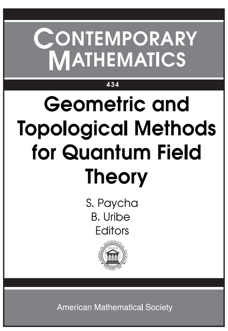
The book is intended for researchers interested in approximation theory and numerical methods for partial differential and integral equations.

Contents: Quasi-interpolation; Error estimates for quasi-interpolation; Various basis functions—examples and constructions; Approximation of integral operators; Cubature of diffraction, elastic, and hydrodynamic potentials; Some other cubature problems; Approximation by Gaussians; Approximate wavelets; Cubature over bounded domains; More general grids; Scattered data approximate approximations; Numerical algorithms based upon approximate approximations—linear problems; Numerical algorithms based upon approximate approximations—non-linear problems; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 141

August 2007, approximately 356 pages, Hardcover, ISBN: 978-0-8218-4203-4, LC 2007060769, 2000 *Mathematics Subject Classification:* 41A30, **AMS members US$71**, List US$89, Order code SURV/141

Mathematical Physics



Geometric and Topological Methods for Quantum Field Theory

S. Paycha, *Université Blaise Pascal, Aubière, Cedex, France*, and **B. Uribe**, *Universidad de Los Andes, Bogatá, Columbia*, Editors

This volume, based on lectures and short communications at a summer school in Villa de Leyva, Colombia (July 2005), offers an introduction to some recent developments in several active topics at the interface between geometry, topology and quantum field theory. It is aimed at graduate students in physics or mathematics who might want insight in the following topics (covered in five survey lectures):

- Anomalies and noncommutative geometry,
- Deformation quantisation and Poisson algebras,
- Topological quantum field theory and orbifolds.

These lectures are followed by nine articles on various topics at the borderline of mathematics and physics ranging from quasicrystals to invariant instantons through black holes, and involving a number of mathematical tools borrowed from geometry, algebra and analysis.

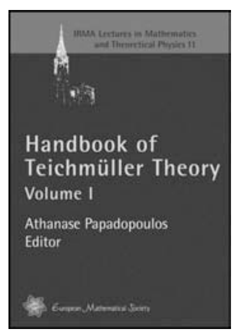
Contents: *Invited lecturers:* **M. Bordemann**, Deformation quantizaton: A mini-lecture; **G. Landi**, Examples of noncommutative instantons; **E. Lupercio** and **B. Uribe**, Topological quantum field theories, strings and orbifolds; **H. Omori**, **Y. Maeda**, **N. Miyazaki**, and **A. Yoshioka**, Non-formal deformation quantization of Fréchet-Poisson algebras: The Heisenberg Lie algebra case; **D. Perrot**, Anomalies and noncommutative index theory; *Contributed talks:* **M. Ángel** and **R. Díaz**, N-flat connections; **A. Cáceres**, Dirac equation in a black hole background; **E. Castillo** and **R. Díaz**, Homological matrices; **A. Giniatoulline** and **O. Zapata**, On some qualitative properties of stratified flows; **M. P. Gomez-Aparicio**, Property (T) and tensor products by irreducible finite dimensional representations for $SL_n(\mathbb{R})n \geq 3$; **R. M. Manasliski**, Painlevé VI equation from invariant instantons; **J. Plazas**, Quantum statistical mechanics and class field theory; **P. Polesello**, Uniqueness of Kashiwara's quantization of complex contact manifolds; **F. Ypma**, K-theoretic gap labeling for quasicrystals.

Contemporary Mathematics, Volume 434

August 2007, 255 pages, Softcover, ISBN: 978-0-8218-4062-7, LC 2007060762, 2000 *Mathematics Subject Classification:* 53-06, 55-06, 58-06, 81-06, **AMS members US$63**, List US$79, Order code CONM/434

New AMS-Distributed Publications

Analysis



Handbook of Teichmüller Theory

Volume I

Athanase Papadopoulos, *Institut de Recherche Mathématique Avancée, Strasbourg, France*, Editor

The Teichmüller space of a surface was introduced by O. Teichmüller in the 1930s. It is a basic tool in the study of Riemann's moduli spaces and the mapping class groups. These objects are fundamental in several fields of mathematics, including algebraic geometry, number theory, topology, geometry, and dynamics.

The original setting of Teichmüller theory is complex analysis. The work of Thurston in the 1970s brought techniques of hyperbolic geometry to the study of Teichmüller space and its asymptotic geometry. Teichmüller spaces are also studied from the point of view of the representation theory of the fundamental group of the surface in a Lie group G, most notably $G = \mathrm{PSL}(2,\mathbb{R})$ and $G = \mathrm{PSL}(2,\mathbb{C})$. In the 1980s, there evolved an essentially combinatorial treatment of the Teichmüller and moduli spaces involving techniques and ideas from high-energy physics, namely from string theory. The current research interests include the quantization of Teichmüller space, the Weil-Petersson symplectic and Poisson geometry of this space as well as gauge-theoretic extensions of these structures. The quantization theories can lead to new invariants of hyperbolic 3-manifolds.

The purpose of this handbook is to give a panorama of some of the most important aspects of Teichmüller theory. The handbook should be useful to specialists in the field, to graduate students, and more generally to mathematicians who want to learn about the subject. All the chapters are self-contained and have a pedagogical character. They are written by leading experts in the subject.

This item will also be of interest to those working in geometry and topology.

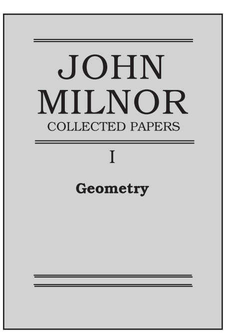
A publication of the European Mathematical Society. Distributed within the Americas by the American Mathematical Society.

Contents: A. Papadopoulos, Introduction to Teichmüller theory, old and new; *Part A. The metric and the analytic theory, 1:* **G. D. Daskalopoulos** and **R. A. Wentworth**, Harmonic maps and Teichmüller theory; **A. Papadopoulos** and **G. Théret**, On Teichmüller's metric and Thurston's asymmetric metric on Teichmüller space; **R. C. Penner**, Surfaces, circles, and solenoids; **J.-P. Otal**, About the embedding of Teichmüller space in the space of geodesic Hölder distributions; **W. J. Harvey**, Teichmüller spaces, triangle groups and Grothendieck dessins; **F. Herrlich** and **G. Schmithüsen**, On the boundary of Teichmüller disks in Teichmüller and in Schottky space; *Part B. The group theory, 1:* **S. Morita**, Introduction to mapping class groups of surfaces and related groups; **L. Mosher**, Geometric survey of subgroups of mapping class groups; **A. Marden**, Deformations of Kleinian groups; **U. Hamenstädt**, Geometry of the complex of curves and of Teichmüller space; *Part C. Surfaces with singularities and discrete Riemann surfaces:* **C. Charitos** and **I. Papadoperakis**, Parameters for generalized Teichmüller spaces; **M. Troyanov**, On the moduli space of singular euclidean surfaces; **C. Mercat**, Discrete Riemann surfaces; *Part D. The quantum theory, 1:* **L. O. Chekhov** and **R. C. Penner**, On quantizing Teichmüller and Thurston theories; **V. V. Fock** and **A. B. Goncharov**, Dual Teichmüller and lamination spaces; **J. Teschner**, An analog of a modular functor from quantized Teichmüller theory; **R. M. Kashaev**, On quantum moduli space of flat $PSL_2(\mathbb{R})$-connections; List of contributors; Index.

IRMA Lectures in Mathematics and Theoretical Physics, Volume 11

May 2007, 802 pages, Hardcover, ISBN: 978-3-03719-029-6, 2000 *Mathematics Subject Classification:* 30-00, 32G15, 30F60; 30C62, 57N16, 53A35, 20F65, 30F20, 30F25, 30F10, 30F30, 30F40, 30F45, 14H15, 20H10, 30F15, 53B35, 57M60, 14H60, 14D20, 57M20, 20F38, 57M07, **AMS members US$102**, List US$128, Order code EMSILMTP/11

Geometry and Topology



John Milnor Collected Papers

Volume I: Geometry

John Milnor, *SUNY at Stony Brook, NY*

This volume contains papers on geometry of one of the best modern geometers and topologists, John Milnor. This book covers a wide variety of topics and includes several previously unpublished works. It is delightful reading for any mathematician with an interest in geometry and topology and for any person with an interest in mathematics. (A number of papers in the collection, intended for a general mathematical audience, have been published in the *American Mathematical Monthly.*) Each paper is accompanied by the author's comments on further development of the subject.

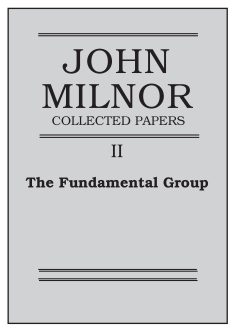
This volume contains twenty-one papers and is partitioned into three parts: differential geometry and curvature, algebraic geometry and topology, and Euclidean and non-Euclidean geometry. Although some of the papers were written quite a while ago, they appear more modern than many of today's publications. Milnor's excellent, clear, and laconic style makes the book a real treat.

This volume is highly recommended to a broad mathematical audience, and, in particular, to young mathematicians who will certainly benefit from their acquaintance with Milnor's mode of thinking and writing.

A publication of Publish or Perish, Inc.

Contents: Differential geometry and curvature; Algebraic geometry and topology; Euclidean and non-euclidean geometry.

October 1994, 295 pages, Hardcover, ISBN: 978-0-914098-30-0, 2000 *Mathematics Subject Classification:* 01A75; 53-03, 55-03, 57-03, **AMS members US$47**, List US$59, Order code MILNOR/1



John Milnor Collected Papers

Volume II: The Fundamental Group

John Milnor, *SUNY at Stony Brook, NY*

This volume contains papers of one of the best modern geometers and topologists, John Milnor, on various topics related to the notion of the fundamental group. It is excellent reading for any mathematician with an interest in geometry and topology and for any person with an interest in mathematics.

This volume contains sixteen papers and is partitioned into four parts: Knot theory, free action on spheres, torsion, and three-dimensional manifolds. Each part is preceded by an introduction containing the author's comments on further development of the subject. Although some of the papers were written quite a while ago, they appear more modern than many of today's publications. Milnor's excellent, clear, and laconic style makes the book a real treat.

This volume is highly recommended to a broad mathematical audience, and, in particular, to young mathematicians who will certainly benefit from their acquaintance with Milnor's mode of thinking and writing.

A publication of Publish or Perish, Inc.

Contents: Part 1: Knot theory; Part 2: Free actions on spheres; Part 3: Torsion; Part 4: Three-dimensional manifolds.

December 1995, 302 pages, Hardcover, ISBN: 978-0-914098-31-7, 2000 *Mathematics Subject Classification:* 54-XX, 55-XX, **AMS members US$47**, List US$59, Order code MILNOR/2

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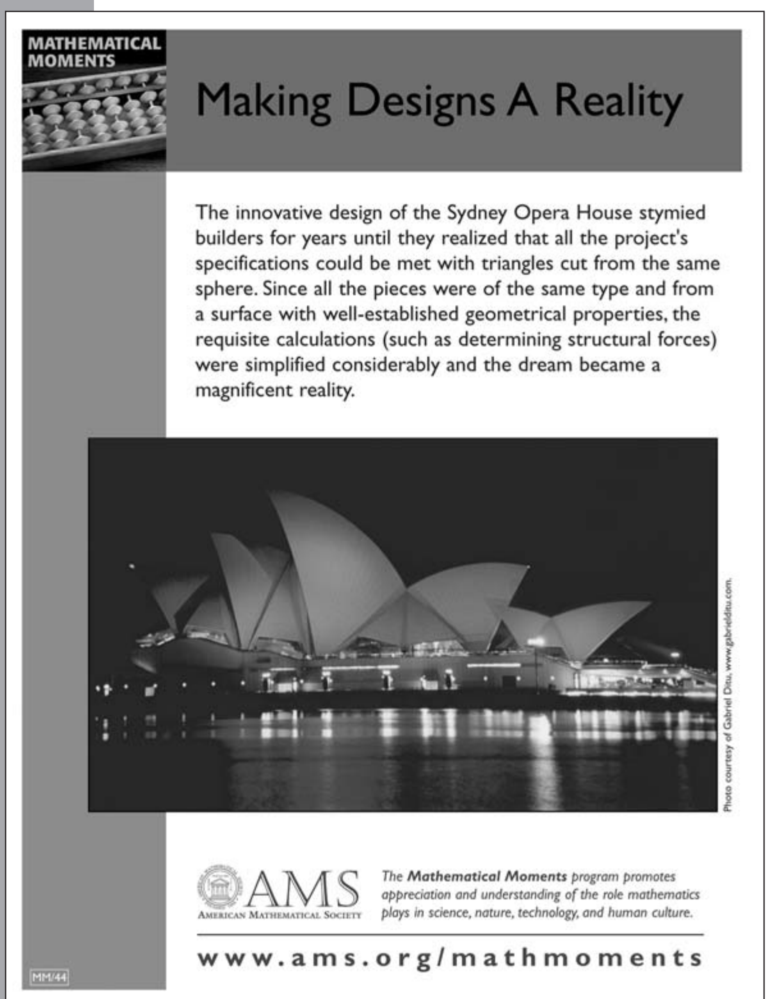

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Upcoming deadlines for classified advertising are as follows: September 2007 issue–June 28, 2007;October 2007 issue–July 26, 2007; November 2007 issue–August 28, 2007; December 2007 issue–October 1, 2007; January 2008 issue–October 26, 2007; February 2008 issue–November 28, 2007.

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.

About the Cover

In 1934 Lipman Bers Escaped from Riga to Prague

This month's cover accompanies the short excerpt in this issue from the memoir written by Lipman Bers about his stay in Prague 1934–1938. Those were difficult times. Czechoslavakia alone among the countries of Europe had a reputation for welcoming exiles. When Chamberlain and the French gave away the country they gave away more than the Czechs alone. In the memoir Bers refers to the "famous" pink passport issued to foreigners seeking asylum, and it is his own that is shown on the cover, along with his matriculation certificate at the University of Prague. What other mathematicians passed through with one of these passports?

