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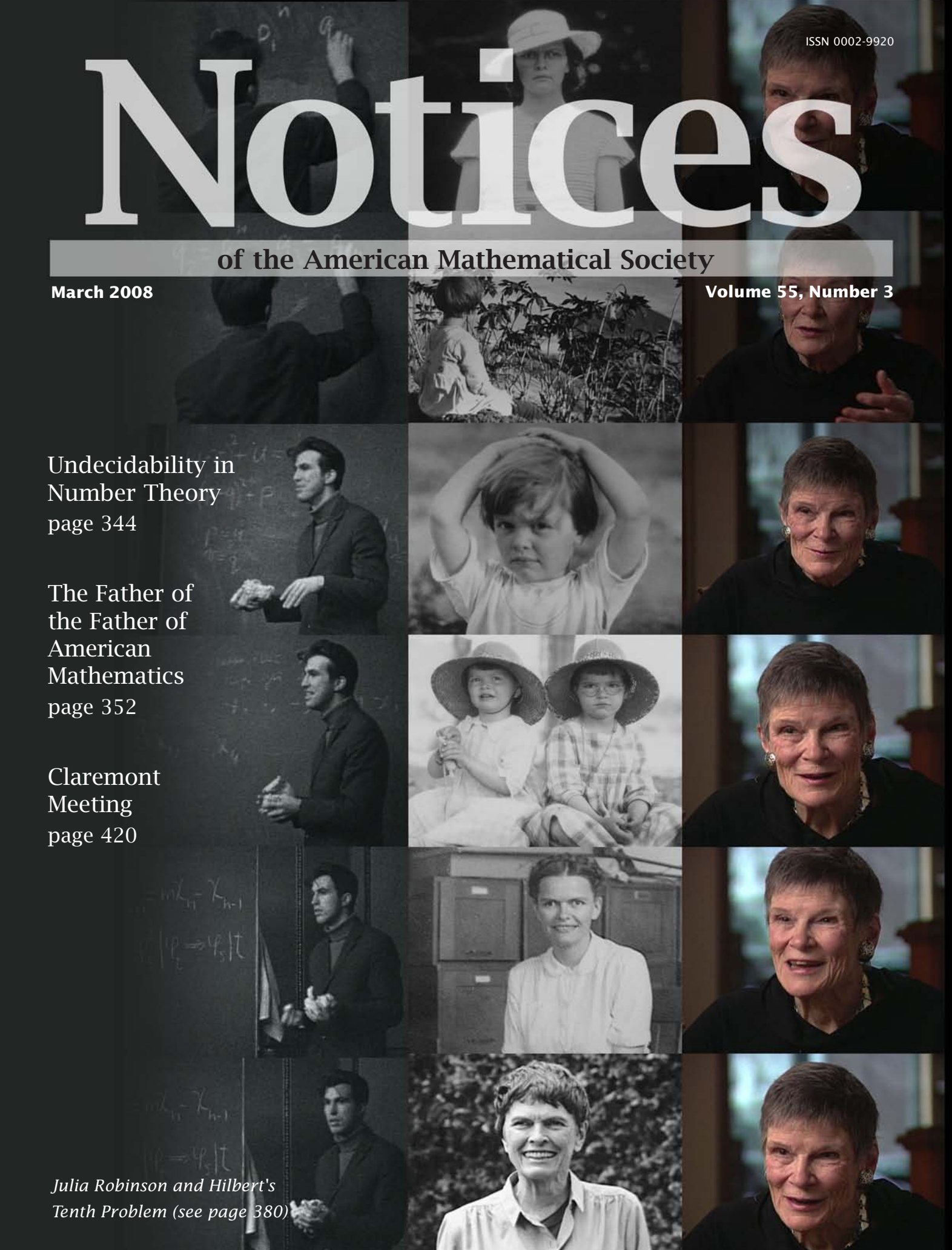
Notices

of the American Mathematical Society

March 2008 Volume 55, Number 3



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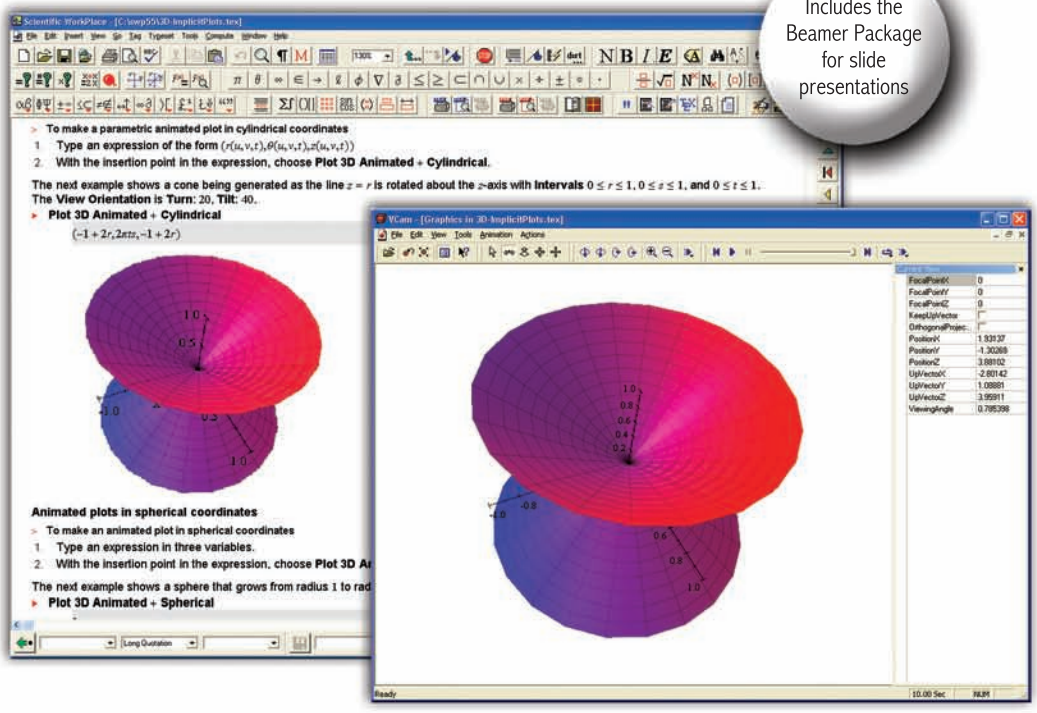

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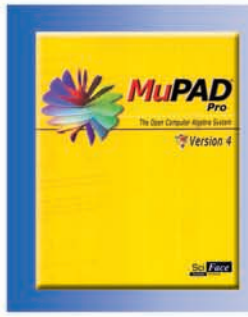

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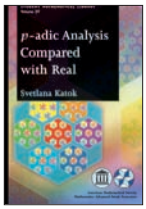

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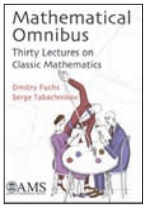

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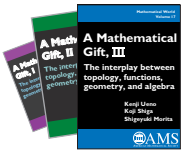

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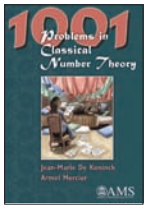

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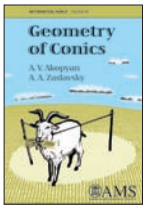

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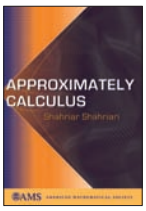

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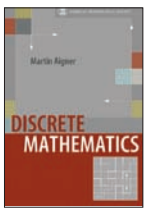

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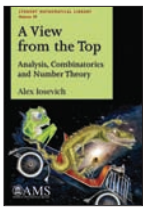

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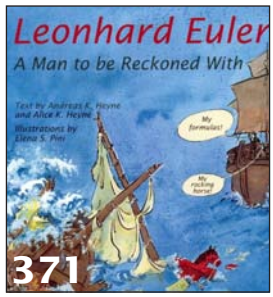

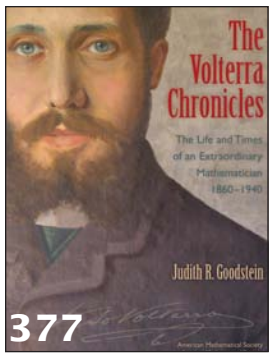

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Math Year in Germany

The entire year 2008 has been officially declared "Mathematics Year" in Germany. This has created an unprecedented opportunity to work on the public's view of the subject. Although the math year is primarily a German affair, I believe that a number of the lessons we learned in preparing the year, and in promoting it to the media, may be of interest also for the U.S. and international readership of the *Notices*.

Since 2000, which was the "Year of Physics" in Germany, the German Federal Ministry of Science and Education has dedicated each year to one particular science. By now the science years have many traditional and well-tested components:

· big events, among them the opening and closing gala and the week-long "Science Summer";

· exhibitions, including a large one on the "Science Ship" that will be traveling on the Rhine, Danube, and Elbe rivers all summer;

· a major media and PR campaign.

One fourth component is new for 2008:

· Much more than in previous science years we are working to reach the schools (teachers, parents, and thus students).

The motto for the year is "Mathematics. Everything that counts!". The posters and activities for the schools declare "You're better at math than you think!"

Four partners carry the Mathematics Year 2008: Besides the Federal Ministry of Science and the "Science in Dialogue" agency (representing the German Research Foundation and the major research organizations such as the Max Planck Society), they are the Deutsche Telekom Foundation, and the German Mathematical Society (DMV). I am acting as the DMV president—it's important to have an official function when dealing with politics. We have a budget of roughly 7.5 million Euro (US$10 million): That's a lot of money, but it's easily spent if you get into professional PR, organize big events, etc.

A professional advertising agency, Scholz & Friends, is designing the year (logo, print and web appearance), organizing the major events, and running the editorial (and campaign) office. However, unlike in previous years, we insisted on having an additional "content office" for media work: This is where we bundle expertise from the community, make sure it is represented in the year, and make sure that there's "math inside" (and that the math is correct) in the publications. The hope is that when the year is over, the mathematics content office will remain as a platform to present math to the public.

Lessons to be learned:

1. *Mathematics is multi-faceted.* It includes "learning to calculate", but also much more: It is high-tech, it is art, it is puzzles, etc. Our main message for the year is: "There is lots to discover!" People who think they don't like math haven't seen much of it.

2. *Math is difficult.* Don't try to say it's all easy. It isn't. Otherwise it wouldn't be interesting for the brightest.

3. *Don't try to teach.* There's no hope that people will know more math at the end of the year. If many people think of math as something interesting at the end of the year, we will have been very successful.

4. *Images, colors, graphics, photographs are important.* Several math calendars were produced for the year, with great images—they immediately sold out!

5. *People are important.* A subject is "abstract" for the press as long as they don't have people to talk to, to write about. For all the press materials, we are presenting and portraying mathematicians "to talk to".

6. *Talk to the press.* Press releases are ignored by the major media. You have to talk to the key editors about topics that you can present especially for them. My experience is: They are interested!

7. *Use professionals.* For us, the year is an opportunity to get help and learn from the advertising agency, but also from all the other major players. For example, the Deutsche Telekom Foundation has been funding math education projects for years, and they are also sponsoring new programs for math teacher education and development.

8. *Make it a community effort.* We are working hard to get hundreds of people from all over Germany involved, inviting people to become "math makers" for the year. This is the only way to have activities all over the country. A "top down" campaign cannot have a broad effect.

9. *Use the opportunities.* The physics community (represented by the German Physics Society) profited a lot from the Year of Physics 2000 and used it to build infrastructure, enlarge their membership base, and professionalize their web, print, and media appearance. Mathematicians all over Germany are working hard to grab the opportunities.

This is my personal collection of lessons and might be revised in the course of the year. Comments very welcome!

—Günter M. Ziegler
Technische Universität Berlin
ziegler@math.TU-Berlin.DE

Letters to the Editor

Some Statements in the Klein Protocols

I have read with interest the article on the Felix Kein Protocols in the September issue of the *Notices* and have to call the reader's attention to two surprising statements by the authors.

The first one is rather innocuous. On p. 967 we are told that Klein's "intuitive method of analogy did not meet with universal approval." This is supported by a long quotation of Poincaré which ends with: "A logician would have rejected such an idea with horror…in his mind it could never have been born." Anyone having read in detail Poincaré's opinions on logic and logicians would have considered this appreciation as a compliment paid to Klein, not to mention that a number of Poincaré's proofs lack rigor. The standards have somewhat changed but Poincaré was less careful than most of the great mathematicians of his age.

The second point is a far more annoying error of judgment. On p. 968 the authors use the expression "pearl of anthropological wisdom" to qualify the following "observations" of Steckel "on the conduct of members of different races (Germans, Jews, Poles)": "Germans calculate 71/4 minus 3/4 in the form 7 minus 1/2 = 61/2 grasping the task intuitively; Jews calculate 71/4 = 29/4…thus applying general logical rules… ." I am sorry to say that this "pearl" seems a rubbish anticipation of Bieberbach's famous (or rather infamous) article on the J type, putting in one box "Aryan" mathematics and in another box French and Jewish mathematics. I am not an expert in mathematics under the third Reich and the preceding period but found that Google is enough to find several articles putting in adequate perspective this Steckel "pearl". I find it extraordinary that this extravagant appreciation was published in an otherwise decent article in the *Notices* in 2007. I am thus led to a simple question: was the article in question (whose general interest is beyond contest) refereed? Was it read by a person distinct from any of the authors?

—Gabriel Sabbagh
Equipe de Logique
Université Paris
sabbagh@logique.jussieu.fr

(Received November 18, 2007)

Reply to Sabbagh

We'd assumed that our phrase in question, "…and the occasional pearl of anthropological wisdom…" would be read ironically. Our interest in reproducing the ensuing offensive quote was to underline the distressing anticipation of "Aryan mathematics".

—Yuri Tschinkel
New York University
tschinkel@cims.nyu.edu

(Received December 7, 2007)

Open Source Software

I very much enjoyed reading the opinion piece "Open Source Mathematical Software", in the November 2007 *Notices*, by David Joyner and William Stein. I think the reason I enjoyed it so much was that its intersection with my daily life was not only uncountably dense but of positive Lebesgue measure. I am a statistician at the National Cancer Institute, and my work regularly involves analyzing data, computation, using and contributing open source computational software. I say "computational" because I do not wish to offend anyone, for there are those out there who think statistics is not mathematics. On the other hand, there are those out there who might wonder why the moniker "mathematical" is applied to a piece of software involving double precision arithmetic and/or optimization, and may even become suspicious in such cases.

When anyone says "Open Source" I think immediately of the GNU project, Linux, TEX/LATEX, and of course, the R project and Bioconductor. The last two of these, in case there are any readers who are unaware, are a general purpose statistical package and a statistical package devoted to molecular biology, respectively, and are the only two in my list of open source software that are of an explicit mathematical nature. I recall using Maple on occasion in the past, and will make it a point to try out SAGE.

The authors' point that open source projects are expensive (in person hours) to create and maintain is well taken. Some institutions generously support them. Everyone needs to be reminded that kudos and citations are a kind of "open source" support, in that they are free to dish out, but en masse are as important as financial support. Furthermore, as the R project is an open source project with its statistical foundations in double precision computing, optimization, and linear algebra one could conjecture that the mathematical community interested in creating and maintaining open source computational software would do well to include the R project and Bioconductor into their studies.

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History of the Kazhdan-Lusztig Conjectures

In the article "The Character Table for E_8", (*Notices,* October 2007, 1122–1134) there is a very brief discussion of the history of the Kazhdan-Lusztig conjecture on page 1128. The sentence "MacPherson suggested that their observations might be formalized using intersection homology" misrepresents that history. Lusztig had learned of intersection homology from a lecture by MacPherson in England in 1977. He and Kazhdan conjectured in 1979 that their newly defined polynomials corresponded to intersection homology of Schubert varieties. (This geometric conjecture was not written down until it was proved by Kazhdan and Lusztig in a paper published in 1980.) Two conversations among Kazhdan, Lusztig,

and MacPherson after the geometric conjecture was formulated concerned the reconciliation of the conjecture with calculations made by MacPherson in special cases, including that of Schubert varieties in Grassmann manifolds.

I apologize for this inaccuracy.

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Senderov's "Killer" Problems

I read with interest the article "Bella Abramovna Subbotovskaya and the Jewish People's University". In the summer of 1975, I was in a Soviet math camp preparing to compete in the International Math Olympiad on behalf of the Soviet Union. Before Subbotovskaya founded the Jewish People's University and long before Valera Senderov went to prison, he approached my fellow team members and me to ask us to solve "killer" problems. Valera wanted to train the Jewish students in these mathematical ideas, giving them a better chance of passing the oral exam at Moscow State University. I have archived some of these "killers" on my website http://www.tanyakhovanova.com/coffins.html for those of your readers who are curious to see them.

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Mathematical Attitude

We recently received our copy of the excellent AMS publication *2007 Assistantships and Graduate Fellowships in the Mathematical Sciences*. Next year we will be conducting a search to fill a tenure-track position so the information on "Current Employment Trends in the Mathematical Sciences" [Pages vii–x] was of particular interest.

But, in the section titled "Employment Options for Mathematicians" I was shocked, amused, disappointed, but not surprised by the sentence which reads: "If you believe that you may want to pursue a career in business and industry, it is important to seek a graduate program that will provide you with a versatile foundation in mathematics as well as skills in communication, teamwork, and problem solving."

This is great advice, but why not for everyone? The implication seems to be that college professors do not need to be versatile in mathematics, or to worry about communications or teamwork, or problem solving. Go in your office, keep the door shut most of the time, study, think, and publish.

Does the attitude expressed in your sentence capture the collective will of our increasingly marginalized profession? Mathematics (including actuarial science) now represents less than 1% of bachelor's degree recipients [NSF 2004 data]. There are many reasons for the decline in the study of mathematics, and our attitude may not be the most significant. But, our attitude is something we can actually control.

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Correction: "Crystals That Nature Might Miss Creating"

As the author of the recent article "Crystals that nature might miss creating" in the *Notices* (**55**, No. 2, February 2008), which characterized two crystal structures by certain properties of symmetry, I must notify *Notices* readers that the crystal structure that I named the K_4 crystal was already known in crystallography. I was informed by Stephen T. Hyde, professor and Federation Fellow in the Applied Mathematics Department of the Research School of Physical Sciences, Australian National University, that the first description of the structure goes back to a pioneer of the area, A. Wells, who called it "(10,3)-a" (A. F. Wells, *Three Dimensional Nets and Polyhedra*, Wiley, 1977), and that Michael O'Keeffe and colleagues have discussed this structure in some detail and renamed it "srs" due to its chemical relevance, in "Three-periodic nets and tilings: regular and quasiregular nets" (Olaf Delgado Friedrichs, Michael O'Keeffe, and Omar M. Yaghi, *Acta Cryst.* **A59** (2003), 22–27). Furthermore, the structure also crops up in liquid crystals, as it defines one labyrinth of the "Gyroid" 3-periodic minimal surface (it is also called the "medial graph" in "Medial surfaces of hyperbolic structures", G. E. Schroeder, S. J. Ramsden, A. G. Christy, and S. T. Hyde, *Eur. Phys. J. B* **35** (2003), 551–564). See also S. T. Hyde and S. J. Ramsden, "Polycontinuous morphologies and interwoven helical networks", *Europhys. Lett.* **50** (2000), 135–141.

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Submitting Letters to the Editor

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

Identifications

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Undecidability in Number Theory

Bjorn Poonen

Does the equation $x^3 + y^3 + z^3 = 29$ have a solution in integers? Yes: $(3, 1, 1)$, for instance. How about the equation $x^3 + y^3 + z^3 = 30$? Again yes, although this was not known until 1999: the smallest solution[1] is $(-283059965, -2218888517, 2220422932)$. And how about $x^3 + y^3 + z^3 = 33$? This is an unsolved problem.

Of course, number theory does not end with the study of cubic equations in three variables: one might ask also about

$$x^{1729}y^{1093}z^{196884} - 163xyzt^{262537412640768000} = 561.$$

D. Hilbert, in the list of 23 problems he published after a famous lecture in 1900, asked his audience to find a method that would answer all such questions. More precisely, *Hilbert's tenth problem* (hereafter denoted H10) asks for an algorithm that takes as input a multivariable polynomial $f(x_1, \ldots, x_n)$ with integer coefficients and outputs YES or NO according to whether there exist integers $a_1, a_2, \ldots, a_n$ such that $f(a_1, \ldots, a_n) = 0$.

In 1970, Yu. Matiyasevich, building on earlier work of M. Davis, H. Putnam, and J. Robinson, showed that *no such algorithm exists*.

The purpose of this article is to discuss

- some of the concepts in the proof,
- a few by-products of the proof, and
- current research on related problems that are still open, such as the analogue for rational number solutions.

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[1] *Discovered by E. Pine, K. Yarbrough, W. Tarrant, and M. Beck following an approach suggested by N. Elkies.*

H10 and the DPRM Theorem

The notion of algorithm

To make sense of the negative answer to H10, we need a precise notion of algorithm. In 1900 such a notion had not yet been developed. But in the 1930s, several rigorous models of computation were proposed and were shown to be equivalent; one of these was the *Turing machine*. The equivalence made believable the *Church-Turing thesis*, which is the assertion that every purely mechanical procedure can be carried out by a Turing machine.[2] Because of this, "algorithm" is taken to mean "Turing machine".

An informal description of a Turing machine may be more enlightening than a mathematically precise definition. A Turing machine is equivalent to a finite-length program running on a physical computer, except that the computer has unlimited time and memory and is not subject to physical errors (such as data loss from power outages). The memory is sometimes modeled as an infinite tape, initialized to the binary representation of the nonnegative integer input. The computer reads and writes 0s and 1s from and to the memory tape during its operation, and may or may not print characters on a separate output tape, following the rules of its program. It might run forever, or it might halt when some condition specified by the program is satisfied.

[2] *Quantum computers might seem at first not to fit this framework. But they can be simulated by classical Turing machines in exponential time, and H10 asks for* any *algorithm without being fussy about its running time. When one ignores running time, quantum computers are no more powerful than classical ones.*

Turing machines may accept any objects as input if we fix an encoding of these objects as nonnegative integers. For example, a polynomial with integer coefficients could be represented by the concatenation of the ASCII codes of the characters in a TEX string for the polynomial. The exact encoding does not matter as long as a Turing machine can convert between the proposed encodings.

Diophantine, listable, and computable sets

Davis, Putnam, Robinson, and Matiyasevich deduced the negative answer to H10 from a stronger theorem having many more implications. To explain it, we need a few definitions.

Definition 1. A set $A \subseteq \mathbb{Z}$ is *diophantine* if there exists a polynomial $p(t, \vec{x}) \in \mathbb{Z}[t, x_1, \ldots, x_n]$ such that

$$A = \{a \in \mathbb{Z} : (\exists \vec{x} \in \mathbb{Z}^n)\ p(a, \vec{x}) = 0\}.$$

One should think of p as defining a family of polynomial equations, depending on a parameter t; then A is the set of values of the parameter for which the resulting equation in the remaining variables $x_1, \ldots, x_n$ has a solution. Equivalently, if B is the set of solutions to $p(t, \vec{x}) = 0$ in $\mathbb{Z}^{1+n}$, then A is the projection of B onto the first coordinate. The definition can be extended in an obvious way to subsets of $\mathbb{Z}^m$ for $m > 1$.

Example 2. The subset $\mathbb{N} := \{0, 1, 2, \ldots\}$ of $\mathbb{Z}$ is diophantine since for $a \in \mathbb{Z}$, we have

$$a \in \mathbb{N} \iff (\exists x_1, \ldots, x_4 \in \mathbb{Z})\ x_1^2 + \cdots + x_4^2 = a.$$

Definition 3. A set $A \subseteq \mathbb{Z}$ is *listable* (or *recursively enumerable*) if there is an algorithm that prints A, i.e., a Turing machine such that A is the set of integers it prints out when left running forever.

Example 4. The set of integers expressible as a sum of three cubes is listable. (Print out $x^3+y^3+z^3$ for all $|x|, |y|, |z| \le 10$; then print out $x^3 + y^3 + z^3$ for $|x|, |y|, |z| \le 100$; and so on.) A similar argument shows that any diophantine subset of $\mathbb{Z}$ is listable.

Definition 5. A set $A \subseteq \mathbb{Z}$ is *computable* (or *recursive*) if there is an algorithm for deciding membership in A, i.e., an algorithm that takes as input an integer a and outputs YES or NO according to whether $a \in A$.

Any computable set is listable, since given an algorithm for deciding membership in A, one can apply it successively to 0, 1, -1, 2, -2, …and print each number for which the membership test returns YES.

But it is not obvious that every listable set is computable. An algorithm that prints A does not immediately let one test whether 33 is in A, say: if after running the algorithm for a while the number 33 is not printed, it may be hard to decide whether it will appear later on.

In fact, the next section shows that there exists a listable set that is not computable.

The halting problem

The negative answer to H10 was proved by relating it to undecidability results in logic and computability theory from the 1930s. These undecidability results were proved using diagonalization arguments reminiscent of G. Cantor's famous proof of the uncountability of $\mathbb{R}$.

One such result concerns the *halting problem*, which asks for an algorithm that takes as input a computer program p and an integer x, and outputs YES or NO, according to whether program p run on input x eventually halts (instead of entering an infinite loop, say).