"Religion: konfessionslos", but "Nationalität: Jude" might seem a bit strange nowadays, but even up until not too long ago it seems to have been a feature of documentation in post-war Eastern Europe.

Included here is an additional short excerpt from Bers' memoir, sent by his son Victor Bers, a professor in the Classics Department of Yale University. It has little to do with mathematics, true, but seems to capture well some of the flavor of those long dead days. It helps to know at the beginning that Lipman was carrying his stepfather's passport instead of his own.

The night before my departure was the first time in my life that I had trouble falling asleep. (For many years after, I couldn't fall asleep if I had to go to another town the next day.) I was ordered the next morning to take my small suitcase and board a truck with the company name "W. Weinberg", and get out soon after leaving the town, where a car would pick me up. When the car came, I recognized the driver, an anti-Nazi refugee, who made his living by smuggling. He was to bring me to Tallinn, the capital of Estonia. We avoided the bigger hamlets, and went instead from village to village. The trip lasted eight hours. This was my first car trip except for very short taxi voyages from Riga to the beach. When we were approaching the state boundary separating Latvia from Estonia, my guide reminded me that the internal Latvian passport that I carried was in someone else's name. Once he said this, the whole situation became very unpleasant, and I said only that we would decide how to act at the very last moment.

Actually, everything went very smoothly. The border was guarded by just one soldier, who seemed interested exclusively in the large bottle of vodka which we gave him. Once we realized that, we acted almost automatically. The soldier accepted the passport without looking at the photograph, and put a Latvian stamp in it. In a few minutes we were in Estonia. The driver then gave me back my Latvian internal passport (the one that was actually in my name), and promised to see to it that the false passport would be put back in the legitimate owner's hands as soon as possible. Then the smuggler asked for a rather large sum of money for having driven me across the border. This surprised me because my father had told me that he had already paid the man to do so. But as a young man abroad, under rather complicated circumstances, there was little I could do, and I gave him the money.

We wish to thank Victor Bers and his sister Ruth Shapiro for extraordinary effort in helping us put together the material on Lipman.

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

Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Warsaw, Poland

University of Warsaw

July 31 – August 3, 2007

Tuesday – Friday

Meeting #1029

First Joint International Meeting between the AMS and the Polish Mathematical Society
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: May 2007
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: To be announced

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

Invited Addresses

Henryk Iwaniec, Rutgers University, *Golden nuggets of sieve methods*.

Tomasz J. Luczak, Adam Mickiewicz University, *Title to be announced*.

Tomasz Mrowka, Massachusetts Institute of Technology, *Reflections on homological invariants for knots*.

Ludomir Newelski, University of Wroclaw, *Topological dynamics and model theory*.

Madhu Sudan, Massachusetts Institute of Technology, *List decoding: A survey*.

Anna Zdunik, Warsaw University, *Title to be announced*.

Special Sessions

Arithmetic Algebraic Geometry, **Grzegorz Banaszak**, Adam Mickiewicz University, **Eric Friedlander**, Northwestern University, **Wojciech Gajda**, Adam Mickiewicz University, **Piotr Krason**, Szczecin University, and **Wieslawa Nizio**.

Complex Analysis, **Zeljko Cuckovic**, University of Toledo, **Zbigniew Blocki**, Jagiellonian University, and **Marek Ptak**, University of Agriculture.

Complex Dynamics, **Robert Devaney**, Boston University, **Jane N. Hawkins**, University of North Carolina, and **Janina Kotus**, Warsaw University of Technology.

Complexity of Multivariate Problems, **Joseph F. Traub**, Columbia University, **Grzegoorz W. Wasilkowski**, University of Kentucky, and **Henryk Wozniakowski**, Columbia University.

Control and Optimization of Non-linear PDE Systems, **Irena Lasiecka**, University of Virginia, and **Jan Sokolowski**, Systems Research institute.

Dynamical Systems, **Steven Hurder**, University of Illinois at Chicago, **Michal Misiurewicz**, Indiana University-Purdue University Indianapolis, and **Pawel Walczak**, University of Lodz.

Dynamics, Control and Optimization of Finite Dimensional Systems: Theory and Applications to Biomedicine, **Urszula Forys**, Warsaw University, **Urszula Ledzewicz**, Southern Illinois University, and **Heinz Schaettler**, Washington University.

Ergodic Theory and Topological Dynamics, **Dan Rudolph**, Colorado State University, and **Mariusz Lemanczyk**, Nicholas Copernicus University.

Extremal and Probabilistic Combinatorics, **Joel Spencer**, New York University-Courant Institute, and **Michal Karonski** and **Andrzej Rucinski**, Adam Mickiewicz University.

Function Spaces, Theory of Operators and Geometry of Banach Spaces, **Henryk Hudzik**, Adam Mickiewicz University, **Anna Kaminska**, University of Memphis, and **Mieczyslaw Mastylo**.

Geometric Applications of Homotopy Theory, **Yuli B. Rudyak**, University of Florida, **Boguslaw Hajduk**, Warsaw University, **Jaroslaw Kedra**, University of Aberdeen, and **Aleksy Tralle**, The College of Economics & Comp Science.

Geometric Function Theory, **Michael Dorff**, Brigham Young University, **Piotr Liczberski**, University of Lodz, **Maria Nowak**, Biblioteka Instytutu Matematyki, and **Ted Suffridge**, University of Kentucky.

Geometric Group Theory, **Mladen Bestvina**, University of Utah, **Tadeusz Januszkiewicz**, Ohio State University, and **Jacek Swiatkowski**, University of Wroclaw.

Geometric Topology, **Jerzy Dydak**, University of Tennessee, **Slawomir Nowak**, and **Stanislaw Spiez**, University of Warsaw.

Homotopy Methods in Algebra and Topology, **Wojciech Chacholski**, KTH Stockholm, **Jan Spalinski**, Politechnika Warszawska, and **Michele Intermont**, Kalamazoo College.

Invariants of Links and 3-manifolds, **Mieczyslaw Dabkowski**, University of Texas at Dallas, **Jozef H. Przytycki**, George Washington University, **Adam S. Siroka**, State University of New York at Buffalo, and **Pawel Traczyk**, Warsaw University.

Issues in Reforming Mathematics Education, **Jeremy Kilpatrick**, University of Georgia, and **Zbigniew Semadeni**, University of Warsaw.

Mathematics of Large Quantum Systems, **Michael Loss**, Georgia Institute of Technology, **Jan Philip Solovej**, University of Copenhagen, and **Jan Derezinski**, University of Warsaw.

Noncommutative Geometry and Quantum Groups, **Paul Baum**, Pennsylvania State University, and **Ulrich Kraehmer** and **Tomasz Maszczyk**.

Partial Differential Equations of Evolution Type, **Susan J. Friedlander**, University of Illinois at Chicago, and **Grzegorz A. Karch**, University of Wroclaw.

Quantum Information Theory, **Robert Alicki**, University of Gdansk, and **Mary Beth Ruskai**, Tufts University.

Topological Fixed Point Theory and Related Topics, **Jerzy Jezierski**, University of Agriculture, **Wojciech Kryszewski**, Nicholas Copernicus University, and **Peter Wong**, Bates College.

Topology of Manifolds and Transformation Groups, **Slawomir Kwasik**, **Krzysztof Pawalowski**, and **Dariusz Wilczynski**, Utah State University.

Chicago, Illinois

DePaul University (Loop Campus)

October 5–6, 2007

Friday – Saturday

Meeting #1030

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2007
Program first available on AMS website: August 16, 2007
Program issue of electronic *Notices*: October 2007
Issue of *Abstracts*: Volume 28, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: August 7, 2007

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Martin Golubitsky, University of Houston, *Symmetry breaking and synchrony breaking.*

Matthew J. Gursky, University of Notre Dame, *Origins and applications of some nonlinear equations in conformal geometry.*

Alex Iosevich, University of Missouri, *Incidence theory, Fourier analysis and applications to geometric combinatorics and additive number theory.*

David E. Radford, University of Illinois at Chicago, *Title to be announced.*

Special Sessions

Algebraic Coding Theory (in Honor of Harold N. Ward's Retirement) (Code: SS 19A), **Jay A. Wood**, Western Michigan University.

Algebraic Combinatorics: Association Schemes and Related Topics (Code: SS 1A), **Sung Y. Song**, Iowa State University, and **Paul Terwilliger**, University of Wisconsin.

Algebraic Geometry (Code: SS 5A), **Lawrence Man Hou Ein** and **Anatoly S. Libgober**, University of Illinois at Chicago.

Algorithmic Probability and Combinatorics (Code: SS 22A), **Manuel Lladser**, University of Colorado, and **Robert S. Maier**, University of Arizona.

Analysis and CR geometry (Code: SS 12A), **Song-Ying Li**, University of California Irvine, and **Stephen S.-T. Yau**, University of Illinois at Chicago.

Applied Harmonic Analysis (Code: SS 13A), **Jonathan Cohen** and **Ahmed I. Zayed**, DePaul University.

Automorphic Forms: Representation Theory of p-adic and Adelic Groups (Code: SS 8A), **Mahdi Asgari** and **Anantharam Raghuram**, Oklahoma State University.

Differential Geometry and its Applications (Code: SS 17A), **Jianguo Cao**, University of Notre Dame.

Ergodic Theory and Symbolic Dynamical Systems (Code: SS 7A), **Ayse A. Sahin** and **Ilie D. Ugarcovici**, DePaul University.

Extremal and Probabilistic Combinatorics (Code: SS 3A), **Jozsef Balogh**, University of Illinois at Urbana-Champaign, and **Dhruv Mubayi**, University of Illinois at Chicago.

Free Resolutions (Code: SS 21A), **Noam Horwitz** and **Irena Peeva**, Cornell University.

Geometric Combinatorics (Code: SS 15A), **Caroline J. Klivans**, University of Chicago, and **Kathryn Nyman**, Loyola University Chicago.

Graph Theory (Code: SS 20A), **Hemanshu Kaul** and **Michael J. Pelsmajer**, Illinois Institute of Technology.

Hopf Algebras and Related Areas (Code: SS 2A), **Yevgenia Kashina** and **Leonid Krop**, DePaul University, **M. Susan Montgomery**, University of Southern California, and **David E. Radford**, University of Illinois at Chicago.

Mathematical Modeling and Numerical Methods (Code: SS 16A), **Atife Caglar**, University of Wisconsin-Green Bay.

Model Theory of Non-elementary Classes (Code: SS 23A), **John T. Baldwin**, University of Illinois at Chicago, **David W. Kueker**, University of Maryland, and **Rami Grossberg**, Carnegie Mellon University.

Nonlinear Conservation Laws and Related Problems (Code: SS 11A), **Cleopatra Christoforou** and **Gui-Qiang Chen**, Northwestern University.

Numerical and Symbolic Techniques in Algebraic Geometry and Its Applications (Code: SS 18A), **GianMario Besana**, DePaul University, **Jan Verschelde**, University of Illinois at Chicago, and **Zhonggang Zeng**, Northeastern Illinois University.

Sequence Spaces and Transformations (Code: SS 10A), **Constantine Georgakis**, DePaul University, and **Martin Buntinas**, Loyola University of Chicago.

Singular Integrals and Related Problems (Code: SS 14A), **Laura De Carli**, Florida International University, and **A. M. Stokolos**, DePaul University.

Smooth Dynamical Systems (Code: SS 6A), **Marian Gidea**, Northeastern Illinois University, and **Ilie D. Ugarcovici**, DePaul University.

The Euler and Navier-Stokes Equations (Code: SS 4A), **Alexey Cheskidov**, University of Michigan, and **Susan J. Friedlander** and **Roman Shvydkoy**, University of Illinois at Chicago.

Wave Propagation from Mathematical and Numerical Viewpoints (Code: SS 9A), **Gabriel Koch**, University of Chicago, **Catalin Constantin Turc**, Caltech and University of North Carolina at Charlotte, and **Nicolae Tarfulea**, Purdue University Calumet.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice and **state that they will be attending the American Math Society (AMS) meeting**. The AMS is not responsible for rate changes or for the quality of the accommodations. Rates quoted do not include taxes. **Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation**.

Please note that due to exceptional tourist business (conventions and Chicago Marathon) hotel room rates in the downtown area are extremely high and availability very limited. AMS was able to secure rooms at the Crowne Plaza for $175 per night. This hotel is located within walking distance of the meeting. See information below.

Crowne Plaza Chicago Metro, 733 West Madison Ave.; 800-980-6429 or 312-829-5000; $175/single or double. For more information visit `http://www.crowneplaza.com/chicagometro`. **Deadline for reservations is September 10, 2007**.

Please note the following hotels are located near O'Hare Airport in the Rosemont suburb of Chicago. Both hotels are on the CTA Blue Line ($2.00 from each location and exact change is recommended to simplify entering the train stations) and are approximately 30 minutes to the meeting. From the trains, exit at Jackson Boulevard (300 South).

DoubleTree O'Hare-Rosemont Hotel, 5460 North River Road, Rosemont, IL 60018; 847-292-9100; Fax: 847-292-9295; $110 single/double. For more information visit `http://www.doubletree.com/en/dt/hotels/index.jhtml?ctyhocn=CHIDTDT`. **Deadline for reservations is September 13, 2007**.

Hilton Chicago O'Hare Airport, O'Hare International Airport, P.O. Box 66414, Chicago, IL, 60666; 773-686-8000; Fax: 773-601-2873; US$135 single/double. For more information visit `http://www1.hilton.com/en_US/hi/hotel/CHIOHHH-Hilton-Chicago-O-Hare-Airport-Illinois/index.do`. **Deadline for reservations is September 20, 2007**.

Food Service

Campus dining facilities: 11th floor, DePaul Center, 7:30 a.m. to 2:30 p.m. on Friday. The dining facility is closed on Saturday. Many additional restaurants are located within short walking distance. A list of restaurants will be available.