Theorem 6 (Turing 1936)**.** *The halting problem is undecidable; that is, no Turing machine can solve it.*

Sketch of proof. Fix an encoding of programs as nonnegative integers; identify programs with their integer codes. Suppose that there were an algorithm for deciding when program p halts on input x. Using this we could build a new program H such that for any x,

$$\begin{aligned} &H \text{ halts on input } x \\ \iff\ &\text{program } x \text{ does not halt on input } x. \end{aligned}$$

Taking $x = H$, we find a contradiction: H halts on input H if and only if H does not halt on input H. □

Corollary 7. *There exists a listable set that is not computable.*

Proof. Let A be the set of numbers $2^p 3^x$ such that program p halts on input x. By Theorem 6, A cannot be computable. On the other hand, here is a program that prints A: loop over $N = 1, 2, \ldots$, and during iteration N, for each $p, x \le N$, run program p on input x for N steps, and print $2^p 3^x$ if the program halts within these N steps. □

The DPRM theorem

We are now ready to state the following remarkable theorem.[3]

DPRM theorem (Davis, Putnam, Robinson, Matiyasevich 1970)**.** *A subset of $\mathbb{Z}$ is listable if and only if it is diophantine.*

[3] *Historically, the notions of diophantine, listable, and computable and the DPRM theorem were stated for subsets of $\mathbb{N}$ instead of $\mathbb{Z}$. This makes little difference, however: reductions in both directions are possible because of Example 2 and the equality $\mathbb{Z} = \mathbb{N} \cup (-\mathbb{N})$.*

To prove their theorem, these four authors essentially built a computer out of diophantine equations! They showed that diophantine equations are rich enough to simulate any computer in the sense that given a computer program, one can construct a polynomial equation that has an integer solution if and only if the program halts. The proof of the DPRM theorem looks curiously like the construction of a complicated computer program, with high-level routines built out of more elementary ones, except that instead of routines one has diophantine equations everywhere. An improved version of the original proof may be found in Chapters 1–5 of [YVM93].

A brief history of the DPRM theorem

The DPRM theorem was conjectured in 1949 by Davis, who also carried out the first reductions towards its proof. In 1961, Davis, Putnam, and Robinson proved its analogue for *exponential diophantine equations* over $\mathbb{N}$ (such as $2x^{3y^x z+x^2} = 5x^2 + yz$). This meant that it remained to show that exponentiation was diophantine, i.e., that $\{(a,b,c) \in \mathbb{N}^3 : c = a^b\}$ was a diophantine set. Earlier, in 1952, Robinson had proved that the diophantineness of exponentiation would follow from the existence of a 2-variable diophantine relation of "exponential growth". Finally, in 1970, Matiyasevich used properties of Fibonacci numbers F_n to prove that the relation $m = F_{2n}$ was diophantine; this gave what Robinson needed, and completed the proof of the DPRM theorem.

For more history, see the references at the end of this article, including the film [GC08] and the website [H10web].

Negative answer to H10

The DPRM theorem easily implies a negative answer to H10, as we now explain. The undecidability of the halting problem gave us a listable set that is not computable. By the DPRM theorem, having this is the same as having a diophantine set that is not computable. By definition, this means that we have a polynomial $p(t,\vec{x})$ such that there is no algorithm for deciding for which values $a \in \mathbb{Z}$ the equation $p(a,\vec{x}) = 0$ has a solution in integers $x_1,\dots,x_n$. Thus there cannot be an algorithm for deciding the existence of integer solutions to all polynomial equations.

Remark . H10 was not the first problem outside logic and computability theory to be proved undecidable. In 1947 A. A. Markov and E. Post independently found a finitely presented semigroup for which the word problem is undecidable, and in 1955 P. S. Novikov did the same for a finitely presented group. (The *word problem* for a finitely presented semigroup G with finite set of generators A is the problem of deciding, given two finite sequences of elements of A, whether the product of the first sequence equals the product of the second sequence in G.) The word problem for groups had been motivated by topology, and it was not long afterward that fundamental problems in topology itself were found to be undecidable: for instance, Markov in 1958 proved that the problem of deciding whether two finite simplicial complexes are homeomorphic is undecidable.

Other Fun Consequences of DPRM

Undecidability for polynomials of fixed degree in a fixed number of variables

The proof of the previous section shows that there is a pair (n,d) of positive integers such that there is no algorithm for deciding the existence of integer solutions to n-variable polynomial equations of total degree d. In the 1960s, before the DPRM theorem was proved, the fact that it would imply that equations of bounded degree in a bounded number of variables suffice to represent all diophantine sets was considered by some as evidence that the theorem could not be true!

After 1970, several authors, including Yu. Matiyasevich, J. Robinson, and Z. W. Sun, proved undecidability results for explicit small values of n and d. For instance, it is now known that there is no algorithm for deciding the existence of integer solutions to polynomial equations in 11 variables. In the positive direction, it is known only that there is an algorithm for polynomials in one variable! It is likely that the problem is decidable also for polynomials in two variables, but so far the elaborate machinery developed by arithmetic geometers is too weak to prove even this.

As for degree, a trick discovered by T. Skolem in the 1920s shows that any polynomial equation in integers is equivalent to one of degree at most 4 (and the equivalence is constructive): for instance, $y^2 = x^5 + 7$ is solvable if and only if

$$(u - x^2)^2 + (v - u^2)^2 + (y^2 - xv - 7)^2 = 0$$

is. Thus there is no algorithm for equations of degree 4. In the positive direction, there is an algorithm for equations of degree at most 2 in any number of variables. The situation for degree 3 is still unknown.

Number of solutions

Theorem 8 (Davis 1972)**.** *Let A be a nonempty proper subset of $\mathbb{N} \cup \{\aleph_0\}$. There is no algorithm that takes as input $f(\vec{x}) \in \mathbb{Z}[x_1,\dots,x_n]$ and outputs YES or NO according to whether the cardinality of $\{\vec{a} \in \mathbb{Z}^n : f(\vec{a}) = 0\}$ belongs to A.*

The proof, which is very short, shows that an algorithm for any A as above could be used to give an algorithm for H10.

Simple equations whose smallest solution is huge

Theorem 9. *There is a polynomial $p(t, \vec{x})$ such that for any function $F\colon \mathbb{Z} \to \mathbb{N}$ that is computable and defined on all of $\mathbb{Z}$, there exists $a \in \mathbb{Z}$ such that $p(a, \vec{x}) = 0$ has a solution $\vec{x} \in \mathbb{Z}^n$ but no solution with $\max |x_i| < F(a)$.*

Proof. Use the same p as in the proof of the negative answer to H10. If there were a computable bound on the size of the smallest solution when a solution existed, then one could decide for which $a \in \mathbb{Z}$ the equation $p(a, \vec{x}) = 0$ was solvable simply by searching up to that bound. This contradicts the choice of p. □

Prime-producing polynomials

Before the DPRM theorem was proved, Putnam observed that it would imply the following theorem.

Theorem 10. *There exists a polynomial*

$$F(x_1, \ldots, x_n) \in \mathbb{Z}[x_1, \ldots, x_n]$$

such that the positive integers in its range (as a function $\mathbb{N}^n \to \mathbb{Z}$) are exactly the prime numbers.

Proof. The natural number version of the DPRM theorem gives a polynomial $p(t, \vec{x})$ such that for $a \in \mathbb{N}$, the equation $p(a, \vec{x}) = 0$ is solvable in natural numbers if and only if a is prime. Define $F(t, \vec{x}) := t(1 - p(t, \vec{x})^2)$. It can be positive only when $p(t, \vec{x}) = 0$, and in this case, t is prime and $F(t, \vec{x}) = t$. Conversely, every prime arises this way. □

A reasonably simple prime-producing polynomial in 26 variables was constructed in a paper by J. P. Jones, D. Sato, H. Wada, and D. Wiens: see [YVM93, p. 55]. Later Matiyasevich constructed a 10-variable example.

Riemann hypothesis

The DPRM theorem gives an explicit polynomial equation that has a solution in integers if and only if the Riemann hypothesis (RH) is false. Indeed, one can write a computer program that searches for a counterexample to RH (e.g., by applying the argument principle and numerical integration to rectangles with corners in $\mathbb{Q}[i]$ lying in the strip $1/2 < \operatorname{Re} s < 1$, or by testing an equivalent formulation of RH as in [MDYMJR76, p. 335] or [YVM93, §6.4]); then one can use the DPRM theorem to simulate the program with a polynomial equation.

M. Baker half-jokingly observed that one might try to prove RH by showing that the equation has no solutions modulo 17, say! As one might expect, however, things are not so easy: the equation produced by the DPRM theorem will have solutions modulo any fixed positive integer.

H10 Over Other Rings

Even before 1970, researchers began asking Hilbert's question for rings other than $\mathbb{Z}$.

Definition 11. Let R be a commutative ring. Then *Hilbert's tenth problem over R* (H10 over R) asks for an algorithm that takes as input $f(\vec{x}) \in R[x_1, \ldots, x_n]$ and outputs YES or NO according to whether there exists $\vec{a} \in R^n$ such that $f(\vec{a}) = 0$.

Technically, to make sense of this, we need to fix an encoding of elements of R suitable for input into a Turing machine. In cases where this is not possible (e.g., if R is uncountable), then it is understood that we restrict the possible inputs by requiring that the coefficients of f belong to some "large" countable subring R_0 of R. For instance, if $R = \mathbb{C}$, we might take R_0 to be the subfield of algebraic numbers.

The question of whether H10 over R has a positive answer now depends on the ring R (and possibly also R_0). The remainder of this article will focus on rings R that are of interest to number theorists. For more information about these problems, see [JDLLTPJVG00, AS07].

H10 over rings of algebraic integers

The ring of Gaussian integers, $\mathbb{Z}[i] := \{a + bi : a, b \in \mathbb{Z}\}$, shares many properties with $\mathbb{Z}$, so one might expect a negative answer for H10 over $\mathbb{Z}[i]$. More generally, inside any number field k (i.e., finite extension of $\mathbb{Q}$), one has the *ring of integers* $\mathcal{O}_k$, defined as the set of $\alpha \in k$ satisfying $f(\alpha) = 0$ for some monic $f(x) \in \mathbb{Z}[x]$.

Conjecture 12. *For any number field k, H10 over $\mathcal{O}_k$ has a negative answer.*

Through work of J. Denef, L. Lipshitz, T. Pheidas, A. Shlapentokh, and the author spanning about 30 years, the following is known:

Theorem 13. *For a number field k, H10 over $\mathcal{O}_k$ has a negative answer if any of the following hold:*

(i) *k is totally real (i.e., every homomorphism $k \to \mathbb{C}$ has image contained in $\mathbb{R}$).*
(ii) *k is a quadratic extension of a totally real number field.*
(iii) *k has exactly one conjugate pair of nonreal embeddings.*
(iv) *There exists an elliptic curve E over $\mathbb{Q}$ such that $E(\mathbb{Q})$ and $E(k)$ have the same positive rank.*

To make sense of (iv), recall the *Mordell-Weil theorem*, which states that for any elliptic curve E over a number field k, the abelian group $E(k)$ of points on E with coordinates in k is finitely generated. Condition (iv) is probably satisfied for every number field k, but this seems extremely difficult to prove.

The reason that the proof of the negative answer for $\mathbb{Z}$ cannot be adapted directly to arbitrary $\mathcal{O}_k$ is that it uses the fact that the integer solutions to Pell's equation $x^2 - dy^2 = 1$ for a fixed nonsquare $d \in \mathbb{N}$ form an abelian group of rank 1. It is only for number fields like those in (i)–(iii) of Theorem 13 that something close enough to this holds over $\mathcal{O}_k$.

In contrast with Conjecture 12, if $\overline{\mathbb{Z}}$ is the ring of all algebraic integers, i.e., $\{\alpha \in \mathbb{C} : f(\alpha) = 0 \text{ for some monic } f(x) \in \mathbb{Z}[x]\}$, then H10 over $\overline{\mathbb{Z}}$ has a positive answer, as shown by R. Rumely.

H10 over $\mathbb{Q}$

H10 over $\mathbb{Q}$ is equivalent to one of the big open problems in arithmetic geometry, namely whether there is a general algorithm for deciding whether a variety X over $\mathbb{Q}$ has a rational point.[4]

Reductions. Might one deduce a negative answer to H10 over $\mathbb{Q}$ from the negative answer to H10 over $\mathbb{Z}$? Given a polynomial equation over $\mathbb{Q}$, one can construct an equivalent system of polynomials over $\mathbb{Z}$ by replacing each rational variable by a ratio of two new integer variables, clearing denominators, and adding auxiliary equations to force the denominator variables to take nonzero values in any solution (such auxiliary equations exist since the subset $\mathbb{Z} - \{0\}$ of $\mathbb{Z}$ is diophantine). Since a system of polynomial equations $f_1 = \cdots = f_n = 0$ over $\mathbb{Z}$ is equivalent to a single polynomial equation $f_1^2 + \cdots + f_n^2 = 0$ over $\mathbb{Z}$, the previous sentence shows that H10 over $\mathbb{Q}$ can be embedded as a subproblem of H10 over $\mathbb{Z}$. Unfortunately, this goes the wrong way: the subproblem might still be decidable even though the whole problem is not.[5]

One way to get a reduction in the useful direction would be to show that $\mathbb{Z}$ is *diophantine over* $\mathbb{Q}$, i.e., that there is a polynomial $p(t, \vec{x}) \in \mathbb{Q}[t, x_1, \ldots, x_n]$ such that $\mathbb{Z}$ equals the set of $a \in \mathbb{Q}$ such that $p(a, \vec{x}) = 0$ has a solution $\vec{x} \in \mathbb{Q}^n$. Indeed, we could use this to embed H10 over $\mathbb{Z}$ as a subproblem of H10 over $\mathbb{Q}$: given a polynomial equation to be solved in integers, we could consider the same equation over $\mathbb{Q}$ together with auxiliary equations that force the rational variables to take integer values (this is where we need $\mathbb{Z}$ to be diophantine over $\mathbb{Q}$).

Actually, something a little weaker would suffice for the desired reduction. It would suffice to have a *diophantine model* of the ring $\mathbb{Z}$ over $\mathbb{Q}$, i.e., a diophantine set $S \subseteq \mathbb{Q}^n$ that "looks like $\mathbb{Z}$" in the sense that it is equipped with a bijection $\phi\colon \mathbb{Z} \to S$ such that the graphs of $+$ and $\times$ (subsets of $\mathbb{Z}^3$) correspond under ϕ to diophantine subsets of $S^3 \subseteq \mathbb{Q}^{3n}$.

Even more generally, it would suffice to have a *diophantine interpretation* of $\mathbb{Z}$ over $\mathbb{Q}$: this is like a diophantine model, except that $\mathbb{Z}$ is identified not with a diophantine subset of some $\mathbb{Q}^n$, but with a diophantine subset modulo a diophantine equivalence relation.

Remark. It has been suggested that one might try to build a diophantine model of $\mathbb{Z}$ over $\mathbb{Q}$ using an elliptic curve E with $E(\mathbb{Q}) \simeq \mathbb{Z}$. Such elliptic curves are easy to find, and under the bijection $\mathbb{Z} \to E(\mathbb{Q})$ the graph of $+$ on $\mathbb{Z}$ corresponds to a diophantine subset; unfortunately it is not clear whether the same is true for the graph of $\times$.

Mazur's conjecture. B. Mazur has proposed a conjecture that, if true, would rule out some of these approaches towards a negative answer to H10 over $\mathbb{Q}$. If X is a variety over $\mathbb{Q}$, then the set $X(\mathbb{R})$ of real points on X inherits a topology from the topology of $\mathbb{R}^n$.

Conjecture 14 (Mazur 1992)**.** *For any variety X over $\mathbb{Q}$, the topological closure of $X(\mathbb{Q})$ in $X(\mathbb{R})$ has at most finitely many connected components.*

A deep theorem of G. Faltings can be used to prove Mazur's conjecture for a curve X. But our almost complete lack of understanding of rational points on higher-dimensional varieties makes it difficult to gather much evidence for or against the conjecture in general. See [BM94] for further discussion.

Mazur's conjecture, together with some elementary topology, implies that for any set $S \subseteq \mathbb{Q}^n$ that is diophantine over $\mathbb{Q}$, the closure of S in $\mathbb{R}^n$ has at most finitely many connected components. In particular, it implies that $\mathbb{Z}$ is not diophantine over $\mathbb{Q}$. (This was Mazur's reason for introducing his conjecture.) A more complicated argument of G. Cornelissen and K. Zahidi involving the DPRM theorem shows that Mazur's conjecture implies also that there is no diophantine model of $\mathbb{Z}$ over $\mathbb{Q}$.

On the other hand, it is not known whether Mazur's conjecture rules out also a diophantine interpretation of $\mathbb{Z}$ over $\mathbb{Q}$.

Subrings of $\mathbb{Q}$

Given that we have a negative answer for $\mathbb{Z}$ and do not know the answer for $\mathbb{Q}$, we might ask about rings in between. Every such ring is $\mathbb{Z}[S^{-1}]$ for some subset S of the set $\mathcal{P}$ of all primes: $\mathbb{Z}[S^{-1}]$ consists of the rational numbers whose denominators are divisible only by primes in S. How large

[4] *Readers unfamiliar with the notion of variety will lose little generality, for our purposes, in thinking of X as a system of polynomial equations, and a rational point as a simultaneous solution in rational numbers.*

[5] *On the other hand, if H10 over $\mathbb{Z}$ had had a* positive *answer, it would have implied a positive answer to H10 over $\mathbb{Q}$. It has been argued that this, together with the fact that Hilbert asked his question for $\mathbb{Z}$ instead of $\mathbb{Q}$, suggests that Hilbert expected a positive answer to his tenth problem.*

can we make S and still prove a negative answer for H10 over $\mathbb{Z}[S^{-1}]$?

If S is finite, work of Robinson on diophantine definitions of valuation rings in $\mathbb{Q}$ implies that $\mathbb{Z}$ is diophantine over $\mathbb{Z}[S^{-1}]$, so the negative answer for $\mathbb{Z}$ implies a negative answer for $\mathbb{Z}[S^{-1}]$. If S is infinite, we may measure its size by defining the *natural density* of S as

$$\lim_{X\to\infty} \frac{\#\{p \in S : p \le X\}}{\#\{p \in \mathcal{P} : p \le X\}},$$

if the limit exists.

In 2003 the author proved

Theorem 15. *There exists a computable set $S \subseteq \mathcal{P}$ of density 1 such that*

(i) *There exists a curve E such that $E(\mathbb{Z}[S^{-1}])$ is an infinite discrete subset of $E(\mathbb{R})$. (So the analogue of Mazur's conjecture for $\mathbb{Z}[S^{-1}]$ is false.)*

(ii) *There is a diophantine model of $\mathbb{Z}$ over $\mathbb{Z}[S^{-1}]$.*

(iii) *H10 over $\mathbb{Z}[S^{-1}]$ has a negative answer.*

The proof takes E to be an elliptic curve of rank 1 (minus its point at infinity) and shows that, by choosing S carefully, we can control the subset $E(\mathbb{Z}[S^{-1}])$ of $E(\mathbb{Q})$ sufficiently well to obtain a discrete set that looks enough like $\mathbb{Z}$ to serve as a diophantine model.

Unfortunately, the complement of S in $\mathcal{P}$, while sparse, is still infinite, so Theorem 15 implies nothing about H10 over $\mathbb{Q}$.

First-order Sentences

In terms of logic, H10 asks for an algorithm to decide the truth of *positive existential sentences*

$$(\exists x_1 \exists x_2 \cdots \exists x_n)\, f(x_1, \ldots, x_n) = 0$$

in the language of rings, where the variables run over integers. More generally, one can ask for an algorithm to decide the truth of arbitrary *first-order sentences*, in which any number of quantifiers and boolean operations are permitted: a typical such sentence is

$$(\exists x)(\forall y)(\exists z)(\exists w)\ (x \cdot z + 3 = y^2) \vee \neg(z = x + w).$$

Long before DPRM, the work of K. Gödel, A. Church, and A. Turing in the 1930s made it clear that there was no algorithm for solving the harder problem of deciding the truth of first-order sentences over $\mathbb{Z}$.

First-order sentences over $\mathbb{Q}$

Though it is not known whether $\mathbb{Z}$ is diophantine over $\mathbb{Q}$, we have

Theorem 16 (Robinson 1949)**.** *One can characterize $\mathbb{Z}$ as the set of $t \in \mathbb{Q}$ such that a particular first-order formula of the form*

$$(\forall \vec{x})(\exists \vec{y})(\forall \vec{z})(\exists \vec{w})\ p(t, \vec{x}, \vec{y}, \vec{z}, \vec{w}) = 0$$

is true, when the variables range over rational numbers.

Combining this with the non-existence of an algorithm for first-order sentences over $\mathbb{Z}$, Robinson obtained

Corollary 17. *There is no algorithm to decide the truth of a first-order sentence over $\mathbb{Q}$.*

How complicated must a class of first-order sentences be, in order that we are able to prove that no algorithm can decide the truth of all sentences in the class? Using quaternion algebras, the author in 2007 improved Robinson's result by defining $\mathbb{Z}$ in $\mathbb{Q}$ by a formula with 2 universal quantifiers followed by 7 existential quantifiers:

Theorem 18. *The set $\mathbb{Z}$ equals the set of $t \in \mathbb{Q}$ such that*

$$\begin{aligned}(\forall a, b)(\exists x_1, x_2, x_3, x_4, y_2, y_3, y_4)\\ (a + x_1^2 + x_2^2 + x_3^2 + x_4^2)(b + x_1^2 + x_2^2 + x_3^2 + x_4^2)\\ \cdot\Big[\left(x_1^2 - a x_2^2 - b x_3^2 + ab x_4^2 - 1\right)^2\\ + \prod_{n=0}^{2309} \left((n - t - 2x_1)^2 - 4a y_2^2 - 4b y_3^2 + 4ab y_4^2 - 4\right)^2\Big]\\ = 0\end{aligned}$$

is true, when the variables range over rational numbers.

Corollary 19. *There is no algorithm for deciding, given an algebraic family of morphisms of varieties, whether there exists one that is surjective on rational points.*

Cornelissen and Zahidi obtained an even better result conditional on the truth of a plausible conjecture about elliptic curves.

If we could eliminate the two universal quantifiers in Theorem 18, we would have a negative answer to H10 over $\mathbb{Q}$. But we cannot see how to eliminate even one of them.

Status of knowledge

The table below summarizes what is known regarding the questions

- Is there an algorithm for H10 over R?
- Is there an algorithm to decide the truth of arbitrary first-order sentences over R?

over various rings R, listed roughly in order of increasing arithmetic complexity:[6]

[6] *There is no formal definition of arithmetic complexity, but for fields k we can look at the size of the absolute Galois group $\mathrm{Gal}(k_s/k)$, where k_s is a separable closure of k. Domains may be considered more complex than their fraction fields, since they have "extra structure" coming from the divisibility relation.*

Ring	H10	1st order
$\mathbb{C}$	YES	YES
$\mathbb{R}$	YES	YES
$\mathbb{F}_q$	YES	YES
p-adic fields	YES	YES
$\mathbb{F}_q((t))$	?	?
$\overline{\mathbb{Z}}$	YES	YES
number field	?	NO
$\mathbb{Q}$	?	NO
global function field	NO	NO
$\mathbb{F}_q(t)$	NO	NO
$\mathbb{C}(t)$	?	?
$\mathbb{C}(t_1,\ldots,t_n)$, $n \geq 2$	NO	NO
$\mathbb{R}(t)$	NO	NO
$\mathcal{O}_k$	?	NO
$\mathbb{Z}$	NO	NO

For $\mathbb{C}$ the positive answers are a consequence of nineteenth century elimination theory. For $\mathbb{R}$ they come from A. Tarski's elimination theory for *semialgebraic sets*, subsets of $\mathbb{R}^n$ defined by polynomial equations and polynomial inequalities. For finite fields $\mathbb{F}_q$, the answers are trivially positive! By a p-adic field, we mean a finite extension of the field $\mathbb{Q}_p$ of p-adic numbers; A. Macintyre developed an elimination theory for these, though the positive answers were given before this, in work of J. Ax, Yu. Ershov, S. Kochen, and A. Nerode. It is surprising that the answers for the closely analogous field $\mathbb{F}_q((t))$ of formal Laurent series over a finite field are not known.

We have already mentioned Rumely's positive answer for H10 over $\overline{\mathbb{Z}}$; this was extended to first-order sentences by L. van den Dries. The negative answers for first-order sentences over a number field k and its ring of integers $\mathcal{O}_k$ are due to Robinson.

By *global function field* we mean the field $\mathbb{F}_q(t)$ of rational functions with coefficients in a finite field, or a finite extension of $\mathbb{F}_q(t)$. Such fields are studied both because they are closely tied to algebraic geometry and because they are analogous to number fields in many ways. The breakthrough giving the negative answer to H10 for $\mathbb{F}_q(t)$ for odd q was due to T. Pheidas. The extension to all global function fields (and even finite extensions of $\mathbb{F}_q(t_1,\ldots,t_n)$ for $n \geq 2$) was completed by C. Videla, A. Shlapentokh, and K. Eisenträger. The proofs use the Frobenius endomorphism in an essential way, however, and hence cannot be adapted to number fields.

The negative answer to H10 over $\mathbb{C}(t_1,\ldots,t_n)$ for $n \geq 2$ is due to K. H. Kim and F. W. Roush; this result should be better known among algebraic geometers than it is since it implies that there is no algorithm for the general problem of deciding whether a rational map of varieties $X \dashrightarrow \mathbb{P}^n$ over $\mathbb{C}$ for fixed $n \geq 2$ admits a rational section. The analogue with $\mathbb{P}^n$ replaced by an arbitrary fixed variety Y of dimension at least 2 was proved by K. Eisenträger using work of L. Moret-Bailly. Although the answers for $\mathbb{C}(t)$ are unknown, the answers for $\mathbb{R}(t)$ are negative, as shown by J. Denef.

Our list of results is by no means complete: for instance, we have said nothing about rings of holomorphic or meromorphic functions, function fields over an algebraically closed field of positive characteristic, etc. There remain many open problems for anyone who is interested.

Acknowledgments

I have borrowed extensively from many excellent earlier expositions of the subject; some of these are listed below. I thank M. Davis, E. Frenkel, Yu. Matiyasevich, and A. Shlapentokh for many comments.

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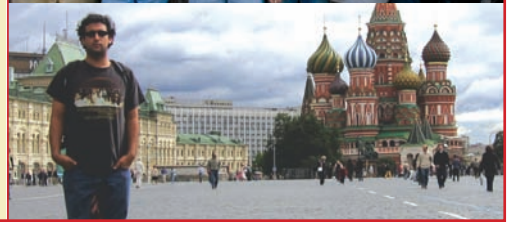

The Father of the Father of American Mathematics

Steve Batterson

At the turn of the twentieth century, University of Chicago mathematician E. H. Moore supervised three doctoral students who went on to lead the United States to its standing as an international center for mathematical research. Moore's students Leonard Dickson, Oswald Veblen, and George D. Birkhoff were the first domestically cultivated Ph.D. recipients (other than their advisor) to attain distinction through their mathematics and their academic progeny. E. H. Moore's role in this chronology has earned him the appellation "father of American mathematics" [1].

The biography and achievements of Moore are well documented [2]. Less accessible is information on Hubert A. Newton, Moore's advisor at Yale University [3]. Newton received a B.A. from Yale in 1850 and became the institution's only professor of mathematics in 1855. Another five years later Yale began the first Ph.D. program in America. As Newton himself never earned a Ph.D., he may be regarded as both the root and the grandfather of American mathematics.

Some of Newton's accomplishments are known. When the National Academy of Sciences was incorporated in 1863, he was one of the initial 50 scholars invited for membership. Moreover, Newton was the confidant and sounding board for J. Willard Gibbs, the greatest American scientist of the nineteenth century. Most of Newton's own research involved the study of meteors and comets. In 1895 he became vice president of the American Mathematical Society.

Hubert Newton died in 1896. His associations with Moore, Gibbs, the first American mathematics Ph.D. program, and the National Academy of Sciences make Newton an intriguing figure in the history of American science. This article employs archival materials to flesh out Newton's development in the context of the meager intellectual

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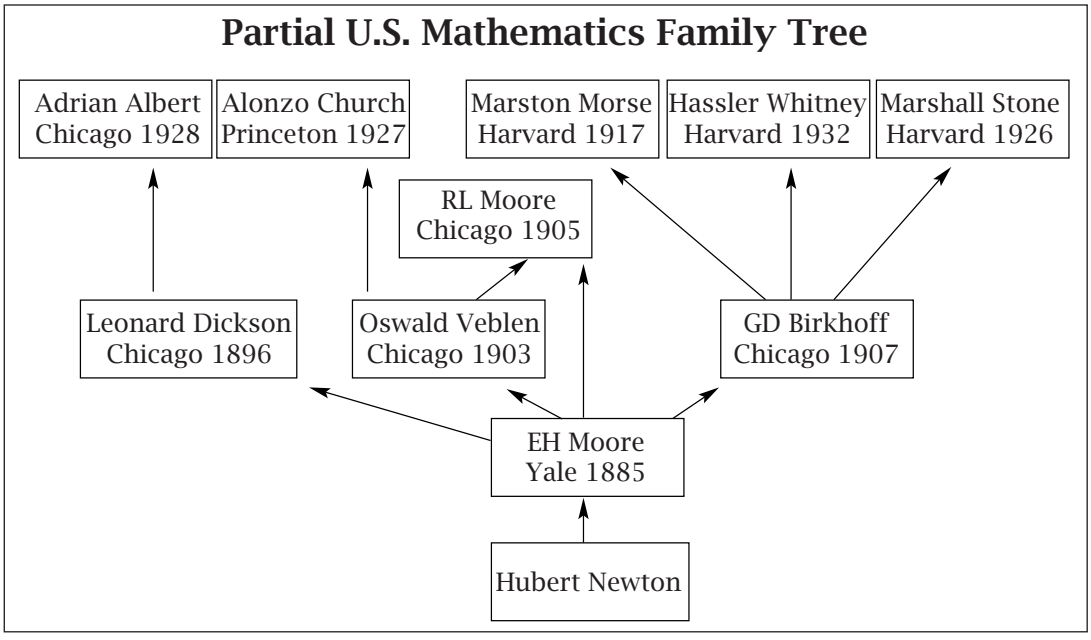


opportunities present in mid-nineteenth century United States.

I am grateful to Diane Kaplan and the Yale archives staff for kindly helping me to locate letters and records at the Sterling Memorial Library. I thank Ellen Neidle, Michele Benzi, and Albert Lewis for reading an early manuscript draft and offering their suggestions and encouragement. Conversations with David Borthwick clarified the celestial mechanics.

Becoming a Mathematician in the 1850s

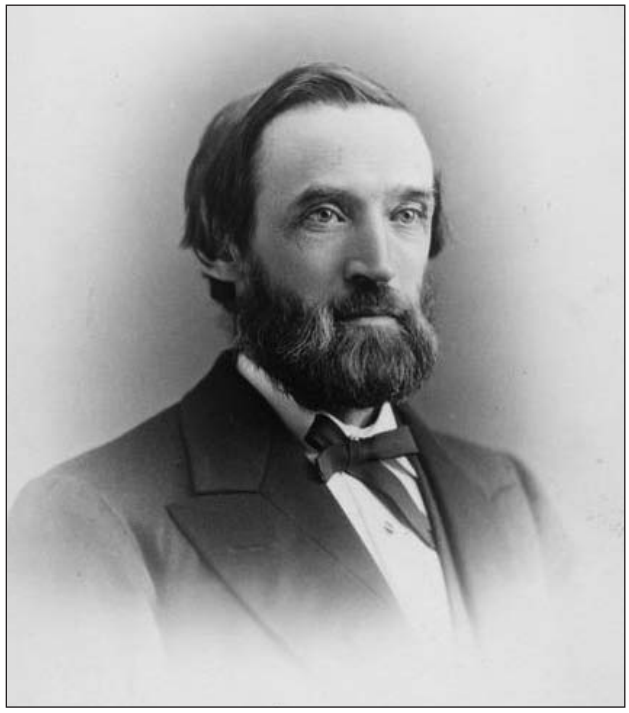
Hubert Anson Newton was born in the central New York town of Sherburne on March 19, 1830. His parents, William and Lois Butler Newton, were descended from families that migrated from England to the United States in the seventeenth century. William's father, Ashael Newton, fought in the Revolutionary War. When William's woolen factory was destroyed by fire for the second time, he became a contractor for the construction of the Erie Canal and other projects. Eventually the Newtons acquired a farm in Sherburne where Hubert was the ninth of eleven children.

In January 1847 Hubert followed his older brother Isaac to Yale. Living Yale alumni would not recognize the program then in place at their alma mater. Entering class enrollments numbered about 100 [4]. Attrition was high. Students were required to begin their day in the chapel at 6:30 for prayers. Recitation classes immediately followed the worship. The undergraduate college faculty consisted of just the president, seven professors, and a similar number of recent graduates who held the title of tutor. The curriculum was heavy in Latin and Greek with emphasis on rote learning.

All students took the same sequence of courses through the middle of their junior year. The offerings in mathematics were at a low level and had remained largely unchanged over the prior quarter century. Topics included algebra, Euclid, trigonometry, navigation, conic sections, spherical geometry, and mechanics. Calculus was among the options available to students for their first elective opportunity which arose at the end of the junior year. Most students selected a modern language instead.

Hubert Newton was a strong, but not exceptional student. Despite joining his classmates in the middle of their first year, Newton shared the freshman mathematics problem-solving prize. In his sophomore year Newton was the outright winner. No further prizes were awarded, perhaps because study of the subject was essentially complete.

Most Yale students were destined for legal or theological careers. Between the importance of honing oratorical skills and the absence of athletic and other campus diversions, debate societies flourished. Well into the third year of study came



MADID#1181: Photographs of Yale affiliated individuals maintained by the Office of Public Affairs, Yale University, 1879–1989 (RU 686). Manuscripts and Archives, Yale University.

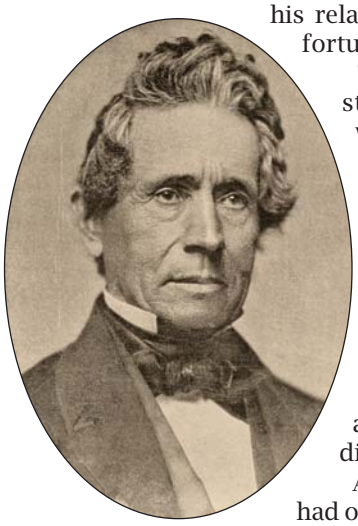
Hubert Newton.

the Junior Exhibition when the better students were selected to deliver orations and dissertations. Although Newton was a dedicated member of a debate society, he was not a scintillating speaker. One contemporary account mentions "a certain hesitation of speech and slowness of utterance" [4, page 397]. Nevertheless, Newton delivered an oration entitled "India" at the Exhibition. The text of his presentation is available in the Yale archives. To a modern reader Newton's well written narrative reeks of ethnocentrism and condescension: "there are indications that show a bright and glorious day to be near. The time when the Hindoos shall be freed from idolatry and become a Christian nation cannot be far distant" [5].

For Newton and the Class of 1850, their senior year took place with Zachary Taylor as United States president, California seeking to become the 31st state, and talk of southern secession in the air. The complex struggle over slavery was focused on the prospect of California tipping the delicate Congressional balance between free and slave states. Such current issues drove the topics for the debate societies. One week Newton assiduously prepared his position on the political compromise proposed by Henry Clay. The next week he readied an argument over whether the dissolution of the Union would be more injurious to the North or the South.

In a letter to a cousin on March 23, 1850, Newton discussed college activities, family news, and his future plans [6]. Two other cousins were among the masses drawn to California by the recent gold

strike. One was in the "diggins" and the other was in Panama making the overland trip between the major boat voyages. Newton was skeptical of his relatives "realizing a very enormous fortune."



Denison Olmsted.

MADID #10594: Images of Yale individuals, ca. 1750–1976 (RU 684), Manuscripts and Archives, Yale University Library.

The debate preparations and his studies had worn Newton out. He was looking forward to graduation on August 15, expecting to stand about fifteenth in his class. The Yale calendar provided a vacation for seniors in July and August, except for those preparing addresses at commencement. With none of his friends planning to attend the ceremony, Newton was inclined to select leisure over an oratory opportunity on the podium.

As for his future plans, Newton had only ruled out joining the gold rush. He wrote to his cousin: "What I shall do after graduation I do not know. I may prepare to teach. I may study theology—perhaps shall study engineering. I hardly think I shall be a lawyer though I may." Notably absent, from today's point of view, is any consideration of obtaining a Ph.D. The explanation is simple. In 1850 no American university offered a doctoral degree. Yale, however, had recently taken a step in the direction of graduate education.

Yale consisted of its undergraduate college, divinity, law, and medical schools [7]. For many years some Yale graduates had remained on campus to continue, informally, their studies of Greek and other college subjects. Meanwhile interest was increasing in applications of sciences such as chemistry that were largely outside the traditional undergraduate curriculum. In 1847 Yale created a Department of Philosophy and the Arts to provide courses for both constituencies. The staff consisted of two new scientists together with professors already on the university faculty.

Although the Department of Philosophy and the Arts would evolve into a graduate school, no degrees were initially offered. The Master of Arts, authorized in the founding of the college in 1701, remained under the control of the undergraduate division. To obtain an M.A. a Yale student merely needed to wait three years after his B.A., pay five dollars, and, "in the interval, have sustained a good moral character" [8, 1856–57].

In its first year the Department of Philosophy and the Arts advertised calculus and analytical mechanics among its offerings. These courses were to be taught by Anthony Stanley. Stanley had become Yale's professor of mathematics in 1836 when Denison Olmsted's responsibilities changed from mathematics and natural philosophy to natural philosophy and astronomy. The academic sessions of 1850–51 were an especially bad time for Newton or for anyone to study mathematics at Yale. Stanley, still the only mathematics professor, was debilitated with tuberculosis. Over the year he would travel the world seeking a climate to facilitate his recovery [9].

After his graduation Newton returned home to Sherburne. Having decided to pursue mathematics further, he sought advice from Olmsted over how to proceed. Only Newton's November 1, 1850, reply survives of their correspondence. That Olmsted raised the possibility of study at Yale, or elsewhere, may be inferred from the context of Newton's words:

> I have pretty much concluded to pursue my studies at home this winter. I ought to look over a part of the mathematical studies of the College course. There are also some books which I think I can read with nearly the same advantage here as elsewhere. These are elementary mathematical books which I have not studied. I am now reading Analytical Geometry. These books I ought to understand to receive the most benefit from a teacher. Such reading would of itself be too dry and for a change I shall read books upon the Natural Sciences. Afterwards I expect to avail myself of the direction of a teacher…If I can have a good offer to teach I may yet accept it. But unless it was a good one I shall refuse [10].

It is notable that Newton recognized the importance of further mathematical training. He continued his reading at home, returning to New Haven in May 1851. By this time Stanley was on his way back from Egypt, but there was little hope that he could resume his duties. Quiet discussion was under way concerning the contingency of a vacancy in the mathematics chair. Olmsted had in mind James Hadley [9, page 290]. Hadley was a brilliant young Greek professor whose wide ranging expertise included mathematics and Sanskrit. These circumstances led to a meeting between Newton and Hadley that Hadley described in his journal:

> Friday, May 9…Newton, class of '50, has come to New Haven to study mathematics—with *me*, if he can. Should like to hear him, but believe it is impossible. My new textbook in history, my Greek optional, my labors in two biennial examinations and in that for the Woolsey scholarship, and besides all, the claims of a courtship nearing its close will leave me little time for a study so arduous.

> Saturday, May 10…more of the time talking with Newton, whom I had seen at 9. He will study by himself, French first and afterwards mathematics. Advised him to procure Moigno's *Calculus* [9, page 214, 215].

In the mid-nineteenth century the best advanced mathematical texts originated in Paris. For an American student a reading knowledge of French was essential. Hadley's Friday entry indicates a desire to take Newton on as a student. Courtship may have been the decisive obstruction. Hadley had recently become engaged. He and his fiancée had just begun seeing each other every day. The injection of Hadley into the story demonstrates the dearth of mathematical expertise in America. Yale was one of the best universities in the United States. Yet their second authority on mathematics was a 30-year-old full time Greek professor.

Hadley recorded one further meeting with Newton. It occurred later in the summer of 1851. The entry mentions that Newton was studying a book by the French mathematician Jean-Marie Duhamel. In the fall Newton returned to Sherburne. It is unclear how he was supporting himself. Perhaps Newton relied on his family or worked on their farm. In the second year after graduation he followed the same routine of study as in his first, remaining at home until May and then going to Yale.

While Newton was in Sherburne, Stanley aborted an attempt to return to the classroom. The tuberculosis was headed into a terminal stage. Hadley moved into the breach to handle calculus in the summer of 1852. By this time the college catalogue lists Newton as a student in the Department of Philosophy and the Arts. Although there is no record, it is likely that Newton took calculus from Hadley in 1852.

The situation in mathematics at Yale was untenable. Stanley was unable to teach. Hadley, whose real love was Greek, had a full plate of other responsibilities. Yale needed another teacher to cover the mathematics instruction. Tutors were always recruited from the best recent graduates. Newton's mathematics prizes and two years of subsequent study gave him a solid resumé, even if he were not a valedictorian or salutatorian. In July 1852 Newton accepted a tutorship. The annual salary was $550 (professors received $1,300).

Tutors held temporary positions that normally lasted a few years. Among the tutors there was a seniority system under which the newest hires taught the courses left over after all others made their selections. Thus a new tutor with a specialty in mathematics might be stuck with conducting Latin recitations. Whether through luck or a special concession to the needs of the college, Newton got mathematics when he assumed his duties in January 1853. Moreover, at age 22, he immediately found himself in charge of the entire mathematics program at Yale.

Newton had taken an important step toward an academic career. Stanley, Olmsted, and Hadley each had apprenticed as tutors at Yale prior to obtaining their professorships. However, with vacancies in a particular chair arising once a generation or so, only an exceptional tutor with fortunate timing had any realistic expectation of promotion. Many tutors went on to careers outside the academy. Some obtained positions at other colleges. Olmsted taught at the University of North Carolina for eight years before being called back to Yale.

Anthony Stanley died in the spring of 1853. For a replacement, Yale would want the leading mathematician from their alumni. On this basis Newton's few months of experience as tutor paled in comparison to the credentials of William Chauvenet and Theodore Strong from the classes of 1840 and 1812 respectively. Chauvenet had been instrumental in the recent founding of the United States Naval Academy where he was the professor of mathematics and astronomy. Moreover, Chauvenet had written a highly acclaimed textbook on trigonometry. Strong was a mathematics professor at Rutgers. He had published research, but was nearing the age of 63.

The Yale mathematics chair was offered to Chauvenet who decided to remain at the Naval Academy [11]. In his declination letter Chauvenet explained that the question was "so nicely balanced that it required but little to turn it either way." He went on to leave the door open by stating "that some of these [reasons] which have weight with me at the present are of a temporary character." The position would remain unfilled as Newton soldiered on with the responsibilities of a professor, the standing of a tutor, and an opportunity to impress.

Today, a young mathematician is advised that research, publication, and networking are the surest paths to advancement. The 1853 culture was vastly different. The notion of a mathematics professor doing research was, literally, foreign. In the entire country only Strong and Benjamin Peirce, at Harvard, were committed to research. Stanley and Chauvenet had attained their standing by being knowledgeable and writing textbooks.

In 1853 no mathematics journal existed in the United States, nor was there any community of mathematicians, either locally or nationally. Nevertheless, societies promoting scientific scholarship functioned effectively at both levels. The Connecticut Academy of Arts and Sciences was established at the beginning of the nineteenth century. In Newton's time the Connecticut Academy was essentially a group of Yale faculty that periodically hosted scientific discussions in their homes. Linkage to a wider geographic community came in 1848 with the founding of the American Association for the

Advancement of Science (AAAS). The fourth AAAS meeting was held in New Haven in 1850, bringing to town the American scientific elite of Joseph Henry, Louis Agassiz, Alexander Dallas Bache, Benjamin Peirce, and Benjamin Gould.

Tutor Newton took advantage of these opportunities, participating in the activities of both the Connecticut Academy and the AAAS. In July 1853 he traveled to the semiannual meeting of the AAAS in Cleveland. There he met Benjamin Peirce. Newton described some work he had done in spherical trigonometry on the effect of the Earth's gravity on an orbiting body. The conversation with Peirce led to Newton's first publication [12]. The one-page paper, and a later revision, appeared in Gould's recently established *Astronomical Journal*.

In 1855 Newton, with this single publication, became the Yale Professor of Mathematics. At the age of 25 he was slightly younger than Stanley and Hadley when they received their permanent appointments. It is unclear what deliberations the administration conducted during the two years that elapsed after the original offer to Chauvenet. Perhaps they hoped that Chauvenet would change his mind, or possibly they were waiting to become convinced of Newton's suitability for the position.

The 1855 European Experience

There was little more that Hubert Newton could then do in the United States to reach the frontiers of mathematical research. The latest discoveries and their exposition were taking place in Europe. Although a transatlantic voyage was then a miserable two-week ordeal, it was not unusual for Yale students to make the journey for further study. In 1854 a few recent graduates were in Germany and writing back of their experiences. Letters from Europe circulated around the Yale campus [9]. The exotic descriptions of educational opportunities would naturally have made an impression on the ambitious Newton. The next step for him was to learn at the feet of the Parisian savants from his texts.

Fortunately for Newton there was a precedent. His predecessor Stanley had been permitted to defer his duties in order to study in Europe. Newton's request for a one-year leave was granted with the stipulation that the compensation for a replacement come out of his $1,600 salary [15, July 1855]. Newton planned his year of European travel to begin with extended study in Paris. Other Yale people had spent time in France, but their academic experiences were largely restricted to nonmathematical subjects at German institutions. Despite the limited information resources of 1855, Newton would have known some of the French names. Joseph Liouville held the mathematics chair at the Collège de France while Duhamel and Augustin Cauchy were among those giving courses at the Sorbonne. As might be expected, Newton encountered some surprises upon arrival. On November 28 he wrote to the Yale treasurer and librarian, Edward Herrick, with this update on his classes:

> For the last two months I have been at Paris waiting for the lectures to commence and employing the time quite profitably in learning the spoken language of France. The lectures commence two months later than I was informed—those at the Collège de France beginning next Monday. Of the 11 courses of scientific lectures at the Sorbonne but three or at most four are worth my while to attend. At the Collège de France there may be two or three more which would make about two lectures a day. I cannot remain here through these courses and how long I shall remain here after I have fairly seen and understood the men is yet to be decided.
>
> Chasles has done an excellent work in reducing to a system the modern labors in the higher Geometry. He has published a "splendid" treatise upon it and gives also an interesting course of lectures. Lamé lectures upon the Math. Theory of Heat and gives a very profound discussion of the subject. The lectures of Sturm and of Cauchy I have attended thus far for the two-fold reason—to see the men—and in hopes they would soon leave the elements. Duhamel, Lefébure de Fourcy, Delaunay—I have dropped [13].

Newton's enthusiastic report on Michel Chasles and Gabriel Lamé to Herrick contrasts with this gloomy excerpt from his letter the previous day to his college roommate John Brewer:

> This morning after taking a cup of coffee and a crust of bread (in France the bread is all crust) I considered more or less attentively some propositions in Geometrie Superieure until 10 o'clock when I took my breakfast. At 10 1/2 was a lecture. I was there 10 minutes late and waited five minutes for the prof. The lecture room does not compare with ours for comfort there being no backs for the seats and no alley so that to reach the front seats we walk down stepping on the seats. A clumsy arrangement that. The Prof. has so far been uniformly late. Perhaps his watch is slow. It must run too slow he finished about 1 3/4 hours after the time for the

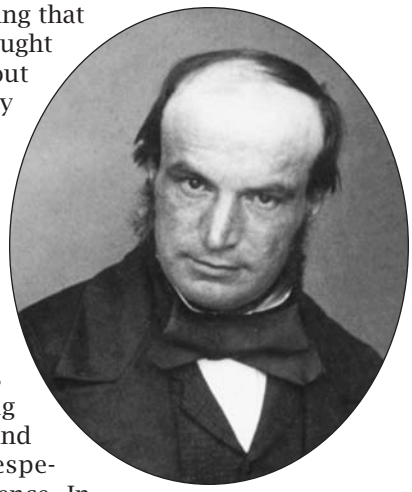
> beginning. But here he comes. He is a man about 65 a little more probably. He has a raw beefy looking countenance and his appearance otherwise is not much different as he need not be ashamed to place himself on the other beam of the scales from Mr. Skinner. He certainly does not give his personal countenance to the remark I have heard made that Mathematicians are spare and skeleton–like…he stands sideways. With one hand in his pocket he chalks out diagrams and formulas with the other. He never looks up at the class. I mistake, he did once look up and the expression was so ludicrous that we could not help laughing. In time he finished. That is at the close of one of his sentences without changing his manner or looking up he closed a book he had on the table walked towards the door and taking his hat stepped out while we waited to hear the next sentence. We looked at the spot where he disappeared then at each other then laughed then concluding the lecture was over disbursed. This lecturer is [obscured word] one of the greatest mathematicians in all Europe [14].

The obscured word in the last sentence is possibly "Sturm". At this time Sturm was just 52 years old, but three weeks from his death. Cauchy was 66.

Newton went on to describe more of his day. In the afternoon he watched the Emperor, Louis Napoleon, review his troops. The "pageant" of "helmets and plumes, cannon and bayonets, horses and men" made for a "sight [that] was truly splendid." Newton felt "fortunate in having witnessed the parade," but uneasy with his first close encounter with militarism. The "bayonets are the empire and make the peace of Paris. God grant we may never need (I will not say have) such an empire, or such a peace in America. …I am glad we have no army. I had rather enter upon a war unprepared if necessary than to support in peace as France does 500,000 men in going through unprofitable evolutions and tempting our powers that be to bring on a war."

Information on the remainder of Newton's year abroad is based largely on two subsequent letters to Herrick [13]. In February Newton went to England for three weeks. His description of this period is dominated by accounts of visits to observatories at Greenwich, Kew, and Cambridge. At Cambridge Newton enjoyed an informative conversation with the British astronomer John Couch Adams. Ten years earlier Adams had predicted the existence of the planet Neptune through calculations based on irregularities in the motion of Uranus. Ten years later Newton and Adams would both contribute to the prediction of meteor showers.

That Newton and Herrick shared an interest in astronomy provides some explanation for the extended discussion of this topic in the letters. Still it is striking that Newton so aggressively sought out telescopes throughout his trip. He had previously visited an observatory in Paris.



Photograph courtesy of the University of St. Andrews Library.

John Couch Adams

Newton went from England to Italy. The Italian itinerary included Rome, Naples, Florence, and Venice. Aside from an observatory in Rome, it seems that his activities consisted of sightseeing and viewing museums and galleries. Newton was especially impressed by Florence. In May he reached Vienna where he wrote his last letter to Herrick. At this point Newton was planning to remain in Vienna for at least a month, visit some German cities, and then return to America in August. He did make contact with fellow alumnus and tutor, Timothy Dwight, who was studying in Bonn and Berlin. In his own memoir Dwight, a future president of Yale, mentions that he and Newton were "traveling companions" for "a short time" [4, page 395].

Establishing a Research Program

With his return to Yale in 1856, Newton took up his duties as professor of mathematics. Meanwhile, inspired by Chasles' synthetic approach to projective geometry, Newton continued his own study of the subject. A key technique was the principle of polar inversion which transforms points and curves into other points and curves with similar intersection properties. Newton considered the problem of constructing a circle tangent to three given circles. If two of the given circles intersect, Newton employed the inversion approach to reduce to the situation of finding a circle tangent to another circle and two lines. Although the solution of the general case was already known, he had found a nice alternative construction.

As with the publication of his earlier paper on orbital mechanics, Newton's timing was fortuitous. For much of the nineteenth century there was no American mathematics journal. However, Newton's geometric discovery coincided with the founding of the short-lived *The Mathematical Monthly*. His solution to the circle problem appeared in volume 1. Two years later Newton followed up with a more substantial contribution to the third (and last) volume of the journal. This paper described

and extended Chasles' intricate straight edge constructions for obtaining points on curves that are stipulated by certain specified data (such as a conic with given points, intersections, or tangencies).