Local Information

Please visit the website maintained by DePaul University at `http://www.depaul.edu` and the department of mathematics at

Other Activities

AMS Book Sale: Stop by the on-site AMS Bookstore—review the newest titles from the AMS, enter the FREE book drawing, enjoy up to 25% off all titles or even take home the new AMS T-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS Book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

Although DePaul University has no parking facilities of its own in the loop area, there are several municipal parking lots in the area. The cost of parking varies.

Registration and Meeting Information

Registration will take place in the lobby on the 8th floor of the DePaul Center, 1 E. Jackson Blvd. from 7:30 a.m. to 5:00 p.m., Friday, October 5, and 8:00 a.m. to noon on Saturday, October 6. Invited addresses will take place on the 8th floor of the DePaul Center and Special Sessions will take place in the DePaul Center and the Lewis Center.

Registration fees: (payable on-site only) US$40/AMS members; US$60/nonmembers; US$5/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Travel

The DePaul Center is located at the intersection of State Street and Jackson Boulevard. It is well served by public transportation and has many nearby parking garages.

By Air: Inquire upon arrival at O'Hare Airport or Midway Airport for public transportation or car rentals. Airport Express vans depart O'Hare every 10 minutes for the 45-minute trip downtown, and from Midway every 15 minutes for the 30-minute trip to downtown.

Driving: From the north and northwest: the campus is accessible from the John F. Kennedy Expressway (I-90/I-94). Exit at Jackson Boulevard (300 South) and turn east. The campus is approximately 1 mile from the expressway at Jackson Blvd.

From the west: The campus is accessible from the Dwight D. Eisenhower Expressway (I-290). As you enter the downtown area the expressway becomes Congress Parkway. Turn left (north) on Dearborn Street (50 West), go two blocks to Jackson Blvd. (300 South) and turn right (east). DePaul University is one block east on Jackson Blvd. at State Street.

From the south: Take I-90/I-94 exit at Jackson Blvd. (300 South) and turn east. The campus is approximately one mile from the expressway on Jackson Boulevard.

By Train or Bus: All rapid transit train lines (CTA) service the campus and include the O'Hare/Congress/Douglas (Blue) and Midway/Loop (Orange). From the trains, exit at Jackson Boulevard (300 South). The fare from each airport is $2.00 and exact change is recommended to simplify entering the train stations.

Car Rental

Avis is the official car rental company for the sectional meeting in Chicago, IL. All rates include unlimited free mileage. Weekend daily rates are available from noon Thursday–Monday at 11:59 p.m. and start at $24 per day. Rates for this meeting are effective September 28–October 13, 2007. Should a lower qualifying rate become available at the time of booking, Avis is pleased to offer a 5% discount off the lower qualifying rate or the meeting rate, whichever is lowest. Rates do not include any state or local surcharges, tax, optional coverages or gas refueling charges. Renters must meet Avis' age, driver, and credit requirements. Reservations can be made by calling 800-331-1600 or online at `http://www.avis.com`. Meeting **Avis Discount Number B159266**.

Weather

The daytime temperatures typically range from 45-65 degrees Fahrenheit, and in the 45 degree range at night. Some light rain is possible.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at `http://www7.nationalacademies.org/visas/Traveling_to_US.html` and `http://travel.state.gov/visa/index.html`. If you need a preliminary conference invitation in order to secure a visa, please send your request to `dls@ams.org`.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

• family ties in home country or country of legal permanent residence

• property ownership

• bank accounts

• employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript). This list is not to be considered complete. Please visit the web sites above for the most up-to-date information.

New Brunswick, New Jersey

Rutgers University-New Brunswick, College Avenue Campus

October 6–7, 2007

Saturday – Sunday

Meeting #1031

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2007
Program first available on AMS website: August 16, 2007
Program issue of electronic *Notices*: October 2007
Issue of *Abstracts*: Volume 28, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: August 7, 2007

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Satyan L. Devadoss, Williams College, *The topology of particle collisions*.

Tara S. Holm, University of Connecticut, *Act globally, compute locally: Localization in symplectic geometry*.

Sir Roger Penrose, University of Oxford, *Spacetime conformal geometry, and a new extended cosmology* (Einstein Public Lecture in Mathematics).

Scott Sheffield, Courant Institute and Institute for Advanced Study, *Random metrics and geometries in two dimensions*.

Mu-Tao Wang, Columbia University, *Isometric embeddings and quasi-local mass*.

Special Sessions

Commutative Algebra (Code: SS 4A), **Jooyoun Hong**, University of California Riverside, and **Wolmer V. Vasconcelos**, Rutgers University.

Geometric Analysis of Complex Laplacians (Code: SS 8A), **Siqi Fu**, Rutgers University, Camden, **Xiaojun Huang**, Rutgers University, New Brunswick, and **Howard J. Jacobowitz**, Rutgers University, Camden.

Invariants of Lie Group Actions and Their Quotients (Code: SS 9A), **Tara S. Holm**, Cornell University, and **Rebecca F. Goldin**, George Mason University.

Mathematical and Physical Problems in the Foundations of Quantum Mechanics (in honor of Shelly Goldstein's 60th birthday) (Code: SS 3A), **Roderich Tumulka** and **Detlef Dürr**, München University, and **Nino Zanghi**, University of Genova.

Noncommutative Geometry and Arithmetic Geometry (Code: SS 10A), **Caterina Consani**, Johns Hopkins University, and **Li Guo**, Rutgers University.

Partial Differential Equations in Mathematical Physics (in honor of Shelly Goldstein's 60th birthday) (Code: SS 2A), **Sagun Chanillo**, **Michael K.-H. Kiessling**, and **Avy Soffer**, Rutgers University.

Partial Differential Equations of Mathematical Physics, I (dedicated to the memory of Tom Branson) (Code: SS 7A), **Sagun Chanillo**, **Michael K.-H. Kiessling**, and **Avy Soffer**, Rutgers University.

Probability and Combinatorics (Code: SS 1A), **Jeffry N. Kahn** and **Van Ha Vu**, Rutgers University.

Set Theory of the Continuum (Code: SS 5A), **Simon R. Thomas**, Rutgers University.

Toric Varieties (Code: SS 6A), **Milena S. Hering**, Institute for Mathematics and Its Applications, and **Diane Maclagan**, Rutgers University.

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. The AMS is not responsible for rate changes or for the quality of the accommodations. When making a reservation, **participants should state that they are with the American Mathematical Society (AMS) Rutgers University meeting**. Cancellation and early checkout penalties vary with each hotel; be sure to check the policy when you make your reservations.

N.B. The number of rooms available at these prices in these hotels is limited! Participants are encouraged to book a hotel room early as rooms may sell out.

The Holiday Inn, Somerset, 195 Davidson Avenue, Somerset, NJ 08873; telephone: 732-356-1700; fax: 732-356-0939; approximately six miles, about a 15-minute ride from the campus meeting site; US$79 for single/double. Rates quoted **do not** include the sales and occupancy tax of 15%. Amenities include two full-service restaurants, as well as a sports bar on the premises, Internet access at no charge, access to fitness center, and an outdoor pool. Parking is complimentary. **Deadline for reservations is September 7, 2007**. There are a number of restaurants within walking distance. Be sure to check cancellation and early checkout policies.

The Double Tree Hotel, 200 Atrium Drive, Somerset, NJ 08873; telephone: 732-469-2600; guest fax: 732-469-4617; approximately six miles, about a 15-minute ride from the campus meeting site; US$89 for single/double. Rates quoted **do not** include the sales and occupancy tax of 15%. Be sure to check cancellation and early checkout policies. Amenities include high-speed Internet access, indoor heated pool w/Jacuzzi, complimentary wireless in lobby and on second floor, indoor pool, fitness center, and free parking. **Deadline for reservations is September 7, 2007**. There is a pub and restaurant on site.

University Inn and Conference Center, 178 Ryders Lane, New Brunswick, NJ 08901-8556; `http://www.univinn.rutgers.edu/`; telephone: 732-932-9144; fax: 732-932-6952; approximately three miles or a 7-minute drive on campus to the meeting site; US$84 single/US$97 double. Rates quoted are inclusive of all taxes and service charges. Be sure to check cancellation and early checkout policies. The meeting site is also accessible by Campus Bus "EE" which offers a limited schedule on Saturday and Sunday. Amenities include complimentary wireless access, hot breakfast served for overnight guests between 7:30 a.m. and 9:00 a.m., free parking, game room, pool table and shuffle board. The Cook/Douglass Recreation Center (walking distance) is available for use by guests; passes and hours are available at the front desk. Houlihans, On the Border, and other restaurants are within walking distance. **Deadline for reservations is September 7, 2007**.

Food Service

The Rutgers Student Center at 128 College Avenue, New Brunswick, is located in the heart of the College Avenue Campus and has a food court with eateries such as: Au Bon Pain, Gerlanda's Pizza, Szechwan Express, Wendy's, Subway, and King Pita. There are many other restaurants in downtown New Brunswick and all are within a few blocks of the campus as listed on the Rutgers university website, `http://ruinfo.rutgers.edu/visitingRU/dining.html#top`.

Local Information

The university's website is `http://www.rutgers.edu/`; the Department of Mathematics is at `http://www.math.rutgers.edu/`. A general website about visiting New Brunswick and Rutgers, The University of the State of New Jersey is at `http://nbweb.rutgers.edu/visitors.shtml`.

Other Activities

AMS Book Sale: Stop by the on-site AMS Bookstore—review the newest titles from the AMS, enter the FREE book drawing, enjoy up to 25% off all titles or even take home the new AMS T-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

Parking on campus is limited and is generally permitted only to those with Rutgers decals. However, we have obtained **permission to use Rutgers parking lots 8, 11, 16, and 30**, near Scott Hall, without charge. **Only** these lots may be used by participants, **parking in other lots could result in your car being ticketed or towed**.

Registration and Meeting Information

The meeting is on the College Avenue Campus of Rutgers University, New Brunswick, NJ. Meeting registration and the Invited Addresses will take place in Scott Hall. Sessions will be held in both Scott Hall and in Murray Hall. See the map at `http://maps.rutgers.edu`.

The registration desk will be in Scott Hall and will be open Saturday, October 6, 7:30 a.m. to 4:00 p.m., and Sunday, October 7, 8:00 a.m. to noon. Fees are US$40 for AMS or CMS members; US$60/ nonmembers; and US$5 students, unemployed mathematicians, and emeritus members. Fees are payable on site by cash, check, or credit card.

Travel and Campus Map (information is as of April 2007 and is subject to change)

Rutgers, State University of New Jersey (College Avenue Campus), is conveniently located in New Brunswick in central New Jersey. The Rutgers on-line maps are at `http://maps.rutgers.edu`. Click on New Brunswick/Piscataway; then on the name College Avenue Campus, click on the second "e" in "Avenue" for a map of the College Avenue Campus. Scott Hall is near the bottom, right of center. The map permits you to recenter and zooms in and out.

By Air: Newark Liberty International Airport (NWR) is approximately 30 minutes to Rutgers-New Brunswick (College Avenue Campus) and is the most convenient airport and is less than an hour by car, bus, or train to New York City. From NWR use the "AIRTRAIN" monorail `http://www.panynj.gov/CommutingTravel/airports/html/ewr_airtrain.html` within NWR Airport to the New Jersey Transit train station in the airport. The one-way train fare to New Brunswick is US$12.00. Taxis from the airport to the New Brunswick area cost between US$45-US$50 plus tip. Check with the taxi dispatcher at the airport for the legal fare to your hotel.

From **LaGuardia Airport (LGA)** the New York Airport Service runs express buses every 20–30 minutes from 7:20 a.m. to 11 p.m. to the Port Authority Bus Terminal, for US$10–US$12. Buses are also available from 8 a.m. to 8 p.m. to Penn Station for approximately US$10–US$12. Numerous limousine services also operate on these routes. For taxis from LGA to the West Side of Manhattan (where Port Authority and Penn Station are located) the approximate metered fare, is US$35, plus tolls and tip. For trains or bus service to New Brunswick from Penn Station and Port Authority, see below. Taxi fare is negotiable from LGA, and may run as high as US$150 to New Brunswick. A lot of airport information can be found at `http://www.panynj.gov/CommutingTravel/airports/html/lg_transportation.html`.

From **JFK Airport, (JFK)** the situation is similar to LGA. The Airport Service Bus is approximately US$15, and runs from 6:15 a.m. to 10:10 p.m. By Yellow Taxi, there is a flat US$45 fare to any destination in Manhattan. This does not include tolls or tips. The US$45 fare is charged per car, not per passenger. From Manhattan, train and bus services to New Brunswick are described below. The websites `http://www.panynj.gov/CommutingTravel/airports/html/lg_transportation.html` and `http://www.citidex.com` have a lot of information.

Transportation to campus and hotels: (information is as of April 2007 and is subject to change)

By Train: New Jersey Transit's Northeast Corridor Line provides New Brunswick with both local and express service between Penn Station in New York, Newark, and Trenton, New Jersey. For information call 973-762-5100 or visit http://www.njtransit.com. The regular one-way fare, from New York to New Brunswick is US$9.50. The New Brunswick train station is a couple of blocks from Scott Hall and also is near many restaurants. Taxis are available at the train station (e.g., Victory Cabs 732-545-6666). Approximate fares from the station, are US$6 to the University Inn and Conference Center, US$11 to the Doubletree and to the Holiday Inn in Somerset.

By Bus: Suburban Transit buses (http://www.suburbantransit.com) run buses approximately every half hour from 6 a.m. to midnight, between the New Brunswick Train Station and the Port Authority Bus Terminal in New York City. The fare is approximately US$8 one way. These buses do not serve NWR.

By Car: Getting to the university by Car: Driving directions to the College Avenue Campus and campus maps can be found at the following link http://maps.rutgers.edu/directions/nb.aspx.

Travel Advisory: The NJ Department of Transportation's (NJDOT) construction activities associated with the Route 18 reconstruction project have begun in the New Brunswick area. As a result, drivers are likely to experience delays, traffic pattern changes, and possible lane and road closures when traveling through the area. For more information related to the Route 18 construction project, visit http://route18update.rutgers.edu/.

Public Transportation: Visit http://nbweb.rutgers.edu/menus/transportation.shtml for links to more information regarding public transportation available to the Rutgers University Campus.

Car Rental: Avis is the official car rental company for the sectional meeting in New Brunswick, New Jersey. All rates include unlimited free mileage. All rates include unlimited free mileage. Weekend daily rates are available from noon Thursday–Monday at 11:59 p.m and start at US$70.00 per day. Rates for this meeting are effective September 30, 2007–October 14, 2007. Should a lower qualifying rate become available at the time of booking, Avis is pleased to offer a 5% discount off the lower qualifying rate or the meeting rate, whichever is lowest. Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges. Renters must meet Avis' age, driver, and credit requirements. Reservations can be made by calling 800-331-1600 or online at http://www.avis.com. Meeting **Avis Discount Number B159266**.

Information for International Participants: Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at http://www7.nationalacademies.org/visas/Traveling_to_US.html and http://travel.state.gov/visa/index.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to dls@ams.org.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

• family ties in home country or country of legal permanent residence

• property ownership

• bank accounts

• employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the web sites above for the most up-to-date information.

Weather

In this region of New Jersey, the averages for the month of October are normally mild (60^{o}F and lows of 50^{o}F). Precipitation in October averages 3.5 inches and snow is not expected (but you never know!).

New England weather varies considerably. It would be wise to consult the weather forecast on the Web (e.g., http://www.weather.com for New Brunswick, NJ) just before coming to the meeting.

Albuquerque, New Mexico

University of New Mexico

October 13–14, 2007

Saturday – Sunday

Meeting #1032

Western Section

Associate secretary: Michel L. Lapidus

Announcement issue of *Notices*: August 2007

Program first available on AMS website: August 30, 2007

Program issue of electronic *Notices*: October 2007

Issue of *Abstracts*: Volume 28, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: August 21, 2007

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Emmanuel Candes, California Institute of Technology, *The Role of Probability in Compressed Sensing*.

Alexander Polischuk, University of Oregon, *Title to be announced*.

Eric Rains, University of California Davis, *Elliptic Hypergeometric Integrals*.

William E. Stein, University of California San Diego, *SAGE: Open Source Mathematics Software*.

Special Sessions

Affine Algebraic Geometry (Code: SS 2A), **David Robert Finston**, New Mexico State University.

Arithmetic and Algebraic Geometry (Code: SS 10A), **Alexandru Buium** and **Michael J. Nakamaye**, University of New Mexico.

Computational Applications of Algebraic Topology (Code: SS 6A), **Ross Staffeldt**, New Mexico State University.

Computational Methods in Harmonic Analysis and Signal Processing (Code: SS 1A), **Emmanuel Candes**, California Institute of Technology, and **Joseph D. Lakey**, New Mexico State University.

Financial Mathematics: The Mathematics of Financial Markets and Structures (Code: SS 12A), **Cristina Mariani** and **Kenneth Martin**, New Mexico State University.

Geometric Structures on Manifolds (Code: SS 11A), **Charles Boyer** and **Krzysztof Galicki**, University of New Mexico.

Harmonic Analysis Applied to Partial Differential Equations (Code: SS 7A), **Justin Homer**, University of California Berkeley, **Changxing Miao**, Institute of Applied Physics and Computational Mathematics, and **Jiaong Wu**, Oklahoma State University.

Harmonic Analysis and Operator Theory (Code: SS 9A), **Maria C. Pereyra** and **Wilfredo O. Urbina**, University of New Mexico.

Mathematical and Computational Aspects of Compressible Flow Problems (Code: SS 8A), **Jens Lorenz** and **Thomas M. Hagstrom**, University of New Mexico.

Methods of Heterogeneous Data Analysis (Code: SS 14A), **Hanna Ewa Makaruk**, Los Alamos National Laboratory, and **Nikita A. Sakhanenko**, University of New Mexico.

Nonlinear Waves in Optics, Hydrodynamics and Plasmas (Code: SS 13A), **Alejandro Aceves** and **Pavel Lushnikov**, University of New Mexico.

Recent Developments in 2-D Turbulence (Code: SS 3A), **Michael S. Jolly**, Indiana University, and **Greg Eyink**, Johns Hopkins University.

Topics in Mathematical Physics (Code: SS 4A), **Rafal Komendarczyk**, University of Pennsylvania, and **Robert Michal Owczarek**, Los Alamos National Laboratory.

Variational Problems in Condensed Matter (Code: SS 5A), **Lia Bronsard**, McMaster University, and **Tiziana Giorgi**, New Mexico State University.

Accommodations

Very Important—please note that the 2007 Albuquerque International Balloon Fiesta takes place at the time of our meeting so it is imperative that you make hotel reservations as soon as possible.

Participants should make their own arrangements directly with the hotel. When making a reservation identify yourself as being with the UNM Math and Stat group attending the AMS Meeting. The AMS is not responsible for rate changes or for the quality of the accommodations. **Hotels have varying cancellation or early checkout penalties; be sure to ask details when making your reservation**.

Double Tree Hotel, 201 Marquette NW, Albuquerque, New Mexico 87102, 866-224-9330, 888-223-4113; rates start at $139/single or $149 double plus tax. Approximately 1 mile to campus. Visit `http://www.doubletree-albuquerque.com`. **Deadline for reservations is September 15**. Be sure to check the cancellation policy.

Plaza Inn Albuquerque, 900 Medical Arts NE, Albuquerque, NM; 505-243-5693 or 800-237-1307; $99/single or double. Approximately 1 mile to campus. Free continental breakfast served daily and shuttle service provided to campus. Visit `http://www.plazainnabq.com/index.htm`. **Deadline for reservations is September 27**. Be sure to check the cancellation policy.

Food Service

A list of local restaurants will be available at the registration desk.

Local Information and Campus Map

For further information please consult the website maintained by the department of math at the University of New Mexico: `http://www.math.unm.edu`. To view a campus map please visit `http://www.unm.edu/campusmap.html`. Dane Smith Hall is building 48 at F-G-3. For travel information please visit: `http://www.math.unm.edu/about/index.php`.

Other Activities

AMS Book Sale: Stop by the on-site AMS Bookstore—review the newest titles from the AMS, enter the FREE book drawing, enjoy up to 25% off all titles or even take home the new AMS T-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS Book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

Visitors can park anywhere on campus on weekends (6:00 p.m. Friday until 8:00 a.m. Monday) without a permit. City parking rules still apply. For further information please visit `http://pats.unm.edu/visitors.cfm`.

Registration and Meeting Information

Registration will take place in Dane Smith Hall located on Las Lomas Blvd., across from University House on Yale Avenue, from 7:30 a.m. to 4:00 p.m. on Saturday, October 13, and 8:00 a.m. to noon on Sunday, October 14. Registration fees: (payable on-site only) US$40/AMS members; US$60/nonmembers; US$5/emeritus members, students, or unemployed mathematicians. Fees are payable by cash, check, VISA, MasterCard, Discover, or American Express.

Travel

By Air: Albuquerque Sunport International Airport: Albuquerque is served by many of the major commercial carriers and several commuter airlines. The Sunport is located two (2) miles south of UNM.

Traveling to Albuquerque by car: Albuquerque is served by two major interstates, I25 (North-South) and I40 (East-West). The Martin Luther King exit 1 mile south of the I25-I40 interchange allows access to the Doubletree Hotel (go approx 1 mile west to downtown—hotel is on right between 2nd. and 3rd. streets) and UNM (go east to University Blvd., enter campus, turn right on Redondo Rd. and follow it to visitor parking or residence halls).

Driving Directions from Sunport to UNM: Take Yale Blvd. exit north until you dead-end at Central Ave. Cross Central Ave. to enter campus.

Transporation from/to the Sunport: Shuttle and taxi service available after all flights outside at baggage claim level. 24/7 service available from Airport Shuttle (505-765-1234; typical charge US$12 one-way and US$22 round-trip) and Albuquerque Cab (505-883-4888, typical charge US$18.00). Sunport provides a shuttle to Rental Car Center. Doubletree hotel does not have a private shuttle.

Getting around Albuquerque is easiest by car, but the city has regular bus service along Central Ave. from downtown to UNM for participants who wish to stay downtown. Taxi service is available but best arranged beforehand.

Car Rental

Avis is the official car rental company for the sectional meeting in Albuquerque, New Mexico. All rates include unlimited free mileage. Weekend daily rates are available from noon Thursday–Monday at 11:59 p.m. and start at US$26 per day. Rates for this meeting are effective October 6, 2007–October 21, 2007. Should a lower qualifying rate become available at the time of booking, Avis is pleased to offer a 5% discount off the lower qualifying rate or the meeting rate, whichever is lowest. Rates do not include any state or local surcharges, tax, optional coverages, or gas refueling charges. Renters must meet Avis' age, driver, and credit requirements. Reservations can be made by calling 1-800-331-1600 or online at `http://www.avis.com`. Meeting **Avis Discount Number B159266**.

Weather

October weather is generally pleasant with daytime temperatures in the 60°F range, and night-time temperatures in the 30–45°F range. For up-to-the-minute weather please visit `http://www.weather.com/outlook/driving/local/USNM0004`.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at `http://www7.nationalacademies.org/visas/Traveling_to_US.html` and `http://travel.state.gov/visa/index.html`. If you need a preliminary conference invitation in order to secure a visa, please send your request to `dls@ams.org`.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

- family ties in home country or country of legal permanent residence
- property ownership
- bank accounts
- employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the web sites above for the most up-to-date information.

Murfreesboro, Tennessee

Middle Tennessee State University

November 3–4, 2007

Saturday – Sunday

Meeting #1033

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: September 2007
Program first available on AMS website: September 20, 2007
Program issue of electronic *Notices*: November 2007
Issue of *Abstracts*: Volume 28, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: July 17, 2007
For abstracts: September 11, 2007

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Sergey Gavrilets, University of Tennessee, *Mathematical models of speciation*.

Daniel K. Nakano, University of Georgia, *Bridging algebra and geometry via cohomology*.

Carla D. Savage, North Carolina State University, *The mathematics of lecture hall partitions*.

Sergei Tabachnikov, Pennsylvania State University, *Ubiquitous billiards*.

Special Sessions

Advances in Algorithmic Methods for Algebraic Structures (Code: SS 3A), **James B. Hart**, Middle Tennessee State University.

Applied Partial Differential Equations (Code: SS 4A), **Yuri A. Melnikov**, Middle Tennessee State University, and **Alain J. Kassab**, University of Central Florida.

Billiards and Related Topics (Code: SS 6A), **Sergei Tabachnikov**, Pennsylvania State University, and **Richard Schwartz**, Brown University.

Combinatorial Enumeration, Optimization, Geometry, and Statistics (Code: SS 13A), **Nicholas A. Loehr**, College of William and Mary, **Gabor Pataki**, University of North Carolina, Chapel Hill, **Margaret A. Readdy**, University of Kentucky and M.I.T., **Carla D. Savage**, North Carolina State University, and **Ruriko Yoshida**, University of Kentucky.

Combinatorial Methods in Continuum Theory (dedicated to Jo Heath, Auburn University, on the occasion of her retirement) (Code: SS 8A), **Judy A. Kennedy**, University of Delaware and Lamar University, **Krystyna M. Kuperberg**, Auburn University, and **Van C. Nall**, University of Richmond.

Differential Equations and Dynamical Systems (Code: SS 1A), **Wenzhang Huang** and **Jia Li**, University of Alabama, Huntsville, and **Zachariah Sinkala**, Middle Tennessee State University.

Financial Mathematics (Code: SS 16A), **Abdul Khaliq**, Middle Tennessee State University.

Graph Theory (Code: SS 2A), **Rong Luo**, **Don Nelson**, **Chris Stephens**, and **Xiaoya Zha**, Middle Tennessee State University.

Lie and Representation Theory (Code: SS 11A), **Terrell L. Hodge**, University of Virginia and Western Michigan University, **Daniel K. Nakano**, University of Georgia, and **Brian J. Parshall**, University of Virginia.

Mathematical Modeling in Biological Systems (Code: SS 9A), **Terrence J. Quinn**, Middle Tennessee State University.

Mathematical Tools for Survival Analysis and Medical Data Analysis (Code: SS 7A), **Curtis Church**, Middle Tennessee State University, **Chang Yu**, Vanderbilt University, and **Ping Zhang**, Middle Tennessee State University.

Nonlinear Partial Differential Equations and Applications (Code: SS 14A), **Emmanuele DiBenedetto**, **Mikhail Perepelitsa**, and **Gieri Simonett**, Vanderbilt University.

Physical Knots and Links (Code: SS 10A), **Yuanan Diao**, University of North Carolina at Charlotte, and **Claus Ernst**, Western Kentucky University.

Recent Advances in Algebraic Topology (Code: SS 12A), **Mark W. Johnson**, Pennsylvania State University, Altoona, and **Donald Yau**, The Ohio State University at Newark.

Splines and Wavelets with Applications (Code: SS 5A), **Don Hong**, Middle Tennessee State University, and **Qingtang Jiang**, University of Missouri-St. Louis.

Using National Assessment of Educational Progress (NAEP) Data to Enhance Assessment and Inform Instruction (Code: SS 15A), **Michaele F. Chappell**, Middle Tennessee State University, and **Judith H. Hector**, Walters State Community College.

Wellington, New Zealand

Victoria University of Wellington

December 12–15, 2007

Wednesday – Saturday

Meeting #1034

First Joint International Meeting between the AMS and the New Zealand Mathematical Society (NZMS).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: June/July 2007
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: September 28, 2007
For abstracts: October 31, 2007

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

AMS Invited Addresses

Marston Conder, University of Auckland, *Chirality*.

Rodney G. Downey, Victoria University of Wellington, *Practical FPT and foundations of kernelization*.

Michael H. Freedman, Microsoft Research, *Physically motivated questions in topology: Manifold pairings*.

Bruce A. Kleiner, Yale University, *Title to be announced*.