Between the printing of the two geometry papers, Newton published an article on a different subject. In 1860 his "On the meteor of November 15th, 1859" appeared in the *American Journal of Science and Arts*. Others had previously provided detailed accounts of sighting the meteor from various eastern locations in the country. Newton collated the data and used triangulation techniques to calculate the visible path of the meteor. The underlying objective of his study was to infer the backward trajectory of the meteor's orbit. To do this he posited a lower bound for the body's velocity based on the observers' estimates of the time that elapsed while the meteor was visible. Newton then went further, making the dubious assertion: "The result of my investigation has been to establish almost beyond a doubt the conclusion, that *this body was not a member of the solar system but came to us from the stellar regions.*"

Publishing research, rather than textbooks, was very unusual for an American mathematics professor in 1860. Newton would continue to do so, writing over 40 papers on meteors and comets. He is best known for his work, described below, on the November Leonid showers. Meteors had long been the subject of considerable interest at Yale. The fascination began in 1807 when a bright overhead explosion of a meteor prompted Yale scientist Benjamin Silliman to perform an analysis on specimens recovered from the event. One decade later Silliman founded the *American Journal of Science and Arts*. A spectacular meteor shower on November 13, 1833, attracted the attention of professor Denison Olmsted and members of the Connecticut Academy. Silliman's journal became a vehicle for accounts of observations and for the proposal of theories about meteors.

Little was understood about the origin, mechanism, and orbits of meteors. Occasional shooting stars of varying intensities were well known to stargazers. What set apart the early morning November 13 event was the extraordinary sight of the sky filled with streaks over a two hour period. Olmsted set out to provide a scientific explanation for the phenomenon, publishing a long article about the shower in the *American Journal of Science and Arts* [16]. He began with verbatim eyewitness testimonies and followed with his own analysis. He noted that several observers, including himself, stated that all of the meteors seemed to originate from a common point in the sky toward the constellation Leo. The identification of this *radiant* was a significant step in understanding meteor showers.

Olmsted concluded that the shower was the result of the Earth coming into close proximity with a comet-like nebulous body that was moving in a different elliptical orbit about the sun. He set out to determine the ellipse, relying on a mistaken inference that the nebulous body was at aphelion (maximum distance from the sun) when meeting the Earth. Olmsted then looked for a feasible orbit that both intersected and was shorter than that of the essentially circular path of the Earth. In the investigation of the 1833 shower, historical accounts surfaced of a similar event in South America on November 12, 1799. One year earlier, on the same day in 1832, another shower had been observed from the Red Sea.

Olmsted pondered an elliptical orbit that revisited the same point after one year and 33 years. To accomplish the former he reasoned that the body must complete an integer number of revolutions each year. By Kepler's third law, for an orbiting body the cube of the length of its semimajor axis is proportional to the square of the period. Using units of years for the period and astronomical units for the semimajor axis, the proportionality factor is one for orbits about the sun. Since the semimajor axis must be at least one half for the orbit of the nebulous body to reach that of the Earth, the period must be greater than the square root of one eighth. But the period was assumed to be the reciprocal of an integer, forcing it to be at least one half year. Since he believed that the orbit was inside that of the Earth, Olmsted concluded that the period of the nebulous body was one half year.

Verification of Olmsted's theory could be provided by showers on subsequent annual anniversaries. Each November Olmsted enlisted a cadre of students and enthusiasts to watch the sky and record data on shooting stars. For the next several years possible recurrences were observed, albeit in much smaller and diminishing intensity. By 1838 even Olmsted had to admit that a shower probably had not occurred [17]. Still he continued the annual vigil. The thread arose in his 1850 correspondence with Newton. Olmsted arranged for his former student to observe the Sherburne sky on the morning of November 13 [10].

Olmsted died in 1859, about the time that Newton began his research on meteors. By then, Olmsted's six month period model was out of favor. In the intervening years showers had been observed in April and August. Intensive literature searches had identified occurrences in various months over the prior thousand years. The spread of data was confusing. Were all the showers linked to a single system? Some claimed that the phenomena originated from a terrestrial cause such as the weather.

Examining texts from the Middle Ages was challenging. To fix precise dates often required interpretation from contextual references such as the death of a king or a now obscure holiday.

After making these determinations and converting to the current Gregorian calendar, the years of the October-November showers were revealing. The showers clustered around the same three stages of each century. These were at the 0th year, the 33rd year, and the 66th year. For example, spectacular 1366 and 1202 showers were described in Portuguese and Arabic writings respectively. The pattern was strikingly consistent with the previously known instances of 1799, 1832, and 1833. The one problem was that the day of the month moved gradually with the year from November 13, 1833, to October 29, 1366, to October 26, 1202. The several-day variation required reconciliation with the notion of a fixed point of intersection from the Earth's orbit.

In 1863 Newton began to bring some clarity. Both the Gregorian and Julian calendars were based on the tropical year (going from solstice to solstice). Due to precession of the Earth's axis, the tropical year is about 20 minutes and 24 seconds short of the sidereal year which is calibrated by a complete revolution of the Earth about the sun. Thus every 70 years or so the hypothetical intersection node should move ahead a day. Newton converted the earlier shower dates to an 1850 sidereal scale and, for the events above, arrived at November 5, 1366, and November 4, 1202 [18]. These were closer to November 13, giving a stronger indication of some sort of periodic dynamic.

Newton put forward his model in 1864 [19]: an elliptical ring (annulus) containing the orbits of a nonuniformly distributed collection of small bodies that are concentrated over a small sector. The sun is one focus of the orbits, but the plane is slightly inclined to that of the Earth's orbit, and the motion is in the opposite direction. The Earth's orbit intersects the annulus. Showers occur in the years that the Earth passes through the loaded sector. Newton looked for a periodic orbit where intersections could happen for two or three consecutive years and then resume after a third of a century. Examination of the data indicated that the showers of 902 and 1833 occurred at about the same phase of a cycle. Dividing their difference by the 28 thirds (of a century cycles) they spanned, Newton adopted the assumption that each body returned to its original location after 33.25 years.

It remained to determine the ellipse and the prime period of the flow. Newton gave the following analysis: Configure the loaded sector to be centered at the intersection node z where the orbit meets that of the Earth. For each point x on the ring let $h_t(x)$ represent its position on the ring after t years. Now consider what happens after one year. To have another shower z must be in the loaded sector. So h_1 maps some other point of the loaded sector to z. Then $h_1(z)$ is near z, on one side or the other. During the year that z moves to $h_1(z)$, the orbit of z passes through the entire ring some nonnegative number of times. Kepler's third law limits the number of revolutions to less than three. Since $h_{33.25}$ is the identity, h_1 is either τ, $1 \pm \tau$, or $2 \pm \tau$ revolutions where $\tau = \frac{1}{33.25}$. The corresponding periods are 33.25 years, 354.6 days, 376.6 days, 180.0 days, and 185.4 days.

Newton argued that while all five periods were possible, 354.6 days was the most probable. He then offered this program to narrow the possibilities: Accurate coordinates for the radiant (which did not then exist) would permit calculation of a tangent vector to the ellipse and then the plane of the orbit. This information, together with a period and the intersection node, determine the orbit for the two body problem (in conjunction with the sun). Corresponding to each of the five hypothetical periods the perturbations due to the planets could, in theory, be computed. These results could then be compared with the known drift of the intersection point. Implementation had to wait for the next shower when a more precise identification of the radiant could be made.

Two years later, in 1866, a shower was seen in Europe on the morning of November 14. John Couch Adams, whom Newton had met earlier in Cambridge, then went to work on the hypothetical orbits. Adams showed that the four shorter paths were not feasible. However, the effects of Jupiter, Saturn, and Uranus on the highly elliptical 33.25 year period orbit summed to an excellent fit for the drift that Newton had computed [20].

As Adams was performing the formidable calculations in 1867, Giovanni Schiaparelli reported that the bodies generating the annual August showers were in the same orbit as a comet first observed in 1862. It was subsequently determined that the Tempel-Tuttle comet was shadowed by the November meteoroids in its orbit [21]. The apparent one-to-one correspondence between comets and meteor showers raised a chicken or egg question which was not fully resolved until the middle of the twentieth century. Each time a comet approaches the sun, particles from it are ejected into nearby clumps. It is the bodies of these dust trails that produce meteor showers when they enter the Earth's atmosphere. Today, supercomputers track the spread of the orbiting dust trails, projecting future encounters with the Earth [22]. The name for the November shower, Leonid, follows the convention of derivation from its radiant.

First Mathematics Ph.D. in the United States?

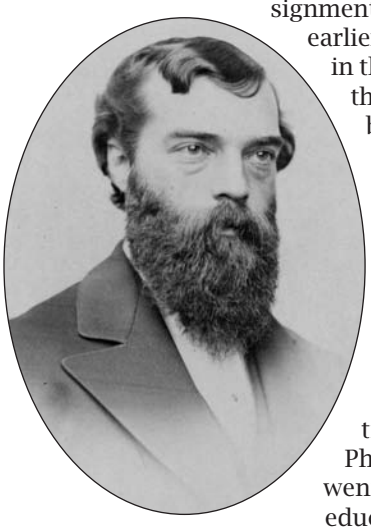
As Newton began research on meteors, he participated in one of the landmark events of American higher education. In 1860 Yale became the first institution in the United States to offer the doctor of philosophy degree. All Yale bachelor's graduates were eligible to become candidates, as well as others meeting additional conditions. Requirements

for the Ph.D. consisted of two years of study from at least two branches of learning, a final examination, and "a thesis giving evidence of high attainment in the branches they have pursued" [8, 1860–61].

At the 1861 Yale graduation, on July 25, Eugene Schuyler, Arthur W. Wright, and James Whiton received the first Ph.D.s ever awarded on American soil. Those in attendance could not have anticipated how many institutions would adopt their own doctoral programs. As might be expected, many of today's conventions were not yet in place. For example, neither subjects nor advisors were associated with the individual awards.

Separate departments such as physics, Latin, or history did not then exist at Yale. Newton, as the professor of mathematics, was a member of the Academical Faculty as well as serving in the Department of Philosophy and the Arts, the umbrella grouping that administered the new degree. In the twentieth century, with partitioning into disciplinary departments, retrospective assignments were made of subject areas to earlier degree conferrals. Doubts arose in these determinations under which the "guiding principle" was to have been the "subject of the dissertation" [23]. While not all dissertations, or even their titles, had survived, in most cases there was considerable information about the subsequent career of the recipient.

Photo below: MADID #6272: Images of Yale Individuals, ca. 1750–1976 (RU684). Manuscripts and Archives, Yale University. Photo at right: MADID #6825: Yale diploma collection, ca. 1702–1950 (rU 150). Manuscripts and Archives, Yale University.

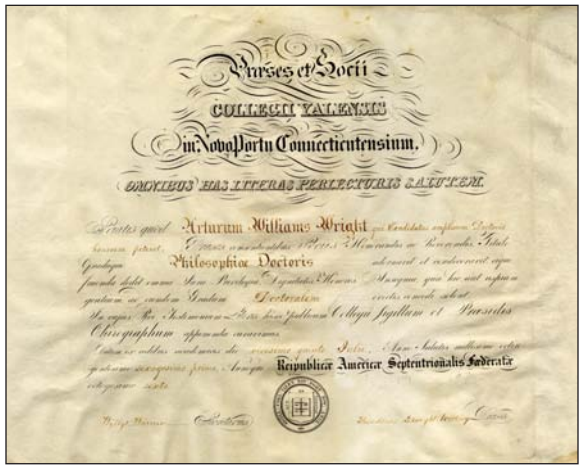


Arthur W. Wright.

Under this process, John Worrall (in 1862) and Charles Rockwood (in 1866) were identified as the first recipients of Ph.D.s in mathematics [24]. Both went on to careers in mathematics education. Worrall taught at various levels in West Chester, Pennsylvania. Rockwood became a mathematics professor at Bowdoin, Rutgers, and then Princeton. Rockwood's thesis was "The Daily Motion of a Brick Tower Caused by Solar Heat". The title of Worrall's thesis is unknown.

Arthur W. Wright was among the three students who finished one year prior to Worrall. Wright's dissertation was entitled "Having Given the Velocity and Direction of Motion of a Meteor on Entering the Atmosphere of the Earth, to Determine its Orbit about the Sun, Taking into Account the Attractions of Both These Bodies". Given that Wright served over thirty years as a physics professor at Yale, it is not surprising that his 1861 Ph.D. was deemed to have been in physics. With further hindsight, there is a strong argument that Wright's degree was actually in mathematics.

Wright received his B.A. in 1859 and began graduate work at Yale. At this time physics was



Wright's Ph.D. diploma.

covered by the professor of natural philosophy and astronomy. With Olmsted's death, the chair was vacant during Wright's first year of graduate study. In 1860 Elias Loomis succeeded Olmsted. The previous year Chester Lyman became professor of industrial mechanics and physics for the Scientific School. The Scientific School was a separate division of Yale that had been formed around the applicable sciences. Members of its faculty also served in the Department of Philosophy and the Arts. Wright was examined on his studies in mathematics, modern languages, mineralogy, and botany [25].

Classifying Wright's thesis among the fields of astronomy, mathematics, and physics runs into the difficulties of ill-defined subject boundaries and overlaps, both of which have shifted over time. It is unfortunate that there are no extant copies of the thesis. Analysis must devolve to the title and must be placed in the context of the contemporary research scene. Meteors were not then a topic in the mainstream of American astronomy. However, astronomy was a most active area of mathematics in general and American mathematics in particular. Benjamin Peirce worked on the orbit of Neptune. The third and fourth presidents of the American Mathematical Society, George Hill and Simon Newcomb, specialized in celestial mechanics.

Newton published papers on meteors in every year of the 1860s. Loomis' limited study of meteors came much earlier in his career. Lyman was more interested in the observational and equipment aspects of astronomy. The title of Wright's thesis places the work at the heart of Newton's current interests. Newton almost certainly served in the, not yet defined, role of Wright's thesis advisor. Considering the examination areas, thesis topic, and faculty of the time, Arthur W. Wright should be regarded as the first student to receive a mathematics Ph.D. in the United States.

Wright maintained his interest in meteors. Newton's 1863 meteor observation reports cite Wright as a partner or teammate. At this time Wright held the title of tutor. Over the next several years he taught Latin and physics to undergraduates. After a year of study in Germany and a professorship at Williams, Wright joined the Yale faculty in 1872. He was professor of molecular physics and chemistry until 1887 when the designation of his chair was changed to experimental physics.

The research interests of Wright and Newton continued to overlap. Wright analyzed occluded gases in meteorites and drew implications on the relation between comets and meteoroids. Later he became a pioneer in X-ray experiments and was known for his work on "the deposition of metallic films by the cathode discharge in exhausted tubes" [26]. In 1881 Wright was inducted into the National Academy of Sciences. He died in 1915 at the age of 79. The A. W. Wright Nuclear Structure Laboratory at Yale honors his memory.

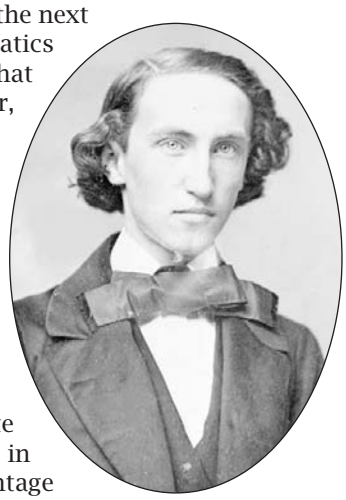
Gibbs and Moore

By all indications Newton was an effective mentor. J. Willard Gibbs was the Yale salutatorian in 1858 and E. H. Moore the valedictorian in 1883. Both won undergraduate mathematics prizes, obtained Yale Ph.D.s, studied abroad, and went on to have an enormous impact on scientific scholarship. Their careers were also shaped, in the formative years, by the influence and support of Hubert Newton.

Gibbs was raised in the Yale community [27]. His father, also named Josiah Willard Gibbs, was a sacred literature professor who died in 1861. Willard, the son, was then in graduate school. He passed examinations in mathematics, ethics, and modern languages. There remains some doubt surrounding Willard's thesis. After his death, a manuscript entitled "On the Form of the Teeth of Wheels in Spur Gearing" was found among his papers. Those associated with the university concluded it to be Gibbs' 1863 thesis. Accordingly, Willard Gibbs' Ph.D. is listed as in engineering.

After completing his degree, Gibbs was appointed to a tutorship. During this period, and possibly earlier, he was involved in Newton's research on meteors. In Newton's 1864 Leonid orbit paper, Gibbs is the one person acknowledged for valuable suggestions. In particular, Newton singled out his help with a delicate aspect of narrowing the periods. Their relationship is especially notable in view of Gibbs' social isolation.

Willard and his two sisters, Julia and Anna, lived the rest of their lives together in the house left to them by their father. Only once did Willard venture far from New Haven. In 1866 the three siblings sailed for Europe where he would study in Paris, Berlin, and Heidelberg. Gibbs set out in Newton's footsteps, taking courses at the Sorbonne and Collège de France from Chasles and others. Over the summer the Gibbs were met by Addison Van Name, the valedictorian from Willard's class who was engaged to Julia. The couple were married in Berlin and returned to New Haven. Anna remained with Willard in Germany. Over the next two years he studied mathematics and physics from professors that included Weierstrass, Kronecker, and Magnus.



Photograph from the Beinecke Rare Book and Manuscript Library.

J. Willard Gibbs.

The trip to Europe stands out as one puzzling aspect of Gibbs' insular life. Transatlantic travel and study in those days required a sort of initiative that otherwise appears to have been absent in Gibbs. The course with Chasles indicates a connection to Newton. It is reasonable to speculate that Newton played some role in persuading Gibbs to take advantage of the resources abroad.

In 1869 Willard and Anna returned to America and joined the Van Names to form a household. Only Addison, as Yale librarian, was employed. Willard continued his independent study. The household was supported by Van Name's salary and the Gibbs' inheritance. Newton was a neighbor. The Newton children recalled Gibbs as a daily visitor, discussing science with their father [28].

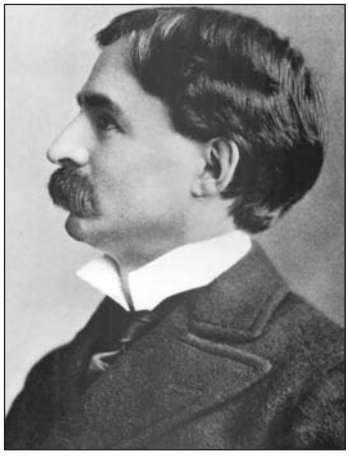
During 1871 Yale was in a period of transition between presidents. A committee that included Newton and Van Name produced a report entitled *The Needs of the University*. Among the recommendations were an infusion of new funding and the creation of additional chairs in physics and other subjects. Newton was the only member of the committee with expertise in mathematics and physics. Shortly after the report was issued, Willard Gibbs was appointed as professor of mathematical physics in the Department of Philosophy and the Arts. The position carried no salary. Essentially it was a research professorship that would involve a small amount of graduate teaching.

The exclusion of undergraduate teaching was understandable in that Gibbs had unfavorable reviews as a tutor. Still, the appointment of an unpublished scholar involved considerable risk to the parties at both ends. Yale was conferring its imprimatur, and Gibbs was embarking on an uncertain path with dim financial prospects. Whatever role Newton had in choreographing this relationship, the returns were immediate and far-reaching. From 1873 to 1878 Gibbs published his seminal work that established a thermodynamic foundation for physical chemistry. Recognition came slowly, and he remained without a salary until 1880. Johns Hopkins then offered a professorship with a $3,000 salary. Yale countered with

$2,000. Gibbs remained in New Haven where he died in 1903.

The founding of the Johns Hopkins University in 1876 changed forever the landscape of United States scholarship. A few other universities had commenced doctoral programs, but, at Hopkins, research and graduate education were the priorities. Moreover, its president, Daniel Coit Gilman, secured the personnel to implement his vision in mathematics, physics, and other subjects. Gilman had graduated from Yale two years after Newton, traveled through Europe, and then returned to his alma mater becoming a member of the Scientific School faculty. He had served with Newton and Van Name on the needs of the university committee but left Yale shortly after a more conservative colleague was selected over him as president.

When E. H. Moore received his Ph.D. from Yale in 1885, mathematics was germinating in the United States. However, Europe remained the center for important investigations. As Moore's thesis advisor, Newton foresaw how Moore's talents would be cultivated by further work in Germany. Newton facilitated Moore's study abroad by loaning him money to spend a year "at Göttingen and Berlin for a promise to pay at some future time" [29].



Photograph from the AMS archives.

E. H. Moore.

Moore attended lectures by Kronecker and Weierstrass, prior to beginning an academic career in the United States. His first lower level positions were at Yale and Northwestern. Despite the arduous teaching loads, Moore continued his research and publication. His real opportunity came in 1891 when Yale Divinity Professor William Rainey Harper became the founding president of the University of Chicago. At Chicago, Harper would bring about the biggest advance in American scholarship since the creation of Johns Hopkins. As had Gilman before him, Harper put considerable effort into recruiting a faculty suited to carry out his plans.

Harper's choice of Moore to lead mathematics contrasted sharply with the experienced scholars selected to head other departments. Moore was an assistant professor at Northwestern which did not then have a doctoral program. While Harper was no doubt impressed by Moore from their interactions at Yale, mathematics was a subject outside Harper's expertise. As Moore's advisor and Harper's colleague, Newton was ideally positioned to supply a decisive endorsement (no record of any evaluation has been found).

At Chicago, Moore's career flourished [2]. An appreciation of mathematical developments in Germany influenced his research, teaching, and administration. To complete his staff Moore hired the German émigrés Oskar Bolza and Heinrich Maschke. Chicago became the first American university to offer mathematics training at the level and breadth available in Europe. Moore himself supervised the theses of Leonard Dickson (1896), Oswald Veblen (1903), and George D. Birkhoff (1907) who became the leading mathematicians at Chicago, Princeton, and Harvard respectively. Their descendents included Adrian Albert, R. L. Moore, Alonzo Church, Marston Morse, Marshall Stone, and Hassler Whitney.

In 1899 the University of Göttingen awarded an honorary Ph.D. to E. H. Moore. Over the early twentieth century Moore and his progeny were at the forefront of the stunning ascendence of American mathematics. Moore's contributions went beyond paternity and his own research. It was largely through his initiative that the New York Mathematical Society became, both in name and character, the American Mathematical Society [30]. Moore was a driving force behind the start-up, in 1900, of the *Transactions of the American Mathematical Society*. Under Moore's painstaking editorship the journal showcased the excellent research produced in America. In just one half century, the United States had advanced from a backwater to a font of mathematical scholarship.

The 1896 Generational Change

Hubert Newton is known to mathematicians of today, if at all, as the thesis advisor to E. H. Moore. During his lifetime, however, Newton was one of the most honored mathematicians in the United States. In the 1860s he was inducted into the American Academy of Arts and Sciences, the National Academy of Sciences, and the American Philosophical Society. In 1868 Newton was awarded an Honorary Doctor of Laws by the University of Michigan. Twenty years later he received the J. Lawrence Smith Gold Medal from the National Academy of Sciences. Other recognitions included foreign membership in the Royal Society of London and the 1885 presidency of the American Association for the Advancement in Science.

Newton's resumé was not that strong in 1863 when President Abraham Lincoln signed the law to establish the National Academy of Sciences. Two weeks earlier Louis Agassiz, Alexander Bache, Benjamin Peirce, and Benjamin Gould had met with Senator Henry Wilson to consider an Academy proposal conceived by Captain Charles H. Davis [31]. Out of this meeting came the draft of the legislation which was to sail through the Congress. The purpose of the organization was twofold: to assist the government on matters requiring scientific

expertise and to recognize investigators who had made significant advances.

The bill named 50 men for inclusion in the National Academy. The old boy selection process and the low level of American science led to a loose interpretation of the standard for original research. Recall that Yale began to award the doctoral degree just one and one half years earlier. Mathematicians joining Newton on the incorporating list were Peirce, Chauvenet, and Strong. They were the leading names of the time. The early influence of the National Academy was limited. Committees advised on a variety of maritime and other issues. Newton participated in an unsuccessful initiative to advocate adoption of the metric system. Over the Academy's first decade, Strong and Chauvenet died. Peirce resigned in 1873 in a dispute over the exclusivity of membership [31, page 119].

Newton, the youngest of the four mathematicians, was the last to die. His death, in 1896, occurred as Moore's first student completed his Ph.D. A transition was taking place in American mathematics. The most prominent senior mathematicians were Hill and Newcomb. Both worked in astronomy and were domestically educated without a Ph.D. The rising stars were Moore, William Osgood, and Maxime Bôcher. Osgood and Bôcher had done their undergraduate work at Harvard and traveled to Germany for their Ph.D.s. Moore completed his formal education at Yale but needed to go abroad to prepare for a research career. Moore's student, Leonard Dickson, had received a complete graduate education. Although Dickson did spend the following year in Leipzig and Paris, the European experience was no longer an essential ingredient in the training of American mathematicians. Birkhoff did not travel to Europe until 1926, thirteen years after he achieved international renown with his proof of Poincaré's last geometric theorem. It is fitting, and no coincidence, that Newton's lifetime spanned the struggle of the United States to become self-sufficient in mathematical research.