Gaven J. Martin, Massey University, *Curvature and dynamics*.

Assaf Naor, Microsoft Research/Courant Institute, *Title to be announced*.

Theodore A. Slaman, University of California Berkeley, *Title to be announced*.

Matthew J. Visser, Victoria University of Wellington, *Title to be announced*.

AMS Special Sessions

Computability Theory, **Rodney G. Downey** and **Noam Greenberg**, Victoria University of Wellington, and **Theodore A. Slaman**, University of California Berkeley.

Dynamical Systems and Ergodic Theory, **Arno Berger**, University of Canterbury, **Rua Murray**, University of Waikato, and **Matthew J. Nicol**, University of Houston.

Geometric Numerical Integration, **Laurent O. Jay**, The University of Iowa, and **Robert McLachlan**, Massey University.

Group Theory, Actions, and Computation, **Marston Conder**, University of Auckland, and **Russell Blyth**, Saint Louis University.

History and Philosophy of Mathematics, **James J. Tattersall**, Providence College, **Ken Pledger**, Victoria University of Wellington, and **Clemency Williams**, University of Canterbury.

Hopf Algebras and Quantum Groups, **M. Susan Montgomery**, University of Southern California, and **Yinhuo Zhang**, Victoria University of Wellington.

Infinite-Dimensional Groups and Their Actions, **Christopher Atkin**, Victoria University of Wellington, **Greg Hjorth**, University of California Los Angeles/University of Melbourne, **Alica Miller**, University of Louisville, and **Vladimir Pestov**, University of Ottawa.

Integrability of Continuous and Discrete Evolution Systems, **Mark Hickman**, University of Canterbury, and **Willy A. Hereman**, Colorado School of Mines.

Mathematical Models in Biomedicine, **Ami Radunskaya**, Pomona College, **James Sneyd**, University of Auckland, **Urszula Ledzewicz**, University of Southern Illinois at Edwardsville, and **Heinz Schaettler**, Washington University.

Matroids, Graphs, and Complexity, **Dillon Mayhew**, Victoria University of Wellington, and **James G. Oxley**, Louisiana State University.

New Trends in Spectral Analysis and Partial Differential Equations, **Boris P. Belinskiy**, University of Tennessee, Chattanooga, **Anjan Biswas**, Delaware State University, and **Boris Pavlov**, University of Auckland.

Quantum Topology, **David B. Gauld**, University of Auckland, and **Scott E. Morrison**, University of California Berkeley.

Special Functions and Orthogonal Polynomials, **Shaun Cooper**, Massey University, **Diego Dominici**, SUNY New Paltz, and **Sven Ole Warnaar**, University of Melbourne.

Water-Wave Scattering Focusing on Wave-Ice Interactions, **Michael H. Meylan**, Massey University, and **Malte Peter**, University of Bremen.

San Diego, California

San Diego Convention Center

January 6–9, 2008

Sunday – Wednesday

Meeting #1035

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), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
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: Expired
For consideration of contributed papers in Special Sessions: July 26, 2007
For abstracts: September 20, 2007

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/national.html.

Joint Invited Addresses

Fan Chung, University of California San Diego, *The mathematics of PageRank* (AMS-MAA Invited Address).

Terence Tao, University of California Los Angeles, *Structure and randomness in the prime numbers* (AMS-MAA Invited Address).

AMS Invited Addresses

James G. Arthur, University of Toronto, *Semisimple groups as universal examples* (AMS Retiring Presidential Address).

Constantine M. Dafermos, Brown University, *Progress in hyperbolic conservation laws.*

Wen-Ching Winnie Li, National Tsing Hua University and Pennsylvania State University, *Combinatorics and number theory.*

Donald G. Saari, University of California Irvine, *A new mathematical frontier: The social and behavioral sciences.*

Peter Teichner, University of California Berkeley, *Quantum field theory and generalized cohomology.*

Wendelin Werner, University of Paris-Sud, *Random conformally invariant pictures* (AMS Colloquium Lectures).

Avi Wigderson, Hebrew University of Jerusalem, *Randomness—A computational complexity view* (AMS Josiah Willard Gibbs Lecture).

AMS Special Sessions

Some sessions are cosponsored with other organizations. These are noted within the parenthesis at the end of each listing, where applicable.

Algebraic Dynamics (Code: SS 37A), **Diana M. Thomas**, Montclair State University, **Lennard F. Bakker**, Brigham Young University, and **Donald Mills**, Rose-Hulman Institute of Technology.

Algebraic Topology (Code: SS 48A), **Nitu Kitchloo**, University of California San Diego, **Ralph L. Cohen**, Stanford University, **James P. Lin** and **Justin Robert**, University of California San Diego, and **Peter Teichner**, University of California Berkeley.

Algebraic and Geometric Aspects of Integrable Systems (Code: SS 43A), **Baofeng Feng**, University of Texas-Pan American, **Wenxiu Ma**, University of South Florida, **Kenichi Maruno** and **Zhijun Qiao**, University of Texas-Pan American, and **Taixi Xu**, Southern Polytechnic State University.

Applications of Computer Algebra in Enumerative and Algebraic Combinatorics (Code: SS 39A), **Akalu Tefera**, Massachusetts Institute of Technology and Grand Valley State University, and **Moa Apagodu**, Virginia Commonwealth University.

Asymptotic Methods in Analysis with Applications (Code: SS 18A), **Diego Dominici**, SUNY New Platz, and **Peter A. McCoy**, U.S. Naval Academy (AMS-SIAM).

Automorphic Forms and Related Topics (Code: SS 1A), **Olav K. Richter**, University of North Texas, **Kathrin Bringmann**, University of Minnesota, and **Harold M. Stark**, University of California San Diego.

Biomathematical Modeling (Code: SS 3A), **Olcay Akman**, Illinois State University, and **Timothy D. Comar**, Benedictine University.

Conformally Flat Lorentzian Manifolds (Code: SS 40A), **Virginie Charette**, Université de Sherbrooke, **William M. Goldman**, University of Maryland, **Karin H. Melnick**, Yale University, and **Kevin Scannel**, Saint Louis University.

Dynamics and Stability of Coherent Structures (Code: SS 45A), **Ricardo Carretero**, San Diego State University, and **Jennifer M. Gorsky**, University of San Diego.

E-Theory, Extensions, and Elliptic Operators (Code: SS 38A), **Constantin D. Dumitrascu**, University of Arizona, and **John D. Trout**, Dartmouth College.

Environmental Mathematics: Some Mathematical Problems on Climate Change and Geophysical Fluid Dynamics (Code: SS 29A), **Samuel S. Shen**, San Diego State University, and **Gerald R. North**, Texas A&M University (AMS-SIAM).

Expanders and Ramanujan Graphs: Construction and Applications (Code: SS 44A), **Michael T. Krebs** and **Anthony M. Shaheen**, California State University, Los Angeles, and **Audrey A. Terras**, University of California San Diego.

Financial Mathematics (Code: SS 11A), **Jean-Pierre Fouque**, University of California Santa Barbara, **Kay Giesecke**, Stanford University, **Ronnie Sircar**, Princeton University, and **Knut Solna**, University of California, Irvine.

Global Optimization and Operations Research Applications (Code: SS 4A), **Ram U. Verma**, University of Central Florida.

Graph Theory (Code: SS 46A), **Andre Kundgen** and **K. Brooks Reid**, California State University, San Marcos.

Groups, Representations, and Character Theory (Code: SS 8A), **Manouchehr Misaghian**, Johnson C. Smith University, and **Mohammad Reza Darafsheh**, University of Tehran, Iran.

Heegaard Splittings, Bridge Positions, and Low Dimensional Topology (Code: SS 20A), **Jesse Johnson**, Yale University, **Abigail A. Thompson**, University of California Davis, and **Robin Wilson**, University of California Santa Barbara.

History of Mathematics (Code: SS 28A), **Joseph W. Dauben**, Lehman College, CUNY, **Patti Hunter**, Westmont College, **Victor J. Katz**, University of District of Columbia, and **Karen H. Parshall**, University of Virginia (AMS-MAA).

Hyperbolic Dynamical Systems (Code: SS 30A), **Todd L. Fisher**, University of Maryland, and **Boris Hasselblatt**, Tufts University.

Interactions Between Noncommutative Algebra and Algebraic Geometry (Code: SS 42A), **Daniel S. Rogalski** and **Lance W. Small**, University of California San Diego, and **James J. Zhang**, University of Washington.

Inverse Problems in Geometry (Code: SS 9A), **Peter A. Perry**, University of Kentucky, and **Carolyn S. Gordon**, Dartmouth College.

Learning and Math Graduate Students in K–12 Classroom (Code: SS 36A), **Richard S. Millman**, University of Kentucky, **Loyce M. Adams**, University of Washington, **Overtoun M. Jenda**, Auburn University, and **M. Helena Noronha**, California State University, Northridge.

Low Genus Curves and Applications (Code: SS 34A), **Kristin E. Lauter**, Microsoft Research, and **Peter Stevenhagen**, Leiden University.

Mathematical Problems in Biological Formations (Code: SS 5A), **Yuanwei Qi**, University of Central Florida.

Mathematics and Education Reform (Code: SS 14A), **Bonnie S. Saunders**, University of Illinois, Chicago, **William H.**

Barker, Bowdoin College, **Dale R. Oliver**, Humboldt State University, and **Michael Starbird**, University of Texas, Austin (AMS-MAA-MER).

Mathematics for Teaching: Educating Elementary and Middle School Teachers for Success (Code: SS 33A), **Babette M. Benken**, California State University, Long Beach, and **Lynn C. McGrath** and **Perla L. Myers**, University of San Diego.

Modular Forms and Modularity (Code: SS 47A), **Ling Long**, Iowa State University, **Wen-Ching Winnie Li**, Pennsylvania State University, and **Tong Liu**, University of Pennsylvania.

Monotone Discrete Dynamical Systems with Applications (Code: SS 26A), **M. R. S. Kulenovic** and **Orlando Merino**, University of Rhode Island, and **Hal L. Smith**, Arizona State University.

Probability Theory and Statistical Mechanics (Code: SS 49A), **Itai Benjamini**, Weizmann Institute and Microsoft Research, and **Wendelin Werner**, University of Paris-Sud.

Progress in Commutative Algebra (Code: SS 24A), **Janet Striuli**, University of Nebraska, Lincoln, **Sean M. Sather-Wagstaff**, Kent State University, and **Lars Winther Christensen**, Texas Tech University.

Recent Advances in Mathematical Biology, Ecology, and Epidemiology (Code: SS 22A), **Linda J. S. Allen**, Texas Tech University, **Sophia R. Jang**, University of Louisiana at Lafayette, and **Lih-Ing W. Roeger**, Texas Tech University.

Representation Theory and Nonassociative Algebras (Code: SS 17A), **Murray R. Bremner**, University of Saskatchewan, **Irvin R. Hentzel**, Iowa State University, and **Luiz A. Peresi**, University of Sao Paulo.

Research in Mathematics by Undergraduates (Code: SS 12A), **Darren A. Narayan** and **Bernard Brooks**, Rochester Institute of Technology, **Jacqueline A. Jensen**, Sam Houston State University, **Vadim Ponomarenko**, San Diego State University, and **Tamas Wiandt**, Rochester Institute of Technology (AMS-MAA-SIAM).

Secant Varieties and Related Topics (Code: SS 19A), **Christopher S. Peterson**, Colorado State University, **Hirotachi Abo**, University of Idaho, and **Anthony V. Geramita**, Queen's University and University of Genoa.

Set Theory and Banach Spaces (Code: SS 35A), **Christian Rosendal**, University of Illinois at Urbana-Champaign, and **Stevo B. Todorcevic**, University of Toronto and CNRS, Université Paris 7 (AMS-ASL).

Stochastic, Large-Scale, and Hybrid Systems with Applications (Code: SS 16A), **Aghalaya S. Vatsala**, University of Louisiana at Lafayette, and **G. S. Ladde**, University of Texas at Arlington.

Structure, Geometry, and Symbolic Computation of Algebraic Groups and Symmetric Spaces (Code: SS 10A), **Jennifer R. Daniel**, Lamar University, and **Aloysius G. Helminck**, North Carolina State University.

Time-Frequency Analysis: Hilbert Huang Transform and Wavelet Analysis (Code: SS 21A), **Yuesheng Xu**, Syracuse University, **Sherman D. Riemenschneider**, West Virginia University, and **Samuel S. Shen**, San Diego State University.

Voting Theory (Code: SS 41A), **Michael A. Jones**, Montclair State University, **Eric I. Gottlieb**, Rhodes College, and **Brian P. Hopkins**, Saint Peter's College.

Wavelet Sets and Tilings of R^n (Code: SS 23A), **Kathy D. Merrill**, Colorado College, and **Lawrence W. Baggett** and **Judith A. Packer**, University of Colorado, Boulder.

Zeta Functions of Graphs, Ramanujan Graphs, and Related Topics (Code: SS 13A), **Audrey A. Terras**, University of California San Diego, and **Matthew Horton**, Wellesley College (AMS-AWM).

The Feynman Integral in Mathematics and Physics (Code: SS 15A), **Lance W. Nielsen**, Creighton University.

The Linear Diophantine Problem of Frobenius (Code: SS 2A), **Matthias Beck**, San Francisco State University, **Stanley Wagon**, Macalester College, and **Kevin M. Woods**, Oberlin College.

The Mathematics of Information and Knowledge (Code: SS 27A), **Peter W. Jones**, Yale University, **James G. Glimm**, SUNY at Stony Brook, and **Steve Smale**, Toyota Institute of Technology at Chicago.

The Scholarship of Teaching and Learning in Mathematics (Code: SS 25A), **Curtis D. Bennett** and **Jacqueline M. Dewar**, Loyola Marymount University (AMS-MAA).

Call for MAA Contributed Papers

The MAA Committee on Contributed Paper Sessions solicits contributed papers pertinent to the sessions listed below. Contributed paper session organizers generally limit presentations to ten or fifteen minutes. Each session room contains a computer projector, an overhead projector, and at least one screen. Please note that the dates and times scheduled for these sessions remain tentative.

Assessment of Student Learning in Undergraduate Mathematics, Monday afternoon, organized by **William O. Martin**, North Dakota State University; **Bernard L. Madison**, University of Arkansas; **Kimberly M. Vincent**, Washington State University; and **Maura B. Mast**, University of Massachusetts-Boston. Assessment continues to be an important issue for the mathematical sciences, with increasing faculty involvement in assessment activities. Departments are expected to document assessment activities focusing on student learning in general education, the major, and graduate programs for program review and institutional accreditation. Project SAUM (Supporting Assessment in Undergraduate Mathematics) and the SIGMAA on Quantitative Literacy (QL) encourage faculty to disseminate information about their experiences by inviting contributed papers that (a) describe assessment projects on student learning in undergraduate mathematical sciences programs, including the areas of quantitative literacy, general education, and the major; (b) report findings of those projects; and (c) describe faculty and departmental responses to those findings. Papers are solicited from any individuals or groups actively involved in assessment of student learning and are not restricted to members of the SIGMAA-QL or participants of Project SAUM workshops. The SIGMAA-QL and Project SAUM are sponsors of this event.

Biomathematics in the Undergraduate Curriculum, Wednesday morning and afternoon, organized by **Timothy D. Comar** and **Lisa G. Townsley**, Benedictine University; **Glenn W. Ledder**, University of Nebraska; and **Olcay**

Akman, Illinois State University. Reports including BIO 2010: Transforming Undergraduate Education for Future Research Biologists (National Research Council, 2003) and Math and BIO 2010: Linking Undergraduate Disciplines (L. A. Steen, ed., MAA, 2005) emphasize that aspects of biological research are becoming more quantitative and that life science students should be introduced to a greater array of mathematical and computational techniques and to the integration of mathematics and biological content at the undergraduate level. This session is designed to highlight successful implementations of biomathematics courses for life science students in the undergraduate curriculum, course projects for biomathematics courses, recruitment of students into biomathematics courses, involvement of these students in biomathematics research, preparation for graduate work in biomathematics and computational biology, and assessment of how these courses and activities impact the students. Topics may include the issues related to the design of effective biomathematics courses for life science students, integration of biology into existing mathematics courses; collaborations between mathematicians and biologists that have led to new courses, course modules, or undergraduate research projects; collaborations between two-year and four-year institutions; effective use of technology in biomathematics courses; and assessment issues. We encourage submissions from teams of mathematicians and biologists. This session is sponsored by the SIGMAA on Mathematical and Computational Biology (BIO).

Building Diversity in Advanced Mathematics: Models that Work, Wednesday morning, organized by **Abbe H. Herzig**, University at Albany, State University of New York, and **Patricia L. Hale**, California State Polytechnic University, Pomona. Papers presented at this session give models of programs that have been successful at supporting diverse groups of people (women of all races, African Americans, Latinos and Chicanos, and Native Americans) in their pursuit of advanced mathematics study and careers. Presentations will span the educational pathway, since issues of diversity need to be addressed at every educational and professional juncture. Proposals are sought that describe successful programs for postdoctoral (faculty), graduate, undergraduate, or precollege students. We interpret "success" broadly, and are looking for ideas that should be shared with others in the mathematics community as models for promoting diversity across the educational spectrum. These might be academic or extracurricular programs, which have targeted any group of people traditionally underrepresented in the mathematical sciences. Historical perspectives are also welcome. The session is cosponsored by the MAA Committee on the Participation of Women, the MAA Committee on the Participation of Minorities, and the AMS-ASA-AWM-IMS-MAA-NCTM-SIAM Joint Committee on Women.

College Algebra: Concepts, Data, and Models, Monday morning, organized by **Florence S. Gordon**, New York Institute of Technology, **Laurette Foster**, Prairie View A&M University, **Mary R. Robinson**, University of New Mexico Valencia Campus, and **Yajun Yang**, Farmingdale State College of New York. The MAA Committee on Curriculum Renewal Across the First two Years (CRAFTY), is conducting a national initiative to refocus the courses below calculus to better serve the majority of students taking these courses. The goal is to encourage courses that place much greater emphasis on conceptual understanding and realistic applications compared to traditional courses that too often are designed to develop algebraic skills needed for calculus. We seek to address all the college level courses below calculus, with particular emphasis on offerings in college algebra and precalculus that focus on conceptual understanding, the use of real-world data, and mathematical modeling. We seek presentations that present new visions for such courses, discuss experiences teaching such courses, discuss implementation issues (such as faculty training, placement, introduction of alternative tracks for different groups of students, transferability issues, etc), present results of studies on student performance and tracking data in both traditional and new versions of these courses and in follow-up courses, discuss the needs of other disciplines and the workplace from courses at this level, and discuss connections to the changing high school curricula and implications for teacher education. This session is cosponsored by CRAFTY and the Committee on Two Year Colleges (CTYC).

Countering "I Can't Do Math": Strategies for Teaching Under-Prepared Math-Anxious Students Interested in Business and the Sciences, Tuesday morning, organized by **Kimberly J. Presser** and **J. Winston Crawley**, Shippensburg University. How can we create a comfortable learning environment for under-prepared or math-anxious students? One option many schools have chosen is to create general education mathematics courses which expose students to new and different types of mathematics. These liberal arts mathematics courses have been very effective in changing student attitudes about math and are effective options for students in majors which are not mathematically intensive. However, for students with math anxiety issues who are interested in math-intensive majors such as Business or Science, remediation programs or courses need to prepare them for a whole series of mathematics courses which include calculus. What remediation programs or courses are effective for preparing math-anxious students to succeed in math intensive majors? What classroom practices are effective with such students and how does research in student learning inform these practices? This session invites papers on all aspects of "what works" in teaching under-prepared, math-anxious students with majors that require a significant amount of mathematics.

Crossing the "Bridge to Higher Mathematics": What Works and Why, Sunday morning, organized by **George J. Davis**, Georgia State University. It has been recognized that students can have a difficult time progressing from the calculus sequence to more advanced theoretical courses in algebra and analysis. A number of courses have been created to help bridge the gap. With titles similar to "Bridge to Higher Mathematics", "Transition to Higher Mathematics", or "Mathematical Reasoning" the intention is to give students an introduction to thinking about mathematics at a higher level. Most faculty agree that the object of such a course should be to instill the idea of proof. There is far less agreement on exactly how the sense of proof should be developed, and what content areas should be chosen for illustration. It is the purpose of this session to bring together faculty who have experience with such a course to discuss what works for their students and why. A typical presentation would begin with a brief sketch of the speaker's student population, followed by a description of their particular course. Emphasis should be given to exactly why the course was designed the way it was, how it is working, and whether or not changes are planned. Presenters are strongly encouraged to provide data to support their claims of success.

Cryptology for Undergraduates, Wednesday morning, organized by **Chris Christensen**, Northern Kentucky University, and **Robert E. Lewand**, Goucher College. In increasing numbers, cryptology courses are being developed to serve the needs of undergraduate mathematics and computer science majors. For mathematics majors, cryptology fits into the undergraduate curriculum in much the same way that number theory does. In addition, cryptology is appearing as a topic in mathematics courses for non-majors, as it is a hook to interest these students in mathematics. This contributed paper session solicits presentations that address topics appropriate for undergraduate cryptology courses for mathematics or computer science majors, or presentations of cryptological topics that could interest and motivate non-mathematics majors.

Curriculum Materials for Preservice Middle School Mathematics Teachers, Monday afternoon, organized by **Laurie J. Burton**, **Maria G. Fung**, and **Klay T. Kruczek**, Western Oregon University. This session invites papers describing curriculum materials, intended for publication and/or sharing with other institutions, designed specifically for the mathematical education of pre-service middle school teachers. These materials should be significantly different than standard pure mathematics materials that cover the same topics. Papers contributed to this session should describe the table of contents of the materials and how this syllabus was chosen and designed, the content and structure of the materials and give central examples, how the authors envision the materials should be used in the classroom and other pertinent pedagogical information, the placement of the materials in an effective program for pre-service middle school teachers (foundational, special topic, capstone, etc.), student support materials (if any), instructor support materials (if any), progress towards completion and dissemination of materials, and the focus on materials for a specific course.

Course materials designed for in-service middle school teachers may also be considered. This session is sponsored by the Committee on the Mathematical Education of Teachers (COMET).

Demos and Strategies with Technology that Enhance Teaching and Learning Mathematics, Monday morning and afternoon, organized by **David R. Hill**, Temple University; **Scott Greenleaf**, University of New England; **Mary L. Platt**, Salem State College; and **Lila F. Roberts**, Georgia College & State University. Mathematics instructors use an ever-expanding variety of instructional strategies to teach mathematical concepts. As new technologies emerge instructors employ them in interesting ways as a means to boost creativity and flexibility in lesson design. Tools an instructor utilizes may include specialized computer applications, animations (possibly with audio), and other multimedia tools on standard delivery platforms or handheld devices. This contributed paper session will focus on novel demos, projects, or labs that mathematics instructors have successfully used in their classrooms that support conceptual understanding. Presenters are encouraged to illustrate their approach with the technology, if time and equipment allow, and to discuss how it is employed in the classroom. Proposals should describe how the presentation with technology fits into a course, the effect it has had on student attitudes toward mathematics, and include a summary of any assessment techniques employed.

Ethnomathematics and Its Uses in Teaching, Sunday morning, organized by **Dorothee J. Blum** and **Ximena P. Catepillan**, Millersville University; **Robert E. Jamison**, Clemson University; **Shemsi I. Alhaddad**, University of South Carolina; and **Amy Shell-Gellasch**, Pacific Lutheran University. This contributed paper session is sponsored by the SIGMAA on the History of Mathematics. We solicit talks that describe research in ethnomathematics or the mathematics and the mathematical sciences of non-western cultures, as well as talks that describe ways to use ethnomathematics in the classroom. Talks may present actual mathematical practices of other cultures or cultural endeavors such as art and architecture that reveal significant mathematical thinking. Presentations may be historical in nature or present current practices.

Great Activities for an Introductory Statistics Class, Sunday morning, organized by **Patricia B. Humphrey**, Georgia Southern University; **Christopher J. Lacke**, Rowan University; and **Ginger Holmes-Rowell**, Middle Tennessee State University. Learning activities can play an important role in teaching an Introductory Statistics Class. For example they can promote conceptual understanding, encourage active participation, and generate student interest. We invite submissions that provide details about learning activities that have proven successful in teaching introductory statistics courses. Activities described in this session could include hands-on data collection, simulations, and visual demonstrations that help exhibit important themes and concepts of statistics. Particularly, activities that can be used during the first few meetings of an introductory statistics course to attract the attention and interest of students and to help the students overcome misconceptions and stereotypes about the course would be valuable contributions to the session. Submissions of innovative and new activities that improve learning at any point in the course are also encouraged. The session is sponsored by the SIGMAA on Statistics Education. In order to be considered for this session applicants should submit a one page summary of the presentation to Pat Humphrey at `phumphre@georgiasouthern.edu` along with the abstract to AMS. Presenters in the session will be considered for the SIGMAA on Statistics Education's Best Contributed Presentation Award.

Guided Discovery in Mathematics Education, Tuesday afternoon, organized by **Jerome S. Epstein**, Polytechnic

University, and **Chris Rasmussen**, San Diego State University. There is strong research evidence in many fields, particularly mathematics and physics, that nonlecture based approaches to teaching are more effective in providing conceptual understanding of the subject. The NSF currently supports extensively new curricula, validation, and research in this area. Physics has extensive published research on the efficacy of such programs. Mathematics education has been much slower to embrace this movement, rightly or wrongly. This session presents papers on work in this area, emphasizing reports with serious evidence, positive or negative, going beyond anecdotal. Sharing information on development and evaluation of such programs can provide a strong spur to further progress. Contributed papers are solicited from programs that have developed serious evidence of the validity of their evaluations and the efficacy of their programs at all levels of mathematics. Mathematics clearly needs much more hard data available to judge the efficacy of such programs and to point the way to real improvements. This has dramatically been the case in physics. This session is sponsored by the SIGMAA on Research in Undergraduate Mathematics Education.

Innovative and Effective Ways to Teach Linear Algebra, Tuesday morning, organized by **David M. Strong**, Pepperdine University, and **Gilbert Strang**, Massachusetts Institute of Technology. Linear algebra is one of the most interesting and useful areas of mathematics, because of its beautiful and multifaceted theory, as well as the enormous importance it plays in understanding and solving many real world problems. Consequently, many valuable and creative ways to teach its rich theory and its many applications are continually being developed and refined. This session will serve as a forum in which to share and discuss new or improved teaching ideas and approaches. These innovative and effective ways to teach linear algebra include, but are not necessarily limited to hands-on, in-class demos; effective use of technology, such as Matlab, Maple, Mathematica, Java, Applets or Flash; interesting and enlightening connections between ideas that arise in linear algebra and ideas in other mathematical branches; interesting and compelling examples and problems involving particular ideas being taught; comparing and contrasting visual (geometric) and more abstract (algebraic) explanations of specific ideas; or other novel and useful approaches or pedagogical tools. Presenters should discuss their own experience in using their presented idea or approach in their own teaching.

Mathematics and the Arts, Monday afternoon, organized by **Douglas E. Norton**, Villanova University. This session invites presentations on connections between mathematics and the arts: from geometry in quatrains to group theory on quilts, from perspective in paintings to patterns and plane tilings, from composition to cartography, sewing to symmetries, tessellations to textual analysis, weaving fabrics to word fashioning, dance to decorative arts, theater and film to theorems on fractals, beadwork to baskets to batiks, architecture to applications of the arts in algebra. We invite explorations of old and new connections, from ancient Islamic tilings to contemporary folk arts to manifolds and Klein bottles, as well as the use of new technologies to illustrate links between mathematics and the various arts. Mathematical concepts increasingly inform artistic presentation, while artistic presentation can often illuminate deep and interesting mathematics. New technologies often provide new tools for exploring these possibilities. Altogether, new approaches, new tools, and new looks at old examples provide new opportunities for working with and teaching mathematics, as well as providing modes of outreach to the general public about the often underappreciated place of mathematics in relation to the arts, culture, and society. This session is sponsored by the SIGMAA-ARTS.