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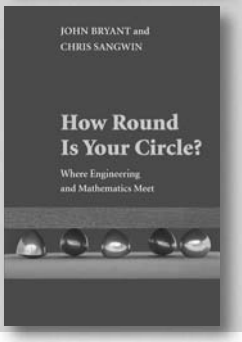

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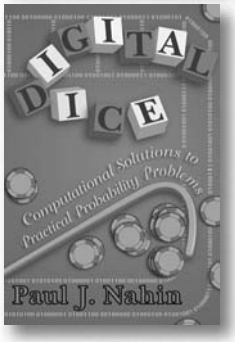

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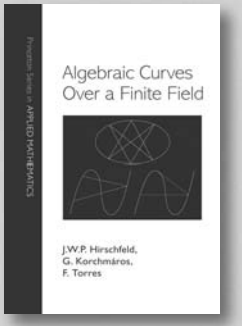

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Differential Geometry, Strasbourg, 1953

Michèle Audin

The picture on the following page, taken in 1953, shows a group of mathematicians on the stairs of the historic Wilhelmian Building of the University of Strasbourg. The picture appeared in the local newspaper *les Dernières Nouvelles d'Alsace* to illustrate an article about a differential geometry conference organized by Charles Ehresmann (1905–1979), who was a professor at the University of Strasbourg, and André Lichnerowicz (1915–1998), who was a professor at the Collège de France. The photograph also appeared in the conference proceedings [6], which were published by the CNRS (Centre National de la Recherche Scientifique). The two organizers stand in the center of the front row. André Lichnerowicz is the taller of the two and easily recognizable by the pipe from which he was inseparable (notice the way the stairs are used!).

This photo inspired me to look back on some of the important results achieved by the participants in the years leading up to the conference and to consider the later impact of those results. The photo also led me to muse on the lives and work of three mathematicians who were students in the Strasbourg School of Ehresmann, namely, Jacques Feldbau, Georges Reeb, and Paulette Libermann.

The newspaper article was published in the Sunday May 31st/Monday June 1st edition, at the end of a very busy week (the French president was trying desperately to find a prime minister) and before another very busy week (the coronation of an English queen). We are lucky that there was nevertheless some space left for a photo and an article about a mathematical conference. The article is unsigned. However, it is clear that the journalist must have had some help in writing it, since he or she wrote a few rather pertinent statements on the difference between local and global geometry—the relation between global differential geometry and topology is also one of the highlights in the introduction of the conference proceedings.

Bernard Malgrange remembers that the participants had a good laugh at the declaration of Shiing-Shen Chern (1911–2004) to the journalist: "This conference is one of the main achievements of our time" (and this statement was quoted in the article!). It seems indeed to have been a great conference. The scientific program included André Weil (1906–1998) lecturing on nearby points on smooth manifolds (sketching, he said, ideas of his master Nicolas Bourbaki—despite a conflict between master and pupil, as the latter explains it in [12, p. 534]), Chern on infinite continuous pseudogroups, Jean-Louis Koszul on Lie groups of transformations (the very first result stated in his paper is the essential "slice theorem"), Nicolaas Kuiper (1920–1994) on locally affine surfaces, and Beno Eckmann on examples of compact complex Kähler manifolds. René Thom (1923–2002) spoke on cobordant manifolds, defining the so-called Thom spaces $MO(n)$, $MSO(n)$ and stating his results on the structure of the oriented and non-oriented cobordism rings Ω^* and $\mathcal{N}^*$, work that would bring him the Fields Medal in 1958. Laurent Schwartz (1915–2002), by then already a Fields Medalist, discussed the current associated with a meromorphic form on an analytic manifold. The two organizers also gave talks. Ehresmann explained the jet spaces he was inventing at that time, and two students of his, Paulette Libermann and Georges Reeb, spoke as well.

This conference was not an accident that came out of nothing. There was tremendous activity around Ehresmann in Strasbourg, including an ongoing seminar called "colloque de topologie de Strasbourg". There remain written reports of the seminar talks, given from 1951 to 1955, by speakers like Karl Stein,

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Photograph: Dernières Nouvelles d'Alsace.

Differential geometry conference, University of Strasbourg, 1953. See photo key, page 369.

Shoshichi Kobayashi, Kazumi Nomizu, Robert Hermann, Thom, Reinhold Remmert, André Haefliger, Reeb, Georges de Rham, Lawrence Markus, Libermann, and of course Ehresmann himself.

Charles Ehresmann had been a student of Élie Cartan (1869–1951), who would have been seen by the conference attendees as a kind of grandfather of the field. As our journalist wrote, a huge number of new problems were investigated or sketched at the conference, and many of them originated in the work of Élie Cartan. Ehresmann, who defended his thesis in 1934, was also a member of the Bourbaki group. He was very active and was one of the lecturers in the so-called "Julia seminar" in 1935–37, the seminar that gave birth to the Bourbaki seminar after the war. From 1939, Ehresmann taught at the University of Strasbourg, where he began to lead an outstanding school of geometry and topology. He is estimated to have directed more than seventy theses, including those of Haefliger and of Wu Wen Tsun. Let us now focus more closely on three of Ehresmann's students in the Strasbourg school, Jacques Feldbau, Georges Reeb, and Paulette Libermann.

The One Who Is Missing

The very first student of Ehresmann was Jacques Feldbau. Born in 1914 in Strasbourg, Feldbau was one of the founders of the theory of fiber bundles. He is the one who first proved that a bundle over a simplex is trivializable and who used this to classify bundles over spheres. This work appeared in a *Comptes-Rendus* note [5] in 1939. Two years later, together with Ehresmann, he wrote two more *Compte-Rendus* notes, in which the two authors introduced the notion of an associated bundle and proved results known today as the exact homotopy sequence of a fibration.

Two years later means 1941. And in the meantime, there was the war (in which Feldbau served in the French air force), the evacuation of Strasbourg University to Clermont-Ferrand, the occupation of France by Nazi Germany, the *Anschluss* of Alsace (which had long been claimed as a part of Germany) by the Third Reich, and the installation of the Pétain government, which very soon (October 1940) promulgated a set of antisemitic laws…So Feldbau (who, as a Jew, was forbidden by the new laws to teach), Ehresmann, and most of the other professors and students of Strasbourg met again, at the end of 1940, in Clermont-Ferrand, in the center of France. And the first of the two joint notes by Ehresmann and Feldbau [4] appeared in June 1941. The second one [3] was presented by Élie Cartan on October 27th but, at that time, it was already impossible for the Académie des

Photograph courtesy of the Feldbau-Debré Family.

Jacques Feldbau.

Sciences to publish the name of a Jew…So the note appeared under the name of Ehresmann alone. It must have been very painful for Élie Cartan to remove Feldbau's name from the paper before publication on December 1st and to reduce the credit given to Feldbau to a mention that the results were obtained by the author "in collaboration with one of his students". See [13, 1].

Feldbau could publish two short notes in the *Bulletin de la Société mathématique de France* (which was edited by Henri Cartan) under the pseudonym of Jacques Laboureur (*Feldbau* in German means agriculture, and *Laboureur* is French for plowman). Feldbau was also one of the inventors of what is called the Whitehead product between homotopy groups (because it was invented and published by Whitehead at the same time). However, he could not publish his results because he was caught in a Gestapo roundup in June 1943 and sent to Auschwitz in October of that year. He survived Auschwitz and even the deadly evacuation of the camp in January 1945 but eventually died of exhaustion the following April, two weeks before the end of the war, in the Bavarian concentration camp of Ganacker. See [2].

This is why Jacques Feldbau—a handsome young man with a very friendly and likeable personality, who practiced all kinds of sports (he was a champion of the butterfly-stroke) and played the piano, and who would have been a great topologist—does not show up in the picture.

The One from Saverne

The second student of Ehresmann, also an Alsatian studying in Clermont-Ferrand, was Georges Reeb. Born in Saverne (40 kilometers west of Strasbourg) in 1920, he is one of the inventors of the theory of foliations. He invented what is now called the "Reeb foliation", a foliation of the 3-sphere, all the leaves of which are diffeomorphic to $\mathbf{R}^2$, except one, which is a (compact!) 2-torus. Another useful tool in topology was named after him, the "Reeb vector field" associated with a contact form. And Reeb's theorem is the one that tells you that, if a compact manifold has a function with only two critical points, this manifold is homeomorphic to a sphere. This is the way you prove that the Milnor spheres, although not diffeomorphic, are homeomorphic to the sphere S^7, a result that came in 1956 [10]—by the way, did you notice the young man above everybody in the back row? Yes, John Milnor, who would be a Fields Medalist in 1962,

Photo courtesy of the Mathematisches Forschungsinstitut Oberwolfach.

Wilhelm Süss (left) and Georges Reeb in Oberwolfach, 1953.

was participating in the conference too. Reeb's talk at the conference was about Finsler (and Cartan) spaces. This paper contains an intrinsic definition of the Liouville form.

Georges Reeb fit all the prejudices French people might have against Alsatians: he was massive and slow, very slow. Slowness is not a quality French mathematicians usually praise very much. But Reeb did not care. He was even proud of it. He used to say that, when he was a professor at Grenoble University (namely, at the time of our picture), the students attending his course suggested recording his lectures on tape, so that they could listen to them at double speed. When I arrived in Strasbourg in 1987, he used to come to the department and go from one office to another talking with people, which had always been his way of working. Since he reckoned I was always in a hurry, he used to tell me the "story of the hurrying Savernois" (both a paradox and a never-ending story). He also told many jokes about his complete baldness—a state he had not reached by 1953, which is why it took me some time to recognize him in the picture. After a number of achievements in geometry, topology, differential equations, and nonstandard analysis, Georges Reeb died in 1993.

The Woman

It was much easier to find Paulette Libermann in the picture, the shorter of the two women in the photo. It was from her that I heard the names of Ehresmann and Feldbau for the first time. This was in the spring of 1975. At that time I was a student in Paris, and I had to choose a few courses from a long list. I remember I took *cohomologie de de Rham des variétés différentielles*, taught by Karoubi, and I found it very fancy, because I did not understand a single word in the title (by the way, Georges de Rham (1903–1990) is the man between Lichnerowicz and Ehresmann in the picture). I chose also *géométrie différentielle*, given by Paulette Libermann, because it seemed to fit. The very first thing I learned in her lectures was the definition of a bundle "in the sense of Ehresmann", which seemed to consist of

an intricate list of symbols (a total space, a base space, a map from one to the other, a fiber space, a group…) and Feldbau's theorem.

Paulette Libermann ("Mademoiselle Libermann", as people used to call her) was very helpful to young mathematicians. I think the very first seminar in Paris in which I was invited to give a talk was hers. Quite a few geometers can probably say the same thing. This might have been because she remembered having been helped herself when she was a student.

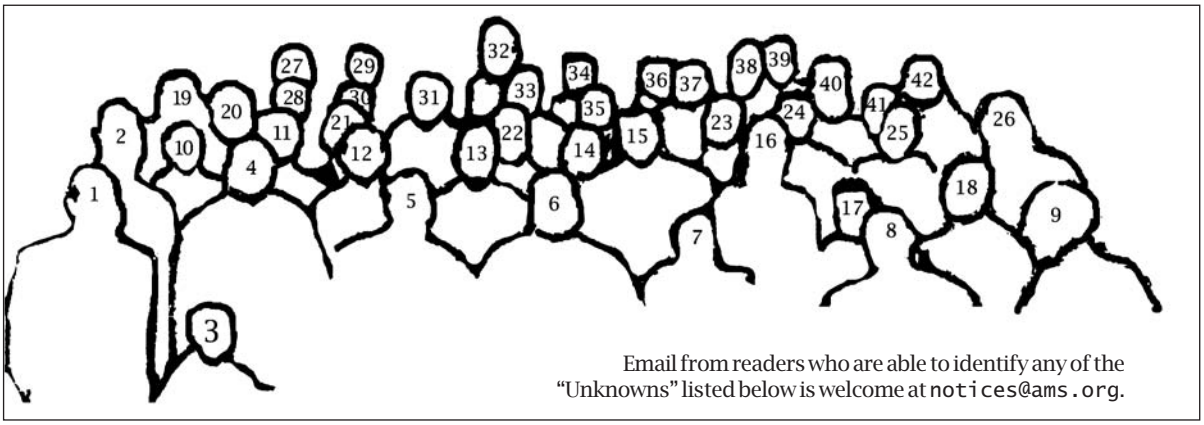
Paulette Libermann also had a difficult story. Born in 1919, she entered the so-called "École normale supérieure de jeunes filles" in 1938. Like the other young ladies of this school, she was supposed to pass a few exams and, after two years, to prepare the concourse of the (feminine) *agrégation* to become a teacher in a secondary school (for girls, of course). Except that two years later meant the fall of 1940, so that she was supposed to begin to prepare for the concourse at the precise time the French legislation I mentioned earlier forbade Jews from taking certain kinds of jobs, among them teaching. So she was not allowed to pass the *agrégation*. With a kind of black humor, Paulette Libermann used to say that the antisemitic laws had been lucky for her, since Élie Cartan, who was teaching these young ladies, suggested that she start research instead.

But life was not that easy. Paulette Libermann and her family had to move to Lyon in 1942, where they lived a half-clandestine life under a fake name. She gave private lessons for a living. But she was luckier than Jacques Feldbau and, at the *Libération* in 1944, she eventually passed the *agrégation*, became a teacher in a secondary school…and, once again at Élie Cartan's suggestion, started her thesis on equivalence problems under the supervision of Ehresmann in Strasbourg. She then got a position as a professor at the University of Rennes, and then at Paris 7.

Photograph courtesy of Corinne Mounier-Veil.

Paulette Libermann.

In her thesis, which she defended in 1953 (the year of the picture), can be found a number of things which lie now at the bases of symplectic geometry—which was not as fashionable then as it is today. For instance, she investigated foliations of symplectic manifolds and the local structure of the manifold together with certain foliations (a generalization of Darboux's theorem); she defined what Alan Weinstein would twenty years later call the affine structure of a Lagrangian foliation (this is at the basis of the theory of integrable systems); she investigated the almost-complex structures on a symplectic manifold that would turn out to be very useful, thirty years later, when Mikhael Gromov introduced and made such beautiful use



Email from readers who are able to identify any of the "Unknowns" listed below is welcome at notices@ams.org.

Key to photo on page 367.
1. Unknown
2. R. Debever
3. Ehresmann's son
4. Shiing-Shen Chern
5. André Lichnerowicz
6. Charles Ehresmann
7. Paulette Libermann
8. Mario Villa
9. Lucien Godeaux
10. Heinz Hopf
11. Wilhelm Süss
12. Laurent Schwartz
13. Georges de Rham
14. Unknown
15. H. Guggenheimer
16. Thomas Willmore
17. Simone Lemoine
18. B. H. Neumann
19. René Thiry
20. E. T. Davies
21. Unknown
22. Unknown
23. Unknown
24. Unknown
25. Nicolaas Kuiper
26. Beno Eckmann
27. Unknown
28. Jean-Louis Koszul
29. Unknown
30. André Weil
31. René Thom
32. John Milnor
33. Marcel Berger
34. Unknown
35. Bernard Malgrange
36. Daniel Bernard
37. André Aragnol
38. G. Legrand
39. Jean-Marie Souriau
40. Unknown
41. Georges Reeb
42. Unknown

of his pseudo-holomorphic curves, creating symplectic topology. Her name is attached to one of the very first textbooks on symplectic geometry (which she wrote jointly with Charles-Michel Marle) [9].

Like Georges Reeb, Paulette Libermann used to tell stories. Unlike him, she was very quick. She was also very lively. The short and tiny young lady of the picture became a short and tiny old (but ever young) lady, and she still was very active, very energetic, traveling all over the world to participate in conferences. The last time I met her, in April 2007, just before I left for a conference in Vietnam, she was sorry not to be able to participate in that conference. This is too far for me, she told me, too tiring, I am getting old. She was eighty-seven. She died in July 2007—and one of the motivations I had in writing this article was to make a tribute to her memory.

Some Others

Two other women participated in the conference, Marie-Hélène Schwartz, who would create a version of Chern classes for singular analytic manifolds (she does not seem to be in the picture), and Simone Lemoine, the one standing near Paulette Libermann, a differential geometer (who would become Simone Dolbeault-Lemoine). Most of the people in the picture were very hard to recognize. As usual, the list of participants does not fit. For instance, Georges Cerf (1888–1979), at that time the director of the mathematics institute in Strasbourg, was there but does not show up in the picture. On the other hand, Bernhard Neumann (1909–2002) is not in the list, but was definitely recognized as the man with the moustache, on the right, by two of his sons.

Heinz Hopf (1894–1971) is the one on the right of Chern, just above. He told the journalist that he was very sorry not to have been able to attend all the talks, because those he listened to were indeed excellent. Bernard Malgrange, who helped me to identify some of the people in the picture, is the second one above Ehresmann, in the same row as Thom (the man between them is Marcel Berger). The man in dark between the two ladies is the English topologist Thomas Willmore (1919–2005).

The man standing in front of Koszul, between Chern and Schwartz, is Wilhelm Süss (1895–1958), the founder of the mathematical institute at Oberwolfach in the Black Forest (hence a neighbor to those in Strasbourg), whose personality was much less controversial in 1953 than it is today (see [7, 11]).

Acknowledgments: I thank Daniel Bernard, Jean Cerf, Jean-Pierre Jouanolou, Bernard Malgrange, Charles-Michel Marle, John Milnor, and Walter Neumann for their help in identifying individuals in the picture.

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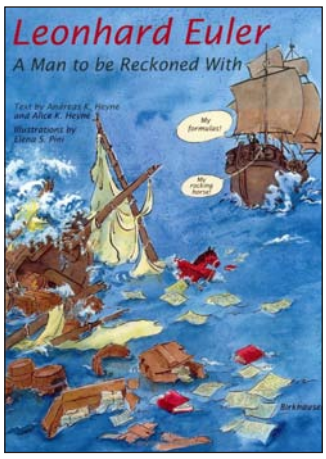

Leonhard Euler, A Man to be Reckoned With

Reviewed by Ivar Ekeland

Leonhard Euler, A Man to be Reckoned With
Andreas K. Heyne and *Alice K. Heyne*
Illustrations by Elena S. Pini
Birkhäuser, 2007
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What do mathematicians do? Mathematics. Do they do anything else?

Some of them become citizens of the world: they get involved in social issues and take political positions. Laurent Schwartz and Steve Smale, for instance, are in that category. Schwartz lost his position at the École Polytechnique for protesting publicly against the use of torture by the French army in Algeria. Smale was subpoenaed by the House Un-American Activities Committee for co-chairing the Vietnam Day Committee in Berkeley and attempting to stop troop trains. There were earlier examples, like Bertrand Russell or Paul Painlevé, who was drawn into politics by the Dreyfus affair and went on to become Minister of War in 1917 (at the time, governments had not yet hit on the Orwellian trick of calling war defense) and Président du Conseil (the equivalent of Prime Minister) in postwar France.

Still others, like René Thom, used mathematics as a starting point of other intellectual endeavors. Most mathematicians, however, only do mathematics: once they have entered that enchanted realm, they never leave it. I remember Antoni Zygmund telling me in Chicago, towards the end of his life, that the only thing he regretted was the time he had *not* spent doing Fourier analysis. Long gone is the time of Fermat, who did mathematics in his spare time, being otherwise occupied by his professional activities as a member of the Toulouse Parliament, presumably scribbling in book margins while listening to legal arguments. Nowadays all mathematicians are professionals, mostly working in universities, and they have little time for anything else. They are absorbed by their careers, which are entirely dependent on peer recognition, distilled by a hierarchy of professional bodies, ranging from recruiting and promotion committees to editorial boards, national academies, and the International Mathematical Union. Of course, in order to compare people, it is easier to have them all work on the same problems. This is why the mathematical community has devised an official set of important problems, and even attached a reward of one million dollars to each of them, so that even the blind can see the path to glory and follow the crowd.

If you ever have to write a biography, pick the first kind of mathematician: it will be very difficult to find anything exciting to say about someone whose entire adult life has been spent within the walls of universities, fighting for promotion, or trying to become a member of the national academy of science. This was the problem facing Andreas and Alice Heyne. Euler studied in Basel under Johann Bernoulli (the elder) and left his hometown and his mentor at twenty to take up a lectureship in Saint Petersburg (1727), where he eventually rose to the rank of professor. He moved to Berlin in 1741 and then back to Saint Petersburg again (1766), where he died in 1783, each time lured away by the prospect of higher

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pay. The book faithfully records these successive moves, and this makes hardly exciting reading, even if Mrs. Euler is cast in the role of the greedy partner: "The salary in Berlin is much better" (page 20), "What about the salary, Leo? — It'll be better than here in any case — Then, there's nothing to be discussed" (page 37). Of course, as we all know, the tedium of academic life is happily relieved by department meetings and program committees. The book tries to convey that sense of excitement by showing a few sittings of the academy of sciences in Saint Petersburg, which is delicately compared to "a fruit salad" (whatever that means) and of the academy of sciences in Berlin, where the president, Maupertuis, is depicted trying to peddle his latest book to his colleagues. We are treated to elderly gentlemen in mortarboards dozing in armchairs while the speaker rambles on, and to a few angry scenes where combatants pull off each other's wigs, revealing downy skulls—valiant efforts to be sure, but a career is not a life, and the fundamental problem remains: is there anything exciting to be said about Leonhard Euler?

Compare, for instance, the two wonderful biographies written by Arild Stubhaug, the first one of Niels Henrik Abel,[1] the second one of Sophus Lie.[2] Abel is a romantic figure, and a great story can be spun around the theme of the country boy who goes to the big city, only to be cheated of his treasure, and comes back to die in poverty, days before fame comes knocking at his door. Stubhaug does not indulge in this kind of theatrics: he writes a very balanced and accurate biography, giving due weight to Abel's mathematical achievements and the intellectual life around him. The fact remains, however, that it is a tragic story: even if the legend is dispelled, it still colors the narrative and lends it a tinge of excitement. Fortunately for him, but unfortunately for us, there is nothing like that in the life of Sophus Lie. He was a giant of a man and also a giant of mathematics; he died at 57 of an illness that would easily have been cured nowadays, but this is hardly enough to lend glamour to the life of a university professor in Leipzig who seemed to have been mostly preoccupied with getting due recognition from Felix Klein.

The right way out is to write an intellectual biography. After all, these people spent most of their time on another planet, and it is the biographer's task to give as full an account of these alien landscapes as possible. That means writing up the history of their mathematical discoveries and of the influence they had on contemporaries, a formidable task because it entails reading an immense number of books, articles, manuscripts, and letters. Very few people, including mathematicians, have the ability, let alone the time, to do that (who has read Sophus Lie? who has read *all* of Sophus Lie?), but this is precisely what Stubhaug has done, setting aside several years of his own life to that task.

This is not what the authors of *Leonhard Euler, a Man to be Reckoned With* have set out to do. Here we have a very short comic strip: 45 pages, with three to ten drawings per page, completed by four pages of densely written text, giving a detailed chronology of Euler and biographical information about his contemporaries. I have enormous respect for the art of comics. I think that Joe Sacco and Chris Ware, for instance, are among the most powerful and creative artists of our time: they have shown that, by an appropriate combination of graphics and text, one can convey the whole range of human experience, from the horrors of war to the intimate suffering of loneliness, in a much more effective way than through writing or a photograph. The book here is nowhere near that class, nor was it its ambition, and it remains to be seen what a true artist could do with Euler's life. As it is, Andreas and Alice Heyne are taking the standard way out when one cannot, or dare not, go into the science: turn the mathematician into an alien, at home in another galaxy, but out of place on planet Earth.

This is a time-honored trick. Ancient historians have recorded very little about the life of Archimedes, but they do tell us that, confronted by a soldier with a drawn sword on the day Syracuse fell to the Romans, the best Archimedes could muster in the way of self-defense was to tell the soldier archly: "Step out of my circles" (the geometric figures, drawn in the dust, which he happened to be working on). The theme of the "crazy mathematician" is alive and well today, and the book puts Euler firmly in that category. His craziness is of the gentler sort: he is childish. He is depicted at home, constantly surrounded by a swarm of children and grandchildren, playing with them, stealing his wife's baking whisk to stir up the water in a bathtub. On one occasion she tells him "Really, Leonhard, the most childish person in this house is you." When the ship carrying the Euler family's baggage sinks with man and mouse, there are two parallel comments, by Leonhard and his grandson: "My formulas!" and "My rocking-horse!" (cover illustration) . His youth in Basel takes up a disproportionate part of the whole book, and twice in later years characters pop up unexpectedly with the shibboleth: "Ych kumm aus Basel (I am from Basel)", including an improbable fireman in Saint Petersburg who rescues Euler by carrying him forcibly down a ladder, away from his house ablaze and his unfinished calculations (Archimedes again). He even gets a chance to come back to Basel, when he is offered the chair of his former teacher, Johann Bernoulli I. Thank God for

[1]Niels Henrik Abel and His Times: Called Too Soon by Flames Afar, *Springer 2000.*

[2]The Mathematician Sophus Lie: It Was the Audacity of My Thinking, *Springer 2002.*

Mrs. Euler, who finds the right thing to say: "with the salary they're proposing, it's out of the question!" (page 29).

Another possibility for spinning a story out of Euler's life is to turn the reader's attention to the historical context. He certainly lived in interesting times. Travel was difficult and colorful: we are treated to two sea voyages, from Berlin to Saint Petersburg and back, complete with seasickness and shipwreck. Euler had daily interaction with the leading intellectuals of his day, some of whom make their way into the book: the Bernoullis, father and sons, Maupertuis,[3] Voltaire. Unfortunately, these appearances are fleeting: the Bernoullis seem mostly preoccupied with playing cards; Maupertuis, the president of the Berlin academy of science, is ridiculed for his French accent (which makes no sense at all: French was the language of high society, from Frederick the Great down, and all discussions in the academy would have been carried out in French). Voltaire advises Frederick the Great to found an academy in Berlin and disappears from the story; twenty pages later, he reappears as a portrait covered with darts in the dining room of Sans-Souci. How he sank from that exalted position of adviser to the king to an object of ridicule the reader is left to guess. This is a general feature of this book: there are too many unexplained allusions to contemporary events. On page 29, Maupertuis is depicted saying, "and I'm quite certain zat zis letter by Leibniz is a fake"—if you know the story of that letter, and how it connects to the least action principle, this is fine, but if you don't, you won't guess. I happen to be on top of that one, but I have no idea what went on during the battle of Hohenfriedberg, June 4, 1745 (page 24), nor at Kunersdorf (page 33) nor at Landshut (page 36).

This brings us to the great protagonists of that time: Frederick (the Great), Catherine (also the Great), Maria Theresa (not the Great, because there was only one, but still revered today), and her husband, the Emperor Franz I. They are shown at their most human: Frederick is nasty, Catherine is a nymphomaniac (there is an interesting nude scene where the imperial crown of Russia plays the role of the proverbial fig-leaf), Maria Theresa is a prolific mother and a domineering wife, Franz I is a couch potato. They take up much more space than the scientists, and their doings sometimes do not connect very well with the main story. However, what comes very graphically and distinctly out of this book is that Euler had direct access to two of the most important monarchs in Europe, the king of Prussia and the tsarina of Russia. Why would they be interested in a mathematician, whose main claim to fame was to have invented the calculus of variations?

Historically, scientists have been very good at capturing and maintaining the attention of people in power. The example was set by Galileo himself,[4] who earned the support of the House of Medici by dedicating to them the newly discovered satellites of Jupiter. From then on, scientists were well aware of the importance of keeping the ear of royalty. Euler did his share, by maintaining a huge correspondence with Sophie-Charlotte of Brandenburg-Schwedt (pages 34–35). It is a public service that he performed for his fellow scientists, as Descartes and Leibniz did in their own time. This effort, however, has to be placed in a broader context. At the time, Prussia and Russia were struggling to reach superpower status in Europe, alongside France and the Habsburg Empire. Then, as today, scientific prestige was an important tool in the international arena: by creating national academies, Prussia and Russia were positioning themselves as major scientific powers, and nothing could make them more credible than attracting Euler, the leading scientist in Europe after the death of Newton.

Of course, science was not as involved in technology as it is now. This was long before the industrial revolution and long before governments became aware that mathematicians were able and willing to devise weapons of mass destruction. The book does bow to this modern view of mathematics, by showing Euler experimenting on ballistics with toy guns shot by his grandsons (page 25). However, this was not really the spirit of the times. As always, war was waged, not only on the battlefield, but also in people's minds. Frederick or Catherine were not interested in science per se; they wanted to propagate ideas that would ultimately weaken their political opponents, the Habsburg Empire or the Russian boyars, by casting them in the role of unenlightened reactionaries, barring the way to progress. Their cause was eagerly embraced in France, where the aristocracy and bourgeoisie were trying to wrest the power away from the king and the land away from the Church. The emerging power wanted science on their side, as the established powers had religion on theirs.

The forces unleashed would result in the French Revolution and shake the European continent for two centuries. We are just emerging from that period and into a new one, where the ruling powers are not as clearly identified, and where the manufacturing of opinion takes entirely different paths. Scientists now play a much more passive role, and mathematicians have definitely been pushed to the periphery. This book serves as a colorful reminder of simpler times, when mathematics and politics had the freshness of discovery.

[3] *On Maupertuis, see the excellent book by Mary Terall,* The Man Who Flattened the Earth, *Chicago University Press, 2002.*

[4] *See the book by Mario Biagoli,* Galileo Courtier: The Practice of Science in the Culture of Absolutism, *Chicago University Press, 1993.*

WHAT IS...

a Systole?

Marcel Berger

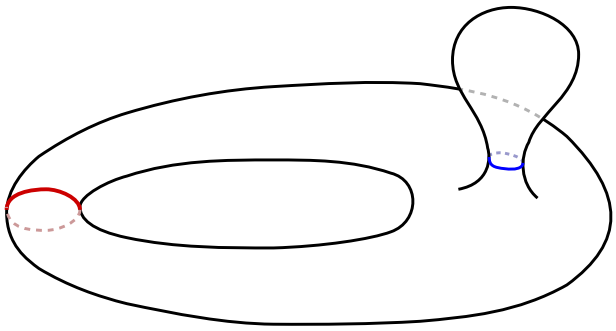

Figure 1. The closed geodesic on the right is not a systole since it is contractible.

Let us take a look at Figure 1, which represents a surface S in ordinary three-dimensional Euclidean space (throughout we will assume surfaces and other objects are compact). A closed curve on S is a curve that looks topologically like a circle. Because our surface S has the topology of a torus, there are closed curves on S that are not contractible to a point. We define the *systole* of S, $Sys(S)$, to be the smallest length of such curves. By a compactness argument, this lower bound is positive and is realized by at least one curve, which is a *closed geodesic*. On surfaces or on general Riemannian manifolds geodesics are those curves that are locally length-minimizing.

The medical term *systole* comes from the Greek word for "contraction". (If you have extra systolic beats in the medical and not geometrical sense, you had better consult your cardiologist.) The mathematical term *systole* was coined in 1980.

As the figure intuitively shows, given $Sys(S)$, the total area of S, $Area(S)$, cannot be too small. A natural question is, What is the relationship between $Sys(S)$ and $Area(S)$? We are looking for a kind of isoperimetric inequality, but in this case it's a game without boundary. The first person to tackle this problem was Loewner, who in 1949 proved that for any surface of the topological type of a torus, $Area(S) \geq \frac{\sqrt{3}}{2} Sys^2(S)$. This is an *isosystolic inequality*. Loewner proved that equality is attained only and exactly for the flat equilateral torus. The proof is not too hard if one knows the basic conformal representation theorem.

Now, any mathematical mind will ask for generalizations of Loewner's theorem, and they could go in at least three directions. First: Consider surfaces more general than the torus, the simplest being the projective plane. Pu, a student of Loewner, proved in 1952, with the same method that Loewner had used, that $Area(S) \geq \frac{2}{\pi} Sys^2(S)$, with equality holding only for the standard metric on S. Second: Consider generalizations in higher dimension. Third: Consider generalizations to submanifolds (that is, generalizing the initial case of curves) of any dimension. In any of these problems, the question splits in two: 1) What is the optimal ratio if it is nonzero? and 2) For which metric is it attained?

Today geometers are fascinated by those problems for several reasons. For one thing, despite the efforts of many, not a single one of those generalizations was obtained before 1983, when Gromov was the first to crack the nut. Also, Gromov's proofs are technically extremely hard, and, even more importantly, they introduced some

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completely new concepts in geometry. And finally, many "elementary" questions remain open today. But what is even more fascinating for Riemannian geometers is the fact that we finally get inequalities on a Riemannian manifold that are true without any curvature restriction; i.e., they are valid for any Riemannian structure on the manifold.

Let us now see what the state of affairs is today and look at the main ideas, concepts, and techniques that enter into the proof. The first case to look at is that of surfaces with any number of holes (the torus is a surface with one hole). In 1960 Accola and Blatter got an inequality, but with a constant that was getting smaller and smaller as the number of holes became larger and larger. Their papers launched the search in this subject. It is interesting to remark that their proofs, which were quite similar, were extensions of Loewner's method in that they used the conformal representation. For us it is the only case where complex analysis on surfaces gives a result that is dead wrong. One had to wait for Gromov in order to have a constant that grows with the genus. Exact constants are not known, and in fact are not that interesting, but one has optimal asymptotic results for them when the number of holes goes to infinity.

Metrics for which the equality is attained are not known, except for the Klein bottle and, as seen above, for the torus and the projective plane. In fact, they are forced to be singular (not smooth) even for this case.

Now let's leave surfaces and consider Riemannian structures on manifolds M of higher dimension d, first for closed curves and for the same definition for the systole $Sys(M)$. We ask if $Vol(M)/Sys^d(M)$ has, for the set of all Riemannian structures on M, a positive lower bound. We of course need M to be nonsimply connected (the algebraic topology wording for asking that not all closed curves in M be contractible). But this condition is not enough; look for example at the product of circle by a sphere. Then the systole is the length of the circle, but the volume of the sphere can be as small as desired. We should have enough families of noncontractible curves; in other words, those curves should fill M in every direction. Such manifolds are called *essential* by Gromov. A typical example is the projective space (of any dimension) $\mathbf{R}P^d$. Gromov proved that there is in fact an isosystolic inequality for any essential manifold. Still, as opposed to the case of $\mathbf{R}P^2$, we do not know for $d \geq 3$ if this constant is that of the canonical metric on $\mathbf{R}P^d$, with equality holding only for that canonical metric.

The proof of Gromov is one of the most baffling we know in geometry and exemplifies his mathematical style. He attacks mathematical problems in three characteristic ways: with radically new techniques, with new and extremely simple invariants that are incredibly hard to study, and with very involved and hard calculations.

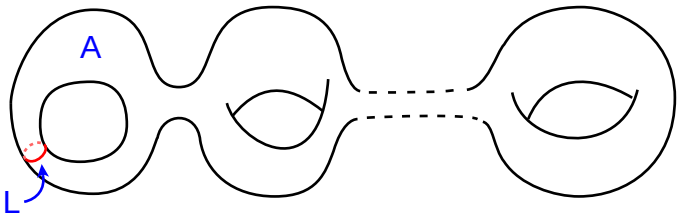
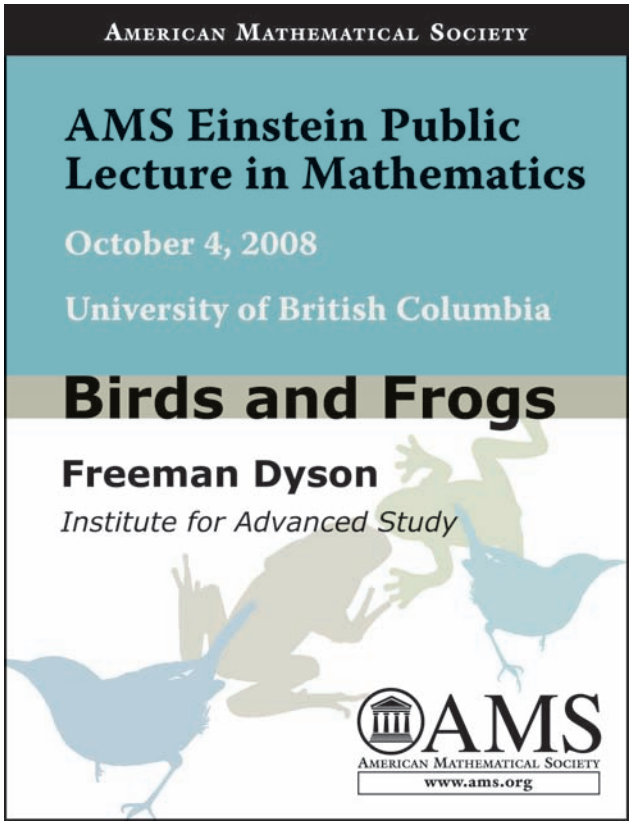


Figure 2. Intuitively, it seems clear that the ratio A/L^2, where L is the length of the shortest non-contractible curve, grows as the genus does. But it is very difficult to prove.

One trick and two new invariants. One first embeds M isometrically in the infinite-dimensional space $C_0(M)$, which consists of the continuous functions on M. The embedding simply sends a point to the function that is the distance to that point. And now we fill up the image of M in $C_0(M)$ by submanifolds of dimension $d+1$ whose boundary is this image. In this situation one can prove (hard) an infinite-dimensional isoperimetric inequality between the volume of M and the volume of the filler. This is an inequality like that for minimal surfaces. One needs thereafter to study the filling volume and the filling radius of M. Those two invariants are so deep, even though they are elementary and natural, that the filling volume of the circle is only conjectured to be 2π (think of a hemisphere). One finishes the proof with an inequality between the filling volume and the filling radius, and the main point is that the filling radius is directly linked to the systole.

Systolic freedom almost everywhere. The natural generalization is to look at what replaces, for higher-dimensional submanifolds in Riemannian manifolds of any dimension, the notion of noncontractible. From algebraic topology the most important notion is that of the homology class of such a submanifold, which is an integral homology class. For a Riemannian manifold M of dimension d we define its k-dimensional systole $Sys_k(M)$ as the infimum of the (k-dimensional) volume of all its submanifolds of dimension k whose homology class is nonzero. Then we look at the quotient $Vol^{k/d}(M)/Sys_k(M)$ and ask whether this quotient, considering all the Riemannian structures on M, is always bounded away from zero. When it is zero, one can talk of *systolic freedom* (or systole softness). The surprising discovery, completely nonintuitive for us and initiated by Gromov, is that this infimum is zero for most manifolds and all pairs $(d \geq 3, k \geq 2)$. The first shock comes with the complex projective plane, for which the pair is



(4,2), because the projective complex lines fill up our space completely in every direction.

To get more definitive results one has to introduce a notion of algebraic topology called stable homology, and this time the invariant attached to a submanifold is its stable homology class, which is a real homology class. Here also it is Gromov who gave deep impetus to the subject. But here one classical tool is available, namely the calculus of differential forms, as well as the basic relation between topology and differential calculus and the basic interplay given by the theorem of de Rham.

For the stable systole problem, the freedom question was completely solved in 2007 by M. Brunnbauer (his papers are available on the `arXiv`).

Despite their quite recent introduction, systoles are already used in various domains, namely in algebraic geometry (to characterize Jacobians among flat tori; this is the so-called *Schottky problem*, which has many algebraic solutions but here is given a geometrical one) and in deep algebraic topology. One-dimensional systoles, which arise when one studies displacements by isometries in essential manifolds, are linked to the notions of entropy and the spherical volume.

Further Reading

Pages 325–353 of the author's book contain a more explicit and detailed exposition of the state of systolic affairs up to 2003 and all the references and credits. The book by Katz covers almost all the results and references for more recent developments and gives fascinating historical data.

[1] M. Berger, *A Panoramic View of Riemannian Geometry*, Springer, 2003.
[2] M. Katz, *Systolic Geometry and Topology*, Amer. Math. Soc., 2007.

The Volterra Chronicles

Reviewed by Irwin W. Sandberg

The Volterra Chronicles: The Life and Times of an Extraordinary Mathematician 1860–1940
Judith R. Goodstein
AMS, 2007
310 pages, US$59.00, ISBN: 978-0821839690

This book by Judith R. Goodstein, a Caltech archivist, is an imposing tribute to Vito Volterra, an exceptional mathematician, physicist, educator, statesman, and man of uncommon integrity. It is also an interesting, carefully written, richly detailed history of his personal life and the times in which he lived. Much of the material was drawn from Volterra's personal correspondence and from interviews with his family members. The book includes translations of actual correspondence, examples of which are given below, as well as several photos that help to round out the biography.

Samuel Giuseppe Vito Volterra was born into a Jewish family in Ancona, Italy's Jewish ghetto in 1860—during the period of the Italian unification and the year of the liberation of the Italian ghettos. His family was of modest financial means, and he had the misfortune that his father Abramo Volterra died when he was about two years old. For these reasons, he and his mother Angelica lived for most of Vito's youth in the home of her brother Alfonso Almagià, first in Turin and later in Florence. Inspired by books he had read, Vito became interested in mathematics and science in his preadolescent years, to the dismay of both his mother and his uncle who, during Vito's early teens, advocated a career in a more practical area such as railroad engineering or land surveying. Alfonso was an official at the Bank of Italy with a modest income that could not support Vito's aspirations. Goodstein tells us that in a letter from Alfonso to his cousin Edoardo Almagià, Alfonso wrote "I make Vito come to the bank every day where I give him some work to do [in which he showed no interest, his uncle made clear]…God grant that he might overcome his disgust for anything that takes him away from his beloved science…[T]hat damned passion for the study of pure mathematics discourages me."

As we know, Vito prevailed—this with the encouragement and assistance of Edoardo and others, including the physicist Antonio Ròiti in whom Vito found a scientific mentor and a person who shared his perspective on mathematics. Volterra's geometry instructor at the Instituto Tecnico, the technical high school in Florence, was Cesare Arzelà during the years before Arzelà began his ascent on the academic ladder. During a class meeting, young Vito solved—on the spot—a problem put on the blackboard by an unannounced inspector from the Ministry of Public Instruction, after Arzelà, to whom the problem was addressed, appeared to be confused.

Volterra was eighteen when he left Florence to become a freshman at the University of Pisa. He took algebra from Cesare Finzi, a fine instructor and a family friend. His calculus class was taught by the brilliant and accomplished Ulisse Dini. In a letter to Vito's mother, who had asked (earnestly) that her son write frequently, one finds:

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> Uncle asks how I like the lectures by Finzi. They are without doubt very beautiful lectures; he is a teacher who explains things with order and clarity, he never gets confused, he is *sufficiently* precise, speaks well and is also good and kind; one really could not ask for a better person to teach algebra. But I always prefer Dini, who gives lectures that are a bit confused, who some days explains and explains without reaching any conclusions and at other times is a bit obscure. I prefer him because he puts his whole soul into his lectures, because the things he explains are almost always his own discoveries—at least the method is really all his own. He speaks simply and gets a little confused but in the end his concepts are infinitely more clear, more concise, and, what is more important, more exact, than those of Finzi. Dini's lectures are always interesting. (p. 39)

It is not surprising that it was Dini who inspired Volterra's interest in pure mathematics. But Enrico Betti, a highly respected professor of mathematical physics and the director of the Pisa school of mathematics, had a strong interest in applications. It was he who served as Volterra's dissertation advisor and who provided the inspiration for Volterra to spend the rest of his career working, in an academic environment, on both pure mathematics and applications in the area of physics. Volterra was twenty-two years old when he graduated from the University of Pisa with a doctorate—not in mathematics, but in physics. By that time he had published five papers. Just one year later, in 1883 and after a competition with six other applicants, he became an associate professor at the University of Pisa—and held its Chair of Rational Mechanics. His promotion to full professor occurred in 1887, the year in which he was awarded a gold medal for mathematics from the Italian Society of Sciences. This medal was the first of his many awards and honors that later included membership in Italy's prestigious Accademia dei Lincei (which translates to "Academy of Lynxes", a name chosen by the academy's founders in 1603 probably because the mythological lynx possessed piercing eyesight). Volterra initiated the powerful branch of mathematics that came to be called functional analysis, and made important contributions in several fields, including elasticity theory, the study of the movement of the earth's axis of rotation, linear integral and differential equations, and later the theory of ecology and biology. He left Pisa in 1893 to accept a professorship in rational mechanics at the University of Turin.

From the perspective of modern mathematics the concept of a functional, while decidedly useful, is a natural and uncomplicated one. After it was introduced by Volterra in his 1887 paper "On functions that depend on other functions," and developed further by him during the succeeding three years, it was rightfully viewed by Jacques Hadamard and others as a highly creative idea. In a classic 1945 essay, Hadamard wrote

> …[B]ut that "functionals" as we called the new conception, could be in direct relation with reality could not be thought of otherwise than as mere absurdity. Functionals seemed to be an essentially and completely abstract creation of mathematicians.
>
> Now, precisely the absurd has happened. Hardly intelligible and conceivable as it seems, in the ideas of contemporary physicists (in the recent theory of "wave mechanics") the new notion, the treatment of which is accessible only to students already familiar with very advanced calculus, is absolutely necessary for the mathematical representation of any physical phenomenon…(p. 70)

Today, functional analysis, as developed much further by Banach, Fréchet, Hahn, and others, plays an important role in the theory of stability of nonlinear automatic control systems, as well as in other areas of engineering and science such as system representation theory. In the stability studies one encounters, for example, Volterra integral equations of the form

$$u(t) = v(t) + \int_0^t k(t-\tau)\eta[v(\tau)]d\tau, \quad t \geq 0$$

in which u and v are the system input and output, respectively, k is associated with the linear part of the system, and η represents the nonlinear part.

While a faculty member at Pisa, Volterra served as an external examiner at a technical institute in Sicily where a student, upset by his failure to pass an exam proctored by Volterra, fired a pistol at him. Fortunately, the student's marksmanship was no better than his performance on the exam: he missed. An interesting thread woven into Goodstein's lively and richly detailed account of Volterra's life and times concerns the disproportionately large number of Jews within Italy's mathematics community. She notes, for example, that in 1895 Volterra received the Accademia dei Lincei's mathematics prize (for "various memoirs on pure and applied analysis"); that the co-winner Corrado Segre, the leader of the Italian school of geometry, was also from a Jewish background; and that, by the time of the collapse of the academy under Mussolini in 1944, seven of the sixteen prize winners in mathematics were Jewish. These Jewish

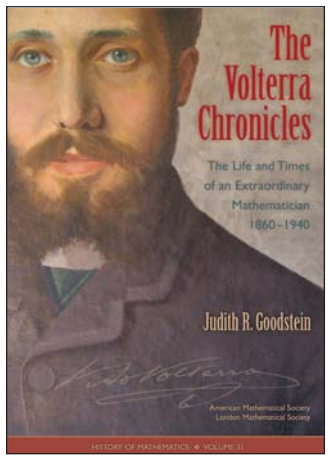
prize winners included Guido Castelnuovo and Federigo Enriques (both known for their contributions in the area of algebraic geometry), as well as Guido Fubini (of Fubini's theorem). The population of Jews in Italy at that time was a tiny fraction of one percent.

When he was about forty, Volterra's mother decided that the time had come for him to marry, and she proceeded to arrange a marriage. His bride was to be the much younger Virgina Almagià, his second cousin and the daughter of Alfonso Almagià whose modest railroad construction business had grown into a large international engineering company. Virgina was educated, intellectually brilliant, and a lovely young woman. Vito's main concern appears to have been that he did not want to be thought of as one who married for money. He sought advice from his mentor Antonio Ròiti who wrote

> …[I]t is therefore necessary to think seriously before taking a very rich wife. I must confess that I have always felt a strong repugnance for this. To give you my opinion without any hesitation, I need to know the education, aspirations, and habits of this young lady and the kind of life she will have to lead to be fully happy after she has been married for many years.
>
> To have an idea of all this, it is necessary to talk to you. For now, I can say at once with a clear conscience that although on one side there is great wealth, on the other side, given your intelligence, your industriousness, and universal esteem you enjoy, no one who has any sense will deny that your social position is already much more brilliant and admirable than that of a person who has millions. Thus, an open minded woman with noble feelings—however rich—should feel honored and elevated by your choice. (p. 107)

There were other considerations too, but in the summer of 1900 Virgina and Vito were married. That year he accepted the mathematical physics chair at the University of Rome where he would stay for more than thirty years. It was no accident that Virgina's parents lived in Rome, but from all accounts Volterra's marriage was a highly successful one. In the ensuing twenty years Volterra's professional stature grew immensely. He traveled extensively and lectured in France, England, Norway, Sweden, and the United States, and was received as a widely respected mathematician of the first rank.

In Italy, he became a Senator of the Kingdom, a lifetime position in the upper house of parliament, where he participated in many of its deliberations. In an early speech to the Italian Senate he called for a revamping of Italy's advanced technical school system, actually arguing that too much mathematics was taught. In his role as a politician, he cited Alois Riedler, a German professor of mechanical engineering, who had said that "an excess of mathematical and theoretical studies not only is useless and takes up precious time, but is absolutely pernicious to the engineer, impairing the education of the spirit." Of course Volterra, who had become Italy's leading mathematician and who pressed for a better balance in engineering education, continued to be a powerful advocate of mathematics in general. Goodstein tells us that Riedler reminded Volterra "not a little of Attila the Hun."



Volterra knew Felix Klein, Hermann Schwarz, and Georg Cantor, as well as many other notable mathematicians of his day, and he developed a particularly friendly relationship with the Swedish mathematician Gösta Mittag-Leffler, a former student of Karl Weierstrass. Volterra spent several days in Wernigerode with Weierstrass and the famous Russian mathematician Sofia Kovalevskaya, who then was a chaired professor at the the University of Stockholm. She too had been a student of Weierstrass. Goodstein relates to us that Mittag-Leffler had met Sofia years earlier and commented to a Swedish associate:

> …as a woman, she is fascinating. She is beautiful and when she speaks, her face lights up with such an expression of feminine kindness and highest intelligence, that it is simply dazzling…[S]he is in all respects a complete "woman of the world." As a scholar she is characterized by her unusual clarity and precision of expression…I understand fully why Weierstrass considers her the most gifted of his students. (p. 72)

The book contains a photo of Kovalevskaya.

Goodstein's last chapter begins with an account of the role Volterra played during the first world war, with some emphasis on his work concerning the firing of cannons aboard hydrogen-inflated dirigibles. This account is not uninteresting, but the most compelling part of the chapter concerns Volterra's final years. The cancer that was

About the Cover

Julia Robinson and Hilbert's Tenth Problem

This month's cover was suggested by Bjorn Poonen's article on undecidability in number theory. The images have been taken from George Csicsery's new documentary film *Julia Robinson and Hilbert's Tenth Problem*, recently premiered at the 2008 Joint Mathematics Meetings in San Diego. The right-hand images portray Julia's sister, Constance Reid, who narrates much of the film and who appeared at the premier. The left-hand sequence is taken from a film of Yuri Matiyasevich lecturing in the Soviet Union in 1970 on his solution of Hilbert's tenth problem, towards which Julia and colleagues had made decisive contributions. In the center are a selection of photographs of Julia at various ages, including one with Constance. The one at the bottom was taken very shortly before her death in 1985.

The one just above that was taken in her office in the "stat lab" of Jerzy Neyman during World War II. Elizabeth Scott, in her memorial of Julia (*Notices* **85** (1985), p. 739) tells a story about this period worth retelling.

Julia was by then married to Raphael Robinson, who had an appointment in mathematics; a university rule made it quite difficult for the mathematics department to employ both of them. Professor Neyman felt that Julie should be employed and encouraged to do research. He argued that statistics, although technically in mathematics, had a lot of autonomy in budget and appointments, including a "line item" for research assistant. Although I already held this position, he arranged that I should be moved to another research position to accommodate Julie's appointment. Fine, except that Personnel suddenly interfered, contending that the position, now that it had changed, should be under Personnel—in essence, out of research. Julie was asked to submit a job description of what she did each day, so she did: "Monday—tried to prove theorem, Tuesday—tried to prove theorem, Wednesday—tried to prove theorem, Thursday—tried to prove theorem, Friday—theorem false." Personnel withdrew.