Mathematics Experiences in Business, Industry, and Government, Tuesday morning, organized by **Philip Gustafson**, Mesa State College, and **Michael G. Monticino**, University of North Texas. This contributed paper session will provide a forum for mathematicians with experience in Business, Industry and Government (BIG) to present papers or discuss projects involving the application of mathematics to BIG problems. BIG mathematicians as well as faculty and students in academia who are interested in learning more about BIG practitioners, projects, and issues, will find this session of interest. This session is sponsored by the MAA Business, Industry and Government Special Interest Group (BIG SIGMAA).

Mathlets and Web Resources for Mathematics and Statistics Education, Wednesday morning, organized by **Thomas E. Leathrum**, Jacksonville State University; **Patricia B. Humphrey**, Georgia Southern University; **Christopher J. Lacke**, Rowan University; **David M. Strong**, Pepperdine University; and Joe Yanik, Emporia State University. This session seeks to provide a forum in which presenters may demonstrate mathlets, activities, and related materials they have created, further developed, and/or successfully used in mathematics or statistics classes. Mathlets are small computer-based (but ideally platform-independent) interactive tools for teaching math, frequently developed as World Wide Web materials such as scripts or Java applets, but there may be many other innovative variations. Mathlets allow students to experiment with and visualize a variety of concepts in mathematics and statistics, and they can be easily shared by instructors around the world. We invite submissions that detail the following about one or more items found on, or developed for, the World Wide Web: what it is, what resources are required (for students, instructors, or developers), how it can be used in a classroom, time involved (in and out of class), success or failure in terms of pedagogical intent, assessment methods and issues, and suggestions for improvement. Presenters should provide a Web address where the materials can be found. The session is jointly sponsored by the SIGMAA on Statistics Education and MAA CTiME (Committee on Technology in Math Education). Presentations related to statistics will be considered for the SIGMAA on Statistics Education's Best Contributed Presentation Award. Presenters who wish to be considered for the award should also send a one-page summary of their presentation to Patricia Humphrey, `phumphre@georgiasouthern.edu`, by the abstracts deadline.

Philosophy of Mathematics, Monday morning, organized by **Kevin M. Iga**, Pepperdine University, and **Bonnie Gold**, Monmouth University. This session, sponsored by the SIGMAA for the Philosophy of Mathematics, invites papers on any topic on the interaction between mathematics and philosophy excluding formal logic/set theory. Possible topics include the nature of mathematical objects, philosophical issues and controversies around the notion of mathematical proof and the development of mathematical knowledge, what characterizes mathematics as a discipline as distinct from other disciplines, the relation between mathematics and the physical world, the meaning of probability, the philosophical issues involving the interface between statistics and mathematics, the role of esthetics in the development of mathematics. The papers that stem from some specific problems are encouraged, and so are the ones cutting across disciplines.

The Power of Inductive and Recursive Thinking, Sunday afternoon, organized by **William A. Marion**, Valparaiso University. Mathematics has sometimes been defined as the study of patterns. If this description is not unreasonable, then it is incumbent upon us as mathematics faculty to help students think inductively: observe patterns and make conjectures about what they have observed. In addition, for some problems that fit the inductive model a more elegant solution can be expressed in the form of a recursive description. Beyond conjecturing, we must help students develop sound mathematical arguments that demonstrate the correctness of their conjectures. A variety of proof techniques are available, but one that has become ever more useful, especially in the discrete world, is the principle of mathematical induction. This session solicits papers highlighting innovative strategies to improve students' ability to think inductively and see the world recursively. Hands-on activities, paper and pencil exercises, and computer lab exercises are welcome. Creative examples that help students understand when and why induction works and/or that give them practice in how to correctly use the technique in its variety of forms—weak, strong, and structural—are encouraged. These examples should go beyond or expand upon those usually found in traditional textbooks.

Preparing Faculty for Success in a Problem-Solving and Technology-Rich Curriculum, Sunday morning, organized by **Alex J. Heidenberg**, **Gerald C. Kobylski**, **Barbra Melendez**, and **Rodney Sturdivant**, U.S. Military Academy. Preparing faculty to teach in a problem-solving and technology-rich environment is becoming increasingly difficult. At the department level we often spend time discussing new mathematical content with our faculty; however, most do not address pedagogical issues. Faculty might not often take time to reflect on teaching and learning. This session invites presentations about faculty development programs that focus on preparing faculty, experienced and inexperienced, adjunct faculty, and/or teaching assistants to teach in a problem solving curriculum that leverages the use of technology. Of particular value will be presentations which discuss and inspire teacher and student creativity, gauge teacher effectiveness, programs that integrate new faculty into the department, and programs that prepare new faculty to teach mathematics. Each presentation should address the specific goals of their institutions' faculty development program and their techniques used to attain these goals.

Research and Professional Development Activities for Math Majors, Monday afternoon, organized by **Suzanne M. Lenhart**, University of Tennessee; **Mike O'Leary**, Towson University; and **Margaret M. Robinson**, Mount Holyoke College. This session will feature a variety of activities that enrich the education of math majors beyond the usual curriculum. Talks about internships and research experiences would be included. Activities which help to educate the students about the spectrum of the mathematics community are also appropriate. The session is sponsored by MAA CUPM Subcommittee on Research by Undergraduates.

Research on the Teaching and Learning of Undergraduate Mathematics, Wednesday afternoon, organized by **David E. Meel**, Bowling Green State University; **Michelle J. Zandieh**, Arizona State University; and **Chris Rasmussen**, San Diego State University. Research papers that address issues concerning the teaching and learning of undergraduate mathematics are invited. Appropriate for this session are theoretical or empirical investigations conducted within clearly defined theoretical frameworks using either qualitative or quantitative methodologies. Of highest priority are proposals that report on completed studies that further existing work in the field.

Serving Students Who Have Taken Calculus in High School, Sunday afternoon, organized by **Ann E. Watkins**, California State University, Northridge, and **Daniel J. Teague**, North Carolina School of Science and Mathematics. The number of students taking calculus in high school is growing rapidly. Over 250,000 students took an AP Calculus exam last year and an almost equal number of students took calculus in high school but did not take an AP exam. Further, students are taking calculus earlier in high school—last year over 50,000 students who were not yet seniors took an AP Calculus exam. Thus both high schools and colleges now are seeing large numbers of students who have completed calculus. The MAA-NCTM Committee on Mutual Concerns invites contributed papers that describe ways that these students are being served, after they finish calculus, by high schools and colleges. We seek presentations from college or high school instructors that describe advanced courses or other alternatives offered by high schools, explain modifications to freshman-level calculus courses, describe special courses for entering freshmen who have completed calculus in high school, or offer data on what happens to these students in high school or once they enter college. This session is sponsored by the MAA-NCTM Committee on Mutual Concerns.

Topics and Techniques for Real Analysis, Monday morning, organized by **Erik O. Talvila**, University College of the Fraser Valley; **Robert W. Vallin**, Slippery Rock University; and **James E. Peterson**, Benedictine College. Real analysis is a core subject in the mathematics program. We need to keep the course relevant and we need to ensure that students are actually learning something in their real analysis courses. This session is about topics that we might like to add to real analysis courses and about how we can improve presentation of traditional and new topics.

Using Ideas from Asian Mathematics in the Classroom, Sunday afternoon, organized by **Victor J. Katz**, University of the District of Columbia, **Kim L. Plofker**, Brown University, and **Frank Swetz**, Pennsylvania State University, Harrisburg. Historically, there was much mathematics developed in China, India, and the Islamic World in the time period from the beginning of our era through the fifteenth century. Although some of these mathematical ideas were transmitted to Europe during that same time period, many other Asian mathematical accomplishments were not translated into any European language until the nineteenth or twentieth century. But today, much of the corpus of Indian, Chinese, and Islamic mathematics is available in English translation. And given the increasingly multicultural makeup of our student bodies, it is important that college teachers be familiar with these ideas so that they can use them in their teaching. They will then not only understand that mathematical thinking has been a part of every literate culture of which we are aware, but also be able to communicate to their students the worldwide nature of mathematics and how its history plays a vital role in its current use and future development. We therefore solicit contributions which display the use of topics from the mathematics of China, India, and Islam in the undergraduate classroom. This session is sponsored by the SIGMAA on the History of Mathematics.

Using Innovative Technologies to Implement Active Learning in Mathematics (and in other STEM disciplines), Wednesday morning, organized by **Marilyn A. Reba**, Clemson University, and **Beth Simon**, University of California San Diego. Innovative technologies—tablet PCs, wacom boards, smart-boards, sympodiums, clickers, projectors, and classroom interaction software—are being used to implement active learning in mathematics and other STEM disciplines. These technologies support instructors, individual students, or teams of students in various ways. For example "digital ink" can be used to "hand write" solutions-avoiding equation editors and supporting in-class graph sketching. But the digital nature of this ink supports solutions that can be projected, discussed, annotated, and saved. Some systems support electronic, simultaneous participation by students, allowing instructors to gauge student understanding while maintaining the pace of the course. By integrating with electronic projection of lecture materials, instructors can project and discuss student work—sometimes anonymously. This session invites reports on creative uses of this technology in the classroom to support active learning—spanning various technologies, whether you use public-domain or commercial classroom interaction software or none at all, whether you move the equipment in and out of different classrooms or anchor it in one, and whether you teach in mathematics or another STEM discipline. Our goal is to demonstrate how these technologies can improve the teaching and learning of mathematics, for example, by assisting in the demonstration of difficult concepts, by providing new ways for students to participate (even anonymously) in class, and by redefining active learning in both small and large enrolment courses.

General Session, Sunday, Monday, Tuesday, and Wednesday mornings and afternoons; organized by **Sarah L. Mabrouk**, Framingham State University. Papers may be presented on any mathematical topic. Papers that fit into one of the other sessions should be sent to that organizer, not to this session.

Submission Procedures for MAA Contributed Papers

Send your abstract directly to the meeting website (abstracts should not be sent to the organizer(s) who will automatically receive a copy). Please read the session descriptions thoroughly as some organizers require an additional summary of your proposal be sent to them directly. Participants may speak in at most two MAA contributed paper sessions. If your paper cannot be accommodated in the session for which it was submitted, it will be automatically considered for the general session. Speakers in the general session will be limited to one talk because of time constraints. Abstracts must be submitted by Thursday, **September 20, 2007**.

All accepted abstracts will be published in a book available at the meeting to all registered participants. Abstracts must be submitted electronically. While no knowledge of LaTeX is necessary for submission, LaTeX and AMS-LaTeX are the only typesetting systems that can be used if mathematics or any text markup (e.g., accent marks) is included. The abstracts submissions page is at `http://www.ams.org/cgi-bin/abstracts/abstract.pl`. Simply select the San Diego meeting, fill in the number of authors, and proceed with the step-by-step instructions. Submitters will be able to view their abstracts before final submission. Upon completion of your submission, your unique abstract number will immediately be sent to you. All questions concerning the submission of abstracts should be addressed to `abs-coord@ams.org`.

New York, New York

Courant Institute of New York University

March 15–16, 2008

Saturday – Sunday

Meeting #1036

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: January 2008
Program first available on AMS website: January 31, 2008
Program issue of electronic *Notices*: March 2008
Issue of *Abstracts*: Volume 29, Issue 2

Deadlines

For organizers: August 15, 2007
For consideration of contributed papers in Special Sessions: November 27, 2007

For abstracts: January 22, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Special Sessions

L-Functions and Automorphic Forms (Code: SS 1A), **Alina Bucur**, Institute for Advanced Study, **Ashay Venkatesh**, Courant Institute of Mathematical Sciences, **Stephen D. Miller**, Rutgers University, and **Steven J. Miller**, Brown University.

Baton Rouge, Louisiana

Louisiana State University, Baton Rouge

March 28–30, 2008

Friday – Sunday

Meeting #1037

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: February 2008
Program first available on AMS website: February 14, 2008
Program issue of electronic *Notices*: March 2008
Issue of *Abstracts*: Volume 29, Issue 2

Deadlines

For organizers: August 28, 2007
For consideration of contributed papers in Special Sessions: December 11, 2007
For abstracts: February 5, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Zhongwei Shen, University of Kentucky, *Title to be announced.*

Bloomington, Indiana

Indiana University

April 4–6, 2008

Friday – Sunday

Meeting #1038

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2008
Program first available on AMS website: February 21, 2008
Program issue of electronic *Notices*: April 2008
Issue of *Abstracts*: Volume 29, Issue 3

Deadlines

For organizers: September 4, 2007
For consideration of contributed papers in Special Sessions: December 18, 2007
For abstracts: February 12, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Shi Jin, University of Wisconsin, *Title to be announced.*

Michael J. Larsen, Indiana University, *Title to be announced.*

Mircea Mustata, University of Michigan, *Title to be announced.*

Margaret H. Wright, New York University-Courant Institute, *Title to be announced.*

Special Sessions

Birational Algebraic Geometry (Code: SS 3A), **Mircea I. Mustata**, University of Michigan, and **Mihnea Popa**, University of Chicago.

Combinatorial and Geometric Aspects of Commutative Algebra (Code: SS 1A), **Juan Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Hyperbolic and Kinetic Equations (Code: SS 2A), **Shi Jin**, University of Wisconsin, and **Marshall Slemrod**, Univesity of Wisconsin.

Weak Dependence in Probability and Statistics (Code: SS 4A), **Richard C. Bradley** and **Lahn T. Tran**, Indiana University.

Claremont, California

Claremont McKenna College

May 3–4, 2008

Saturday – Sunday

Meeting #1039

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: March 2008
Program first available on AMS website: March 20, 2008
Program issue of electronic *Notices*: May 2008
Issue of *Abstracts*: Volume 29, Issue 3

Deadlines

For organizers: October 4, 2007

Zhi-Ming Ma, Chinese Academy of Sciences, *Title to be announced*.