Our thanks to George Csicsery for providing the images. His film (on DVD) is distributed by A. K . Peters Ltd. More information can be found at `http://www.zalafilms.com`. The *Notices* will publish a detailed review soon.

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

Mussolini's fascism—together with Mussolini's pacts with Nazi Germany, a regime marked by its rabid anti-Semitism—brought down the Italian golden age of mathematics and science. Volterra was dismissed from his university position and ceased to belong to Italian scientific societies because he refused to sign an oath of allegiance and devotion to the Fascist regime (only eleven other professors in all of Italy refused). Italy's subsequent so called "racial laws" dictated that Jews could not attend public schools or universities, work as journalists, teachers, or notaries, or even use libraries. Volterra died of natural causes in 1940 in such obscurity that three years later, when Rome was occupied by the Nazis, German soldiers actually arrived at the house he had lived in expecting to deport him to a concentration camp. Virgina survived the Nazis with the help of the family's librarian who hid her until a more secure place was found with a group of nuns.

Virgina and Vito had six children, but sadly only four lived to become adults. One became a distinguished judge. Their son Enrico earned a Ph.D. at Cambridge University and taught at the University of Texas at Austin where he was a professor of aerospace engineering. Their daughter Luisa married Umberto D'Ancona, a marine biologist who was the supervisor of her undergraduate thesis at the University of Rome. It was D'Ancona who sparked Volterra's interest in the mathematical study of population dynamics in the Adriatic.

The biography contains three appendices: transcripts of two of Volterra's talks, and an obituary containing a description of Volterra's contributions to mathematics by Sir Edmund Whittaker. Outlines in English of Volterra's life have been available since the 1940s, but for an outstanding account of the life and times of Volterra this is the biography to read.

Where Are Journals Headed? Why We Should Worry About Author-Pay

John Ewing

People often ask me what I think will happen to journals. I'm a mathematician, but I know I won't find the answer there. Mathematics journals account for roughly 5% of scholarly journals[1]—journals in the biological and medical sciences account for about 50%! And this has consequences: At nearly every meeting about journals, biomedical journals dominate the discussion.

The business model adopted by biomedical journals will most likely be the model adopted by all others because biomedical journals not only dominate numbers but revenues as well. Customers (in this case, institutional libraries) don't like to deal with multiple business models. They don't easily divide budgets into new pieces (say, subscriptions versus page charges), and they don't like making complicated purchasing decisions. Dominant products and services usually shape those of lesser importance, and biomedical journals are clearly dominant.

The real question is therefore where are biomedical journals headed, and the answer seems obvious: They are moving towards an open access, author-pay model—one in which journal content is available at no charge to everyone, but authors pay a fee prior to publication. To many biomedical scientists, this feels like the right model. The purpose of publishing a biomedical paper is to make the results available now, not to preserve them for the future. The focus is on immediacy. Paying a "posting-fee" makes sense, and since most biomedical research is supported by grants (often large ones), a relatively small posting-fee is easily absorbed in the grant. This is the model underlying experiments such as the Public Library of Science, and it is the model implicitly promoted by the National Institutes of Health in the U.S., as well as by various biomedical organizations throughout the world. It is the logical successor to the subscription model when papers are made freely available after only a six month embargo.

Should we worry that all scholarly journals may follow a course dictated by one discipline's need for immediacy and availability of ample grant funds? Some open access proponents claim not. Everyone wins, they say, because not only do we gain universal access but, if the posting-fee is only the cost-of-posting, we will also save money—lots of it. As for the lack of grants, institutional budgets will merely shift from subscriptions to "page-charges" (that is, author fees), so that even those without grant funds will be able to publish their research. It's simple, they say, a model that benefits all.

But there are good reasons to worry about this sanguine view of the new model for journals.

(i) In areas where most research is not grant supported, universities and colleges will have to pay author fees by reallocating money from libraries (subscriptions) to other parts of the institution (departments? divisions?) that need the funds. But reallocating money is never a simple process. Will those who pay author fees from grants (biomedical sciences) be willing to give their library budgets to those who cannot (say, the humanities)? I suspect not. Will administrators look for ways to save money by shifting funds to other uses? Long experience suggests they will. Will departments with prestigious faculties demand more of the funds than those with less prestigious? Of course they will, and this will exaggerate differences throughout the university. Various constituencies will vie for funds, with inevitable winners and losers. Perhaps that's not bad, but it's surely not "simple".

(ii) The change in who makes decisions will change the market; this is basic economics. In the

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[1] *These percentages are derived from data in the Genamics JournalSeek database. See* http://journalseek.net/information.htm.

subscription model, users and librarians make decisions; in the author-pay model, authors and publishers make them. To succeed in the subscription model, a journal must secure enough subscriptions by convincing users and librarians that it has intellectual value. To succeed in the author-pay model, a journal must convince enough authors to submit papers and then it must accept enough of them to make money. Price will vie with prestige. The most prestigious journals will charge more and will attract authors who can pay the cost (grants will help). The less prestigious journals will discount their price in order to attract more authors and will increase the acceptance rate. Some institutions may demand that scholars use less-expensive journals; others will demand that their faculty publish only in expensive ones. The result will be a distorted and ugly market, driven by some of the same forces that drive vanity publishing. This is what happens when a market is driven by producers instead of consumers.

(iii) The author-pay model emphasizes immediacy. All money exchanges hands before the article appears when the author pays a "posting-fee". After a short period of time, the material in the journal has no monetary value to the publisher, other than to attract more authors. This is a subtle but profound change from the subscription model. Because anyone can post articles on the Web, unscrupulous publishers will take advantage of this short-term view by accepting marginal papers (or just plain junk) into newly created journals in order to make easy cash. Those who think scholars will not publish in such "instant journals" have not looked at current marginal publishers (who are kept in check only because they have to convince someone to buy their publications). Almost surely, more papers will be published in such a system, and the journal literature will decay over time into a blur of online postings and broken links.

(iv) The large commercial publishers will thrive in this new model. In fact, all large commercial publishers already have units devoted to open access publishing and are (quietly) pushing the author-pay model. Why? They will now produce a product for which they get paid by the supplier, in advance, without risk, and with lower overhead (because they don't have to sell subscriptions). And because the large publishers are diversified, they can take advantage of a changing environment. Small journal publishers in areas that have no grants to pay author fees will quickly go under; large publishers will expand into areas that are most lucrative. Large commercial publishers will end up with less competition in a market that is more easily manipulated—a market they will dominate even more than now. Of course they are pushing the author-pay model!

The fundamental problem for journals is simple—we pay too much for them! It's not access (which has never been better). It's not our business model (which is shared responsibility). It's not *how* we pay but rather how *much* we pay!

Many proponents of the author-pay model think we can solve this problem by switching to a new business model. Some have faith that publishers can be persuaded to set author fees only slightly higher than publication costs. But publishers who have profited from subscriptions in the past will certainly expect to profit from author fees in the future. (I can assure you that commercial publishers have this expectation.) Others believe they can run inexpensive author-pay journals themselves to compete with established journals, miraculously succeeding with upstart author-pay journals where upstart subscription-based journals have failed in the past. But there is no basis for this optimism. Indeed, since we will likely publish far more than ever before, we will likely spend far more as well. And here's the largest worry about the author-pay model: It does not solve the fundamental problem of journals—this model makes it worse!

We are therefore heading in the wrong direction. Scholarly journals are sick and they need attention. But instead of following a regimen of reasoned and disciplined remedies—instead of driving down prices by the steady, concerted actions of authors, editors, and librarians—we are bleeding the patient with open access models, trusting in miracles (that university administrators will shift funds from those with research funds to those without), and praying that publishers will repent their ways.

It is ironic that those leading us down this path of folk remedies and faith healing come from the biomedical sciences.

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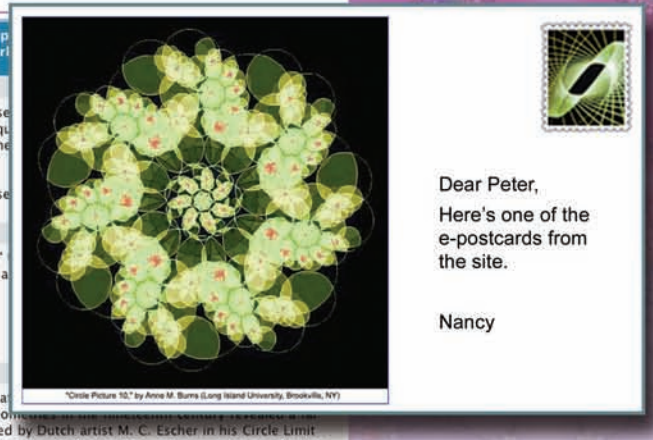

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Hardy's "Small" Discovery Remembered

Indika Rajapakse, Lindsey Muir, and Paul Martin

> What we do may be small, but it has a certain character of permanence; and to have produced anything of the slightest permanent interest, whether it be a copy of verses or a geometrical theorem, is to have done something utterly beyond the powers of the vast majority of men.
> —*Godfrey Harold Hardy*
> A Mathematician's Apology

The most beautiful mathematics to Godfrey Harold Hardy was that which had no application. For Hardy, mathematics was purely for intellectual challenge. He justified the pursuit of pure mathematics with the argument that its very "uselessness" meant that it could not be used to cause harm. Hardy went so far as to describe applied mathematics as "ugly", "trivial", and "dull" [1].

Despite Hardy's aversion to applied mathematics, he had a profound impact on biology. Mathematicians tend not to realize his contribution, which was downplayed by Hardy himself. At the same time, biologists tend not to appreciate his mathematical brilliance. This note is intended to recognize G. H. Hardy's "little" discovery as a contribution to genetics and to revisit a classic paper [2] that has shaped the field for the past century.

Godfrey Harold Hardy, a graduate of Trinity College, Cambridge, began his mathematics career in the early 1900s as a fellow at Trinity [3]. He lectured in mathematics for a number of years and published many papers of such significance that he was considered Britain's leading pure mathematician. Hardy was also responsible for bringing the Indian mathematical genius Srinivasa Ramanujan to England, where they published many papers together and developed the field of number theory. While visiting an ill Ramanujan on one occasion, Hardy mentioned that he had traveled in cab number 1729 and "hoped it was not an unfavorable omen" to which Ramanujan replied "…it is a very interesting number; it is the smallest number expressible as the sum of two cubes in two different ways" (it is expressible as $1729 = 1^3 + 12^3$ or $9^3 + 10^3$, now known as the Hardy-Ramanujan number).

In 1908, Hardy published a paper in *Science* that changed the field of population genetics, entitled "Mendelian Proportions in a Mixed Population". The findings were later known as the Hardy-Weinberg Law (Equilibrium) because the same principle was published by Wilhelm Weinberg in the same year [4]. This principle offered a simple solution for the question of how genetic diversity is maintained in a population. For Hardy, the law was trivial and obvious, and he was reluctant to acknowledge its applications. But one hundred years later, the Hardy-Weinberg Law remains a cornerstone of modern computational genetics.

Preservation of genetic diversity in a population requires stability, or equilibrium, of the genotype distribution from one generation to the next. The following is an outline of Hardy's stability condition for Mendelian proportions [2]. This condition holds for a closed system, where the population mates randomly, or for purposes of simplicity, where every individual mates with every other individual once, and where each mating yields a single offspring, with no selection, mutation, migration, or death.

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Genotypes	A_1A_1	A_1A_2	A_2A_2	2nd generation frequency
A_1A_1	$\frac{P_{11}}{a} \times \frac{P_{11}}{a}$	$\frac{P_{11}}{a} \times \frac{2P_{12}}{a}$	$\frac{P_{11}}{a} \times \frac{P_{22}}{a}$	$\frac{(P_{11}+P_{12})^2}{a^2}$
A_1A_2	$\frac{2P_{12}}{a} \times \frac{P_{11}}{a}$	$\frac{2P_{12}}{a} \times \frac{2P_{12}}{a}$	$\frac{2P_{12}}{a} \times \frac{P_{22}}{a}$	$\frac{2(P_{11}+P_{12})(P_{12}+P_{22})}{a^2}$
A_2A_2	$\frac{P_{22}}{a} \times \frac{P_{11}}{a}$	$\frac{P_{22}}{a} \times \frac{2P_{12}}{a}$	$\frac{P_{22}}{a} \times \frac{P_{22}}{a}$	$\frac{(P_{12}+P_{22})^2}{a^2}$

Recall that in the mammalian genome, each gene is represented by two of many possible variants, called alleles. For example, the gene, or locus, for eye color can exist in many forms, including a "blue" allele coding for blue eyes and a "brown" allele coding for brown eyes. If we consider only the blue and brown alleles, an individual may have two copies of the blue allele (homozygous for the blue allele), one copy of each allele (heterozygous), or two copies of the brown allele (homozygous for the brown allele). An individual who is homozygous for the blue allele can be designated as having an "A_1A_1" genotype, while an individual who is homozygous for the brown allele is designated as having an "A_2A_2" genotype.

Consider the following case for alleles A_1 and A_2,

P_{11} = the number of individuals with genotype A_1A_1 (the homozygous A_1 case)

$2P_{12}$ = the number of individuals with genotype A_1A_2 or A_2A_1 (the heterozygous case)

P_{22} = the number of individuals with genotype A_2A_2 (the homozygous A_2 case)

Therefore, we can write the first generation proportions of individuals as $P_{11} : 2P_{12} : P_{22}$. Let the total number of individuals in the first generation be represented as a, where $a = P_{11} + 2P_{12} + P_{22}$. The second generation proportions of individuals can be derived from the table seen above.

Therefore, we can write the second generation proportions of individuals as

$$(P_{11} + P_{12})^2 : 2(P_{11} + P_{12})(P_{12} + P_{22}) : (P_{12} + P_{22})^2$$

Let the total number of individuals in the second generation be represented as b, where $b = (P_{11} + P_{12})^2 + 2(P_{11} + P_{12})(P_{12} + P_{22}) + (P_{12} + P_{22})^2$. Hardy's stability condition requires that the proportion of individuals with any given genotype remains constant across generations and is therefore established as follows

$$(1) \qquad \frac{P_{11}}{a} = \frac{(P_{11} + P_{12})^2}{b}$$

$$(2) \qquad \frac{2P_{12}}{a} = \frac{2(P_{11} + P_{12}(P_{12} + P_{22})}{b}$$

$$(3) \qquad \frac{P_{22}}{a} = \frac{(P_{12} + P_{22})^2}{b}$$

Solving the above system simultaneously yields $P_{12}^2 = P_{11} \times P_{22}$, the stability condition for the two-allele case. This provides a null hypothesis for biologists investigating the distribution of genetic characteristics in a population.

Since $a^2 = (P_{11} + 2P_{12} + P_{22})^2 = P_{11}^2 + 4P_{12}P_{11} + 4P_{12}^2 + 2P_{11}P_{22} + 4P_{12}P_{22} + P_{22}^2 = (P_{11} + P_{12})^2 + 2(P_{11} + P_{12})(P_{12} + P_{22}) + (P_{12} + P_{22})^2 = b$, this demonstrates that $a^2 = b$, as required by the assumption of a closed system.

Let the haplotype frequency of allele $A_1 = p$, and the haplotype frequency of allele $A_2 = q$, recalling that a haplotype is a combination of alleles at multiple genetic loci that are transmitted together from one generation to the next. Accordingly, and $p = \frac{2P_{11}+2P_{12}}{2a}$, and $q = \frac{2P_{22}+2P_{12}}{2a}$, where homozygous individuals are counted twice, heterozygous individuals counted once, and the number of haplotypes is twice the population size. Hence, $p = \frac{P_{11}+P_{12}}{a}$, and $q = \frac{P_{22}+P_{12}}{a}$. Since $p + q = 1$, the modern population genetics interpretation, $p^2 + 2pq + q^2 = 1$ must hold, which states that $\Pr(A_1A_1) = p^2$, $\Pr(A_1A_2) = 2pq$, and $\Pr(A_2A_2) = q^2$.

We can extend the two allele case to a general case as follows. Under the same assumptions as above and additionally that a given gene includes k alleles, say $A_1, A_2, \cdots, A_k$ and P_{ij} is the number of people with the genotype A_iA_j, where i, j can be any real number.

The following generations will approach values in proportion to those suggested by counting all possibilities of mating (the way Hardy did). Thus, if in addition the values satisfy (or nearly satisfy) the stability condition $P_{ij}^2 = P_{ii} \times P_{ij}$, then we can assume that the probabilities for each genotype in each generation will be the same as the

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probabilities for each genotype in the preceding generation. That is, the proportion of individuals with each genotype will stay the same, while genetic diversity will be maintained in a predictable way. This formulation is the k allele analog of the Hardy-Weinberg Law.

Certain violations of the closed system assumption lead to departure from Hardy-Weinberg Equilibrium. One such violation is non-random mating, where preferential mating according to genotype may occur in the population. We will not explore the mathematical details, but we can represent this case as follows: $\Pr(A_1A_1) = p^2 + pqF$, $\Pr(A_1A_2) = 2pq(1-F)$, and $\Pr(A_2A_2) = p^2 + pqF$, where F is defined as the inbreeding coefficient [5]. F can be thought of as the probability that two alleles are identical due to parents passing on the same allele to their progeny. It is therefore also a measure of the degree of parental relatedness. When $0 < F < 1$, homozygosity in the population increases, which may reduce health and reproductive fitness.

The modern interdisciplinary approach has gathered great minds to work on some of the most challenging problems in biology. Hardy's contribution has greatly influenced the growing field of computational genetics. Today, applied mathematics is a critical component of genetics and has the potential to revolutionize the field and profoundly impact modern medicine. If Hardy were alive today, it would be interesting to know whether he would join these minds or remain steadfast in his pursuit of pure mathematics. Despite his disdain for applied mathematics, Hardy was one of the greatest contributors to contemporary mathematical biology, and at this one hundred year anniversary, his "small" discovery will be remembered as such a great contribution.

Acknowledgements

We thank Robert O'Malley, University of Washington, and Martin Morgan and Rafael Meza, Fred Hutchinson Cancer Research Center. Support of Indika Rajapakse by the Interdisciplinary Training Grant in Cancer Research (NIH grant T32 CA80416) is gratefully acknowledged.

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2007 Annual Survey of the Mathematical Sciences

(First Report, Part II)

Report on the 2007–2008 Faculty Salaries

Polly Phipps, James W. Maxwell, and Colleen Rose

This report of the 2007 Annual Survey provides information on the distribution of 2007-2008 academic-year salaries for tenured and tenure-track faculty at four-year mathematical sciences departments in the U.S. The information is gathered from departments using a questionnaire initially distributed in June of 2007. This year's salary report includes, for the first time, separate reporting on the salaries of newly appointed tenure-track assistant professors. This report has traditionally appeared as part of the First Report of the Annual Survey, published in recent years in the February issue of Notices of the American Mathematical Society.

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

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

Faculty Salary Survey

The charts on the following pages describe the distribution of academic-year salaries for tenured and tenure-track faculty in each of the departmental groupings used in the Annual Survey. Salaries are described separately by rank, and for the first time, salaries for newly appointed (tenure-track) assistant professors are profiled separately. Salaries are reported in current dollars. Results reported here are based on the departments which responded to the survey with no adjustment for non-response.

Table 1 provides the departmental response rates for the 2007 Faculty Salary Survey. Departments were asked to report for each rank the number of tenured and tenure-track faculty whose

Table 1: Faculty Salary Response Rates

Department	Number	Percent
Group I (Public)	23 of 25	92
Group I (Private)	16 of 23	70
Group II	43 of 56	77
Group III	56 of 74	76
Group IV (Statistics)	39 of 55	71
Group IV (Biostatistics)	17 of 32	53
Group Va	8 of 18*	44
Group M	102 of 189	54
Group B	330 of 1035	32

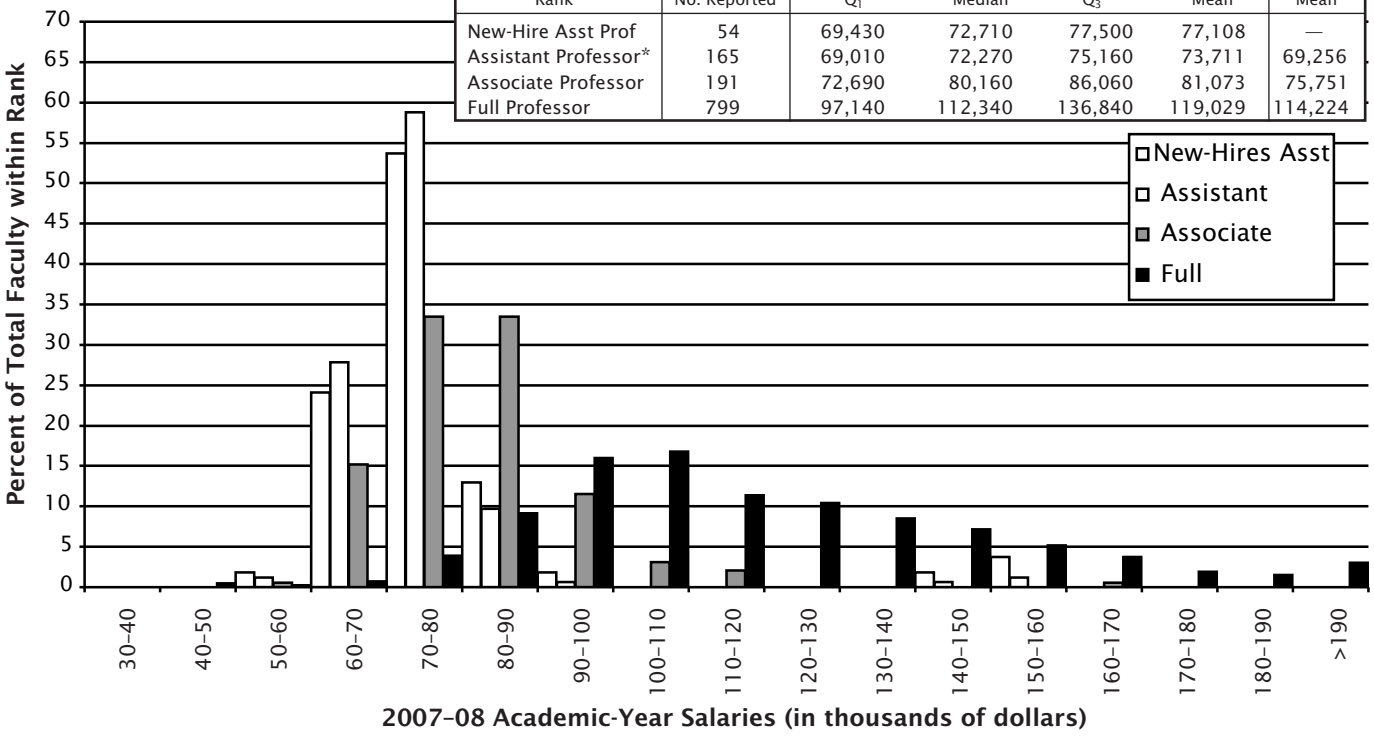
* The population for Group Va is slightly less than for the Doctorates Granted Survey, because two programs do not formally "house" faculty and their salaries.