Richard Schoen, Stanford University, *Title to be announced*.

Richard Taylor, Harvard University, *Title to be announced*.

Xiaoping Yuan, Fudan University, *Title to be announced*.

Weiping Zhang, Chern Institute, *Title to be announced*.

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), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

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 1, 2008

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Urbana, Illinois

University of Illinois at Urbana-Champaign

March 27–29, 2009

Friday – Sunday

Central Section

Associate secretary: Susan J. Friedlander

Announcement issue of *Notices*: To be announced

Program first available on AMS website: To be announced

Program issue of electronic *Notices*: To be announced

Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 29, 2008

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Raleigh, North Carolina

North Carolina State University

April 4–5, 2009

Saturday – Sunday

Southeastern Section

Associate secretary: Matthew Miller

Announcement issue of *Notices*: To be announced

Program first available on AMS website: To be announced

Program issue of electronic *Notices*: To be announced

Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 4, 2008

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

San Francisco, California

San Francisco State University

April 25–26, 2009

Saturday – Sunday

Western Section

Associate secretary: Michel L. Lapidus

Announcement issue of *Notices*: To be announced

Program first available on AMS website: To be announced

Program issue of electronic *Notices*: To be announced

Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 25, 2008

For consideration of contributed papers in Special Sessions: To be announced

For abstracts: To be announced

Waco, Texas

Baylor University

October 16–18, 2009

Friday – Sunday

Central Section

Associate secretary: Susan J. Friedlander

For consideration of contributed papers in Special Sessions: January 15, 2008
For abstracts: March 11, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Michael Bennett, University of British Columbia, *Title to be announced.*

Chandrashekhar Khare, University of Utah, *Title to be announced.*

Huaxin Lin, University of Oregon, *Title to be announced.*

Anne Schilling, University of California Davis, *Title to be announced.*

Special Sessions

Diophantine Problems and Discrete Geometry (Code: SS 3A), **Matthias Beck**, San Francisco State University, and **Lenny Fukshansky**, Texas A&M University.

Dynamical Systems and Differential Equations (Code: SS 1A), **Adolfo Rumbos**, Pomona College, **Mario Martelli**, Claremont McKenna College, and **Alfonso Castro**, Harvey Mudd College.

Operators, Functions and Linear Spaces (Code: SS 2A), **Asuman G. Aksoy**, Claremont McKenna College, **Stephan R. Garcia**, Pomona College, **Michael Davlin O'Neill**, Claremont McKenna College, and **Winston C. Ou**, Scripps College.

Rio de Janeiro, Brazil

Instituto Nacional de Matemática Pura e Aplicada (IMPA)

June 4–7, 2008

Wednesday – Saturday

Meeting #1040

First Joint International Meeting between the AMS and the Sociedade Brasileira de Matemática.
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: February 2008
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

AMS Invited Addresses

Velimir Jurdjevic, University of Toronto, *Title to be announced.*

Richard M. Schoen, Stanford University, *Title to be announced.*

Amie Wilkinson, Northwestern University, *Title to be announced.*

Vancouver, Canada

University of British Columbia and the Pacific Institute of Mathematical Sciences (PIMS)

October 4–5, 2008

Saturday – Sunday

Meeting #1041

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2008
Program first available on AMS website: August 21, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines

For organizers: March 9, 2008
For consideration of contributed papers in Special Sessions: June 17, 2008
For abstracts: August 12, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Richard Kenyon, University of British Columbia, *Title to be announced.*

Alexander S. Kleshchev, University of Oregon, *Title to be announced.*

Mark Lewis, University of Alberta, *Title to be announced.*

Audrey A. Terras, University of California San Diego, *Title to be announced.*

Middletown, Connecticut

Wesleyan University

October 11–12, 2008
Saturday – Sunday

Meeting #1042
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2008
Program first available on AMS website: August 28, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines
For organizers: March 11, 2008
For consideration of contributed papers in Special Sessions: June 24, 2008
For abstracts: August 19, 2008

Kalamazoo, Michigan

Western Michigan University

October 17–19, 2008
Friday – Sunday

Meeting #1043
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2008
Program first available on AMS website: September 4, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines
For organizers: March 17, 2008
For consideration of contributed papers in Special Sessions: July 1, 2008
For abstracts: July 26, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses
M. Carme Calderer, University of Minnesota, *Title to be announced.*

Alexandru Ionescu, University of Wisconsin, *Title to be announced.*

Mark Kisin, University of Chicago, *Title to be announced.*

David Nadler, Northwestern University, *Title to be announced.*

Huntsville, Alabama

University of Alabama, Huntsville

October 24–26, 2008
Friday – Sunday

Meeting #1044
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: August 2008
Program first available on AMS website: September 11, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines
For organizers: March 24, 2008
For consideration of contributed papers in Special Sessions: July 8, 2008
For abstracts: September 2, 2008

Invited Addresses
Mark Behrens, Massachusetts Institute of Technology, *Title to be announced.*

Shanghai, People's Republic of China

Fudan University

December 17–21, 2008
Wednesday – Sunday

Meeting #1045
First Joint Interntional Meeting Between the AMS and the Shanghai Mathematical Society
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

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses
L. Craig Evans, University of California Berkeley, *Title to be announced.*

Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 17, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Boca Raton, Florida

Florida Atlantic University

October 30 – November 1, 2009

Friday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 30, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Riverside, California

University of California

November 7–8, 2009

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 6–9, 2010

Wednesday – Saturday
Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society of Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2009
Program first available on AMS website: November 1, 2009
Program issue of electronic *Notices*: January 2010
Issue of *Abstracts*: Volume 31, Issue 1

Deadlines

For organizers: April 1, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lexington, Kentucky

University of Kentucky

March 27–28, 2010

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 28, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011, *Wednesday – Saturday*

Joint Mathematics Meetings, including the 117th Annual Meeting of the AMS, 94th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 2010
Program first available on AMS website: November 1, 2010
Program issue of electronic *Notices*: January 2011
Issue of *Abstracts*: Volume 32, Issue 1

Deadlines

For organizers: April 1, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Boston, Massachusetts

John B. Hynes Veterans Memorial Convention Center, Boston Marriott Hotel, and Boston Sheraton Hotel

January 4–7, 2012, *Wednesday – Saturday*

Joint Mathematics Meetings, including the 118th Annual Meeting of the AMS, 95th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2011
Program first available on AMS website: November 1, 2011
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 33, Issue 1

Deadlines

For organizers: April 1, 2011
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 9–12, 2013, *Wednesday – Saturday*

Joint Mathematics Meetings, including the 119th Annual Meeting of the AMS, 96th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center

January 15–18, 2014, *Wednesday – Saturday*

Joint Mathematics Meetings, including the 120th Anual Meeting of the AMS, 97th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: **Susan-J. Friedlander**, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: susan@math.nwu.edu; telephone: 312-996-3041.

Eastern Section: **Lesley-M. Sibner**, Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@duke.poly.edu; telephone: 718-260-3505.

Southeastern Section: **Matthew Miller,** Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001, e-mail: miller@math.sc.edu; telephone: 803-777-3690.

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:

2007

July 31–August 3	Warsaw, Poland	p. 927
October 5–6	Chicago, Illinois	p. 928
October 6–7	New Brunswick, New Jersey	p. 931
October 13–14	Albuquerque, New Mexico	p. 933
November 3–4	Murfreesboro, Tennessee	p. 936
December 12–15	Wellington, New Zealand	p. 936

2008

January 6–9	San Diego, California Annual Meeting	p. 937
March 22–23	New York, New York	p. 944
March 28–30	Baton Rouge, Louisiana	p. 945
April 4–6	Bloomington, Indiana	p. 945
May 3–4	Claremont, California	p. 945
June 4–7	Rio de Janeiro, Brazil	p. 946
October 4–5	Vancouver, Canada	p. 946
October 11–12	Middletown, Connecticut	p. 947
October 17–19	Kalamazoo, Michigan	p. 947
October 24–26	Huntsville, Alabama	p. 947
December 17–21	Shanghai, People's Republic of China	p. 947

2009

January 7–10	Washington, DC Annual Meeting	p. 948
March 27–29	Urbana, Illinois	p. 948
April 4–5	Raleigh, North Carolina	p. 948
April 25–26	San Francisco, California	p. 948
Oct. 16–18	Waco, Texas	p. 948
Oct. 30–Nov. 1	Boca Raton, Florida	p. 949
Nov. 7–8	Riverside, California	p. 949

2010

January 6–9	San Francisco, California Annual Meeting	p. 949
March 27–29	Lexington, Kentucky	p. 949

2011

January 5–8	New Orleans, Louisiana Annual Meeting	p. 950

2012

January 4–7	Boston, Massachusetts Annual Meeting	p. 950

2013

January 9–12	San Diego, California Annual Meeting	p. 950

2014

January 15–18	Baltimore, Maryland Annual Meeting	p. 950

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 78 in the the January 2007 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

July 8–July 12, 2007: von Neumann Symposium on Sparse Representation and High-Dimensional Geometry, Snowbird, Utah.


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New and Noteworthy from Springer

Elementary Dirichlet Series and Modular Forms

G. Shimura, Princeton University, New Jersey

The main topics of the book are the critical values of Dirichlet L-functions and Hecke L-functions of an imaginary quadratic field, and various problems on elliptic modular forms. As to the values of Dirichlet L-functions, all previous papers and books reiterate a single old result with a single old method. After a review of elementry Fourier analysis, the author presents completely new results with new methods, though old results will also be proved. Other notable features include new results on classical Eisenstein series, a discussion of isomorphism classes of elliptic curves with complex multiplication in connection with their zeta function and periods, and a new class of holomorphic differential operators that send modular forms to those of a different weight.

2007. Approx. 150 p. (Springer Monographs in Mathematics) Hardcover
ISBN 978-0-387-72473-7 ▶ **approx. $59.95**

Piecewise-smooth Dynamical Systems

Theory and Applications

M. di Bernardo, University of Bristol, UK; University of Naples Federico II, Italy; **C. Budd**, University of Bath, UK; **A. Champneys**, University of Bristol, UK; **P. Kowalczyk**, University of Bristol, UK; University of Exeter, UK

The primary purpose of this book is to introduce a coherent framework for understanding the dynamics of piecewise-smooth and hybrid systems. An informal introduction asserts the ubiquity of such models with examples drawn from mechanics, electronics, control theory and physiology. The main thrust is to classify complex behaviour via bifurcation theory in a systematic yet applicable way. The key concept is that of discontinuity-induced bifurcation, which generalises diverse phenomena such as grazing, border-collision, sliding, chattering and the period-adding route to chaos.

2007. Approx. 504 p. 234 illus. (Applied Mathematical Sciences, Volume 163) Hardcover
ISBN 978-1-84628-039-9 ▶ **$99.00**

Braid Groups

C. Kassel, **V. Turaev**, Université Louis Pasteur - CNRS, Strasbourg, France

Braids and braid groups form the central topic of this text. The authors begin with an introduction to the basic theory highlighting several definitions of braid groups and showing their equivalence. The relationship between braids, knots and links is then investigated. Recent developments in this field follow, with a focus on the linearity and orderability of braid groups. This excellent presentation is motivated by numerous examples and problems.

2007. Approx. 320 p., 60 illus. (Graduate Texts in Mathematics) Hardcover
ISBN 978-0-387-33841-5 ▶ **approx. $59.95**

An Introduction to Echo Analysis

Scattering Theory and Wave Propagation

G. Roach, Strathclyde University, UK

This introduction reviews the principal mathematical topics required for approaching wave propagation and scattering problems, and shows how to develop the required solutions.
The emphasis is on concepts and results rather than on the fine detail of proof. Each chapter ends with a bibliography pointing to more detailed proofs.

2007. Approx. 305 p. (Springer Monographs in Mathematics) Hardcover
ISBN 978-1-84628-851-7 ▶ **$119.00**

Wave Propagation and Time Reversal in Randomly Layered Media

J. Fouque, North Carolina State University; **J. Garnier**, Université de Paris VII, Paris, France; **G. Papanicolaou**, Stanford University, California; **K. Solna**, University of California, Irvine

This book gives a systematic and self-contained presentation of wave propagation in randomly layered media using the asymptotic theory of ordinary differential equations with random coefficients.

2007. X, 440 p. (Stochastic Modelling and Applied Probability, Volume 56) Hardcover
ISBN 978-0-387-30890-6 ▶ **$79.95**

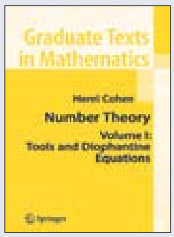
Advanced Linear Algebra

3rd Edition

S. Roman, Irvine, California

For the third edition, the author has: added a new chapter on associative algebras that includes the well known characterizations of the finite-dimensional division algebras over the real field (a theorem of Frobenius) and over a finite field (Wedderburn's theorem); polished and refined some arguments; upgraded some proofs; added new theorems, including the spectral mapping theorem; corrected all known errors; enlarged the reference section considerably.

3rd ed.2007. Approx. 520 p. 25 illus. (Graduate Texts in Mathematics, Volume 135) Hardcover
ISBN 978-0-387-72828-5 ▶ **approx. $69.95**



Number Theory

Volume I: Tools and Diophantine Equations

Volume II: Analytic and Modern Tools

H. Cohen, University of Bordeaux, France

The central theme of this book is the solution of Diophantine equations, i.e., equations or systems of polynomial equations which must be solved in integers, rational numbers or more generally in algebraic numbers. This theme, in particular, is the central motivation for the modern theory of arithmetic algebraic geometry. In this text, this is considered through three of its most basic aspects.

Vol. I ▶ 2007. XXII, 650 p. (Graduate Texts in Mathematics, Volume 239) Hardcover
ISBN 978-0-387-49922-2 ▶ **$59.95**

Vol. II ▶ 2007. XII, 500 p. (Graduate Texts in Mathematics, Volume 240) Hardcover
ISBN 978-0-387-49893-5 ▶ **$59.95**

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