Group I (Public) Faculty Salaries

Doctoral degree-granting departments of mathematics

23 responses out of 25 departments (92%)

Rank	2007–08 No. Reported	Q_1	Median	Q_3	Mean	2006–07 Mean
New-Hire Asst Prof	54	69,430	72,710	77,500	77,108	—
Assistant Professor*	165	69,010	72,270	75,160	73,711	69,256
Associate Professor	191	72,690	80,160	86,060	81,073	75,751
Full Professor	799	97,140	112,340	136,840	119,029	114,224

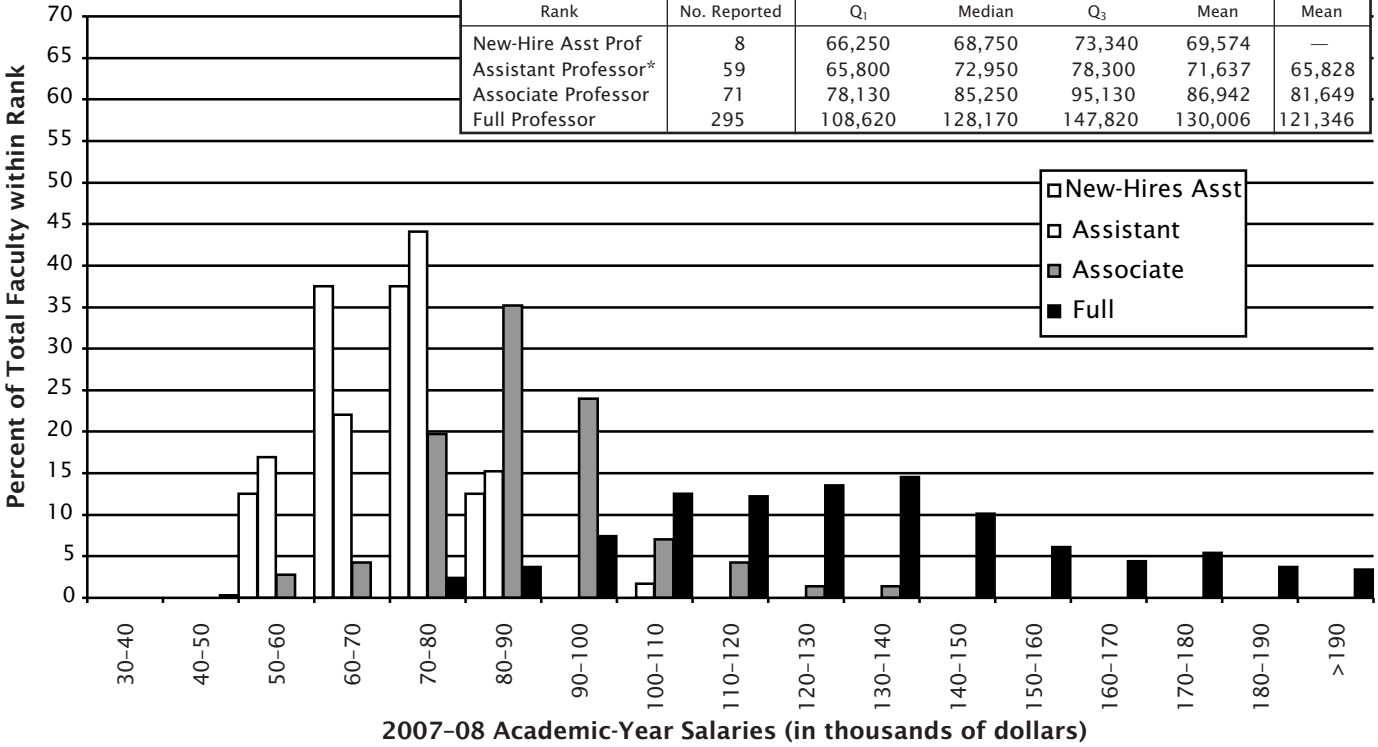


Group I (Private) Faculty Salaries

Doctoral degree-granting departments of mathematics

16 responses out of 23 departments (70%)

Rank	2007–08 No. Reported	Q_1	Median	Q_3	Mean	2006–07 Mean
New-Hire Asst Prof	8	66,250	68,750	73,340	69,574	—
Assistant Professor*	59	65,800	72,950	78,300	71,637	65,828
Associate Professor	71	78,130	85,250	95,130	86,942	81,649
Full Professor	295	108,620	128,170	147,820	130,006	121,346



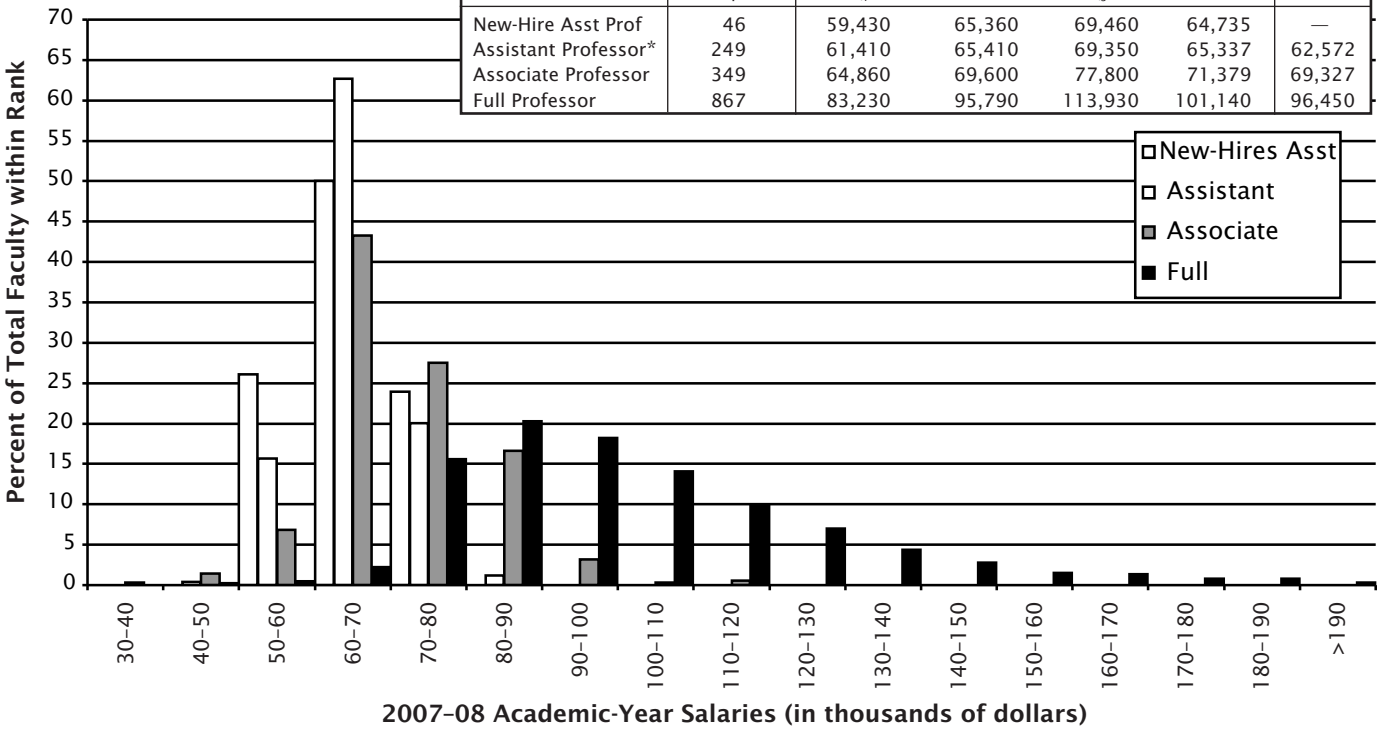
*Includes new hires and is comparable to previous years' figures.

Group II Faculty Salaries

Doctoral degree-granting departments of mathematics

43 responses out of 56 departments (77%)

Rank	2007–08 No. Reported	Q_1	Median	Q_3	Mean	2006–07 Mean
New-Hire Asst Prof	46	59,430	65,360	69,460	64,735	—
Assistant Professor*	249	61,410	65,410	69,350	65,337	62,572
Associate Professor	349	64,860	69,600	77,800	71,379	69,327
Full Professor	867	83,230	95,790	113,930	101,140	96,450

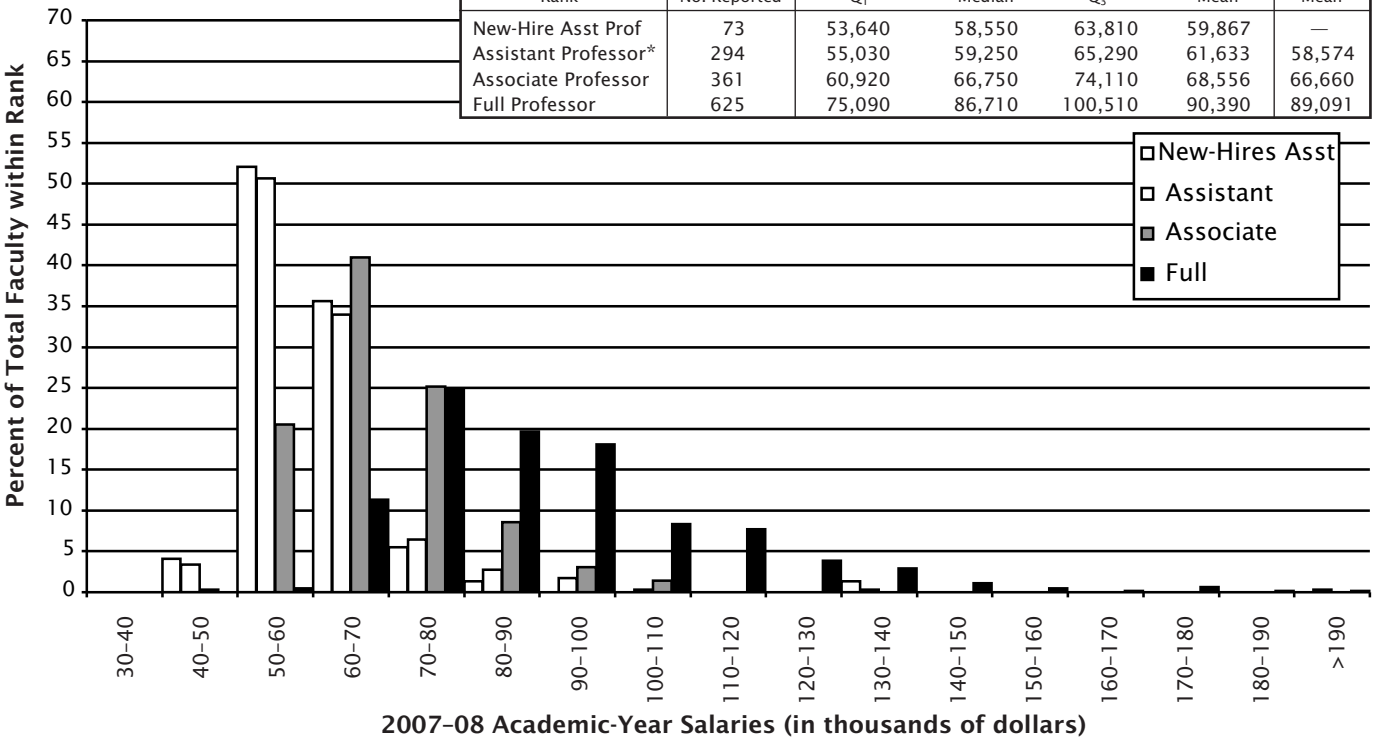


Group III Faculty Salaries

Doctoral degree-granting departments of mathematics

56 responses out of 74 departments (76%)

Rank	2007–08 No. Reported	Q_1	Median	Q_3	Mean	2006–07 Mean
New-Hire Asst Prof	73	53,640	58,550	63,810	59,867	—
Assistant Professor*	294	55,030	59,250	65,290	61,633	58,574
Associate Professor	361	60,920	66,750	74,110	68,556	66,660
Full Professor	625	75,090	86,710	100,510	90,390	89,091



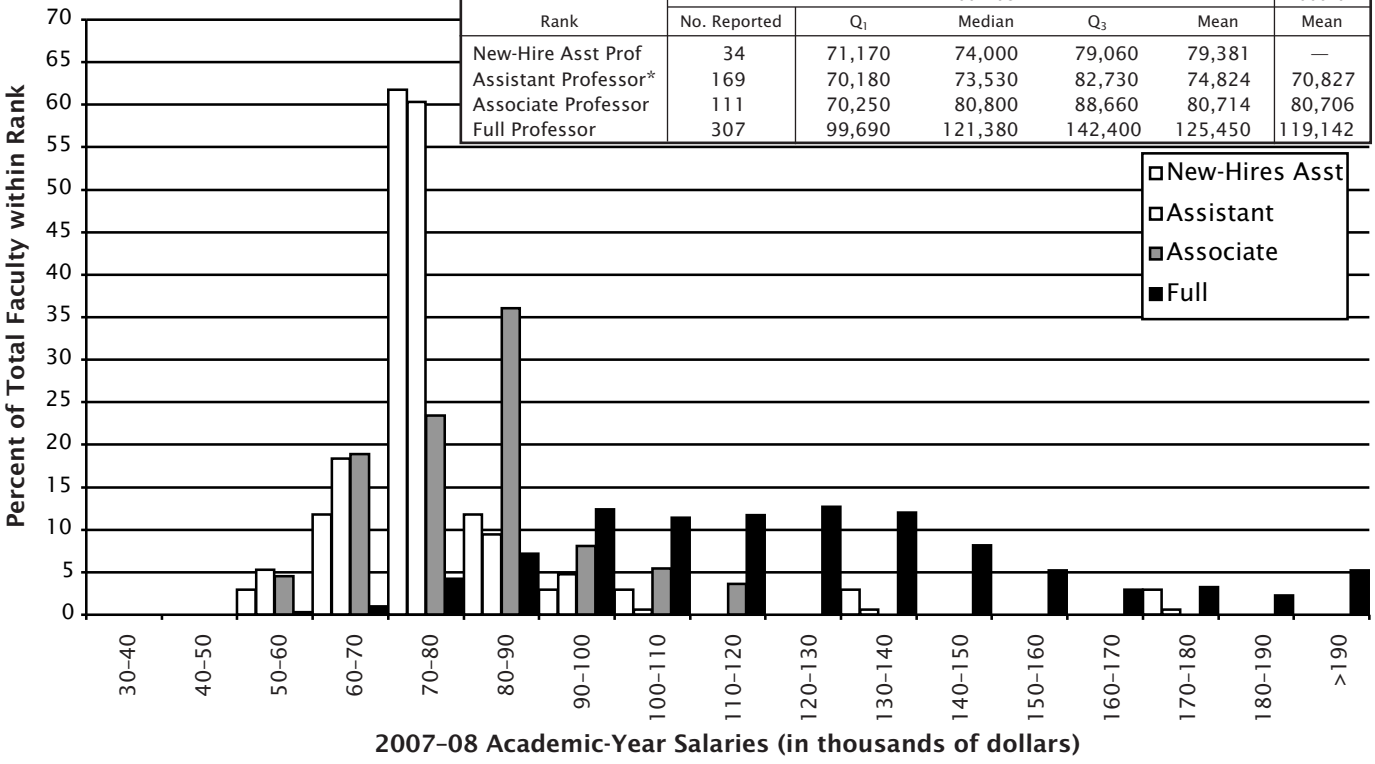
*Includes new hires and is comparable to previous years' figures.

Group IV Statistics Faculty Salaries

Doctoral degree-granting departments of statistics

39 responses out of 55 departments (71%)

Rank	2007–08 No. Reported	Q_1	Median	Q_3	Mean	2006–07 Mean
New-Hire Asst Prof	34	71,170	74,000	79,060	79,381	—
Assistant Professor*	169	70,180	73,530	82,730	74,824	70,827
Associate Professor	111	70,250	80,800	88,660	80,714	80,706
Full Professor	307	99,690	121,380	142,400	125,450	119,142

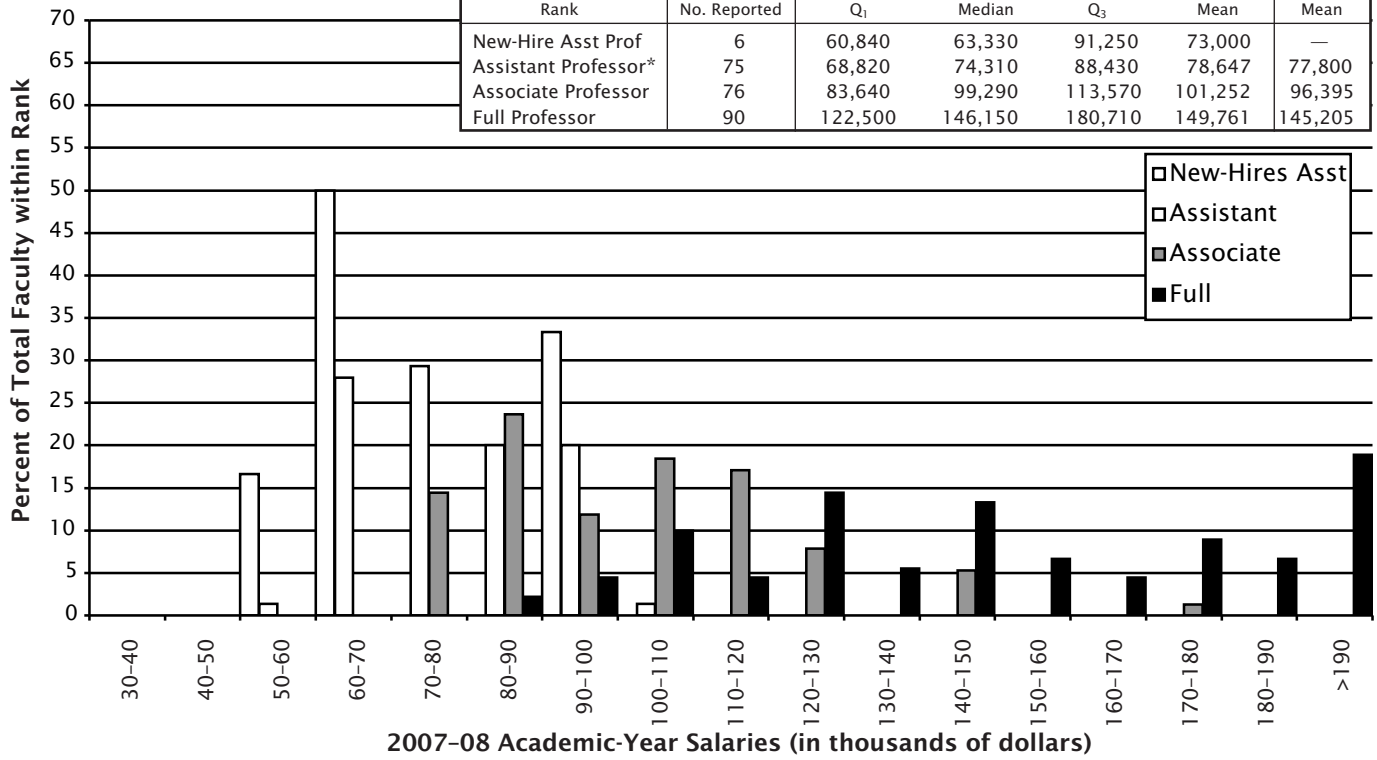


Group IV Biostatistics Faculty Salaries

Doctoral degree-granting departments of biostatistics

17 responses out of 32 departments (53%)

Rank	2007–08 No. Reported	Q_1	Median	Q_3	Mean	2006–07 Mean
New-Hire Asst Prof	6	60,840	63,330	91,250	73,000	—
Assistant Professor*	75	68,820	74,310	88,430	78,647	77,800
Associate Professor	76	83,640	99,290	113,570	101,252	96,395
Full Professor	90	122,500	146,150	180,710	149,761	145,205



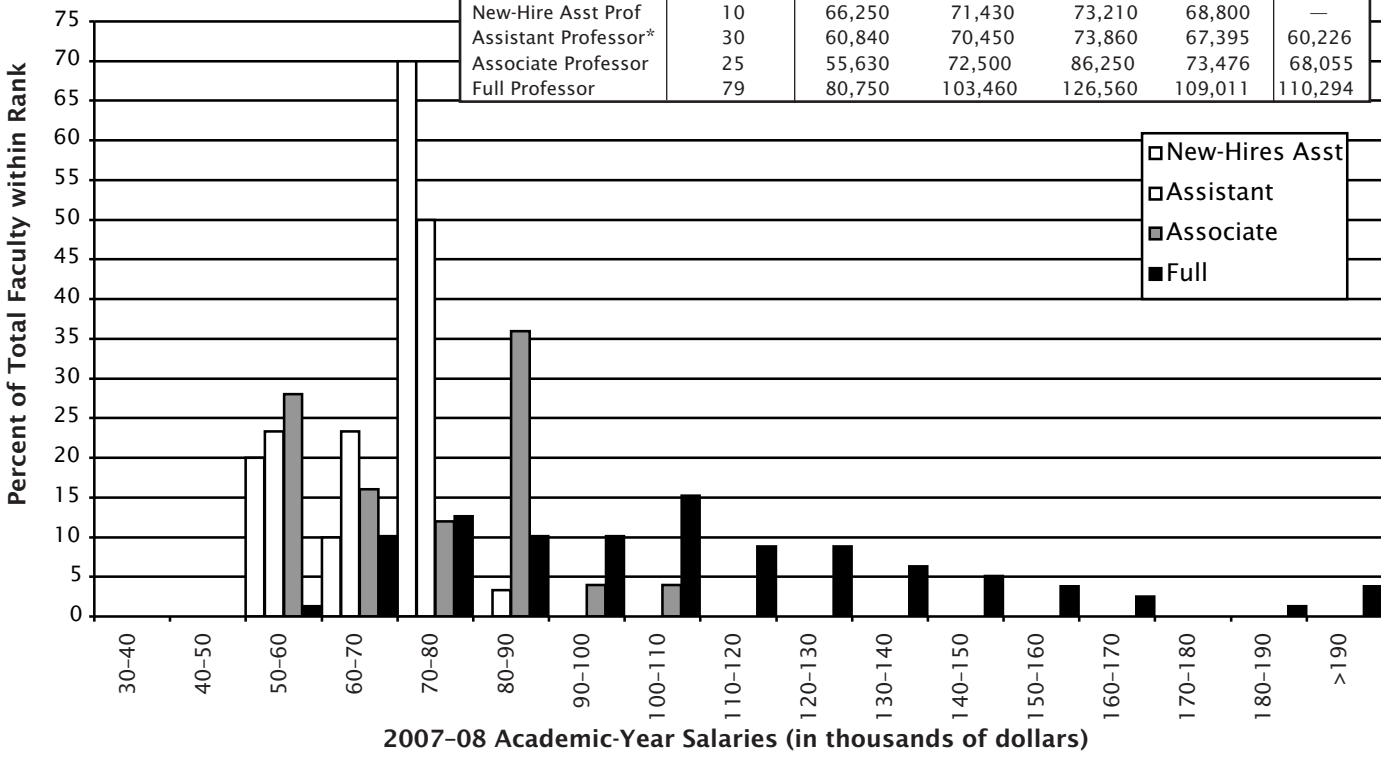
*Includes new hires and is comparable to previous years' figures.

Group Va Faculty Salaries

Doctoral degree-granting departments of applied mathematics

8 responses out of 18 departments (44%)

Rank	2007–08 No. Reported	Q_1	Median	Q_3	Mean	2006–07 Mean
New-Hire Asst Prof	10	66,250	71,430	73,210	68,800	—
Assistant Professor*	30	60,840	70,450	73,860	67,395	60,226
Associate Professor	25	55,630	72,500	86,250	73,476	68,055
Full Professor	79	80,750	103,460	126,560	109,011	110,294



*Includes new hires and is comparable to previous years' figures.

2007–08 academic-year salaries fell within given salary intervals. Reporting salary data in this fashion eliminates some of the concerns about confidentiality but does not permit determination of actual quartiles. Although the actual quartiles cannot be determined from the data gathered, these quartiles have been estimated assuming that the density over each interval is uniform.

When comparing current and prior year figures, one should keep in mind that differences in the set of responding departments may be a significant factor in the change in the reported mean salaries.

Previous Annual Survey Reports

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

Acknowledgments

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

Other Data Sources

American Association of University Professors, *The Annual Report on the Economic Status of the Profession 2006–2007*, Academe: Bull. AAUP (March–April 2007), Washington, DC.

American Statistical Association, *Business, Industry, and Government 2007 Salary Survey*. [http://www.amstat.org/profession/SPAIGsalarysurvey07.pdf] (Published in AmstatNews, July 2007, Issue #361.)

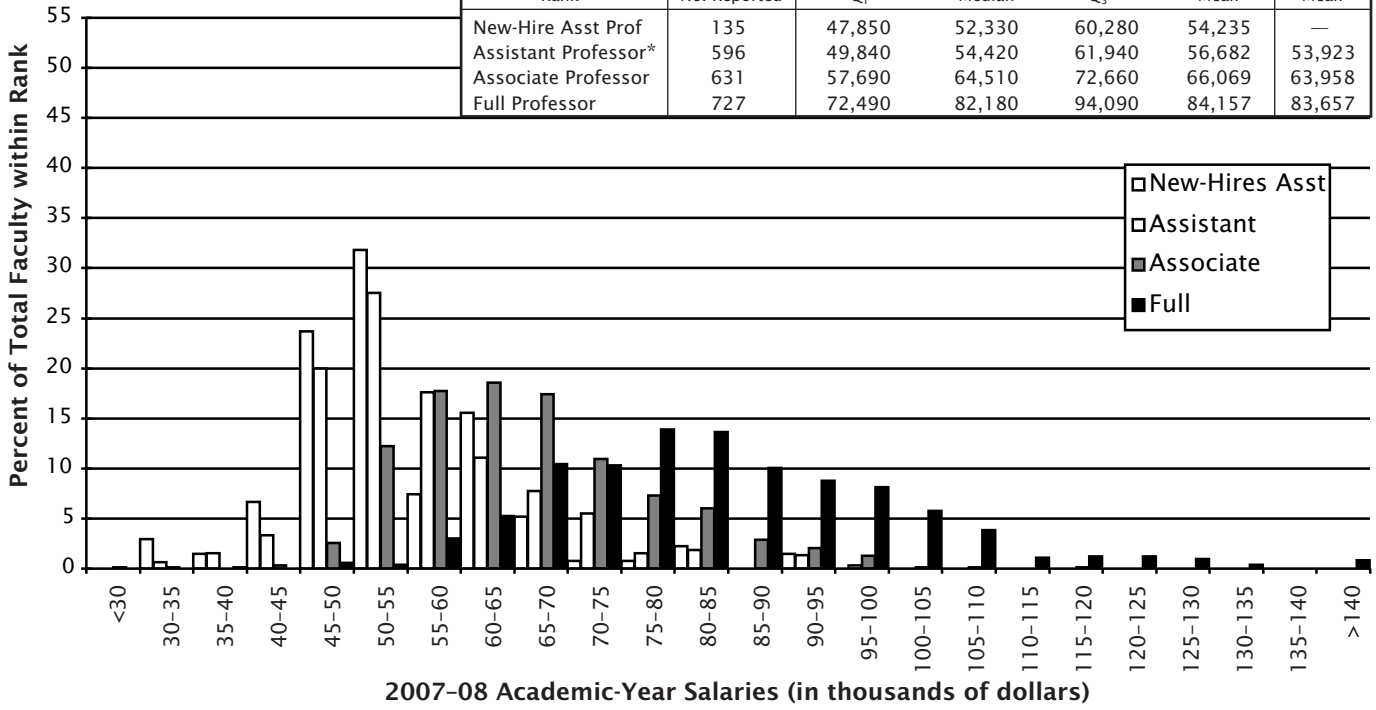
_____, *2006–2007 Salary Report of Academic Statisticians.* [http://www.amstat.org/profession/salaryreport_acad2006-7.pdf].

Group M Faculty Salaries

Master's degree-granting departments of mathematics

102 responses out of 189 departments (54%)

Rank	2007–08 No. Reported	Q_1	Median	Q_3	Mean	2006–07 Mean
New-Hire Asst Prof	135	47,850	52,330	60,280	54,235	—
Assistant Professor*	596	49,840	54,420	61,940	56,682	53,923
Associate Professor	631	57,690	64,510	72,660	66,069	63,958
Full Professor	727	72,490	82,180	94,090	84,157	83,657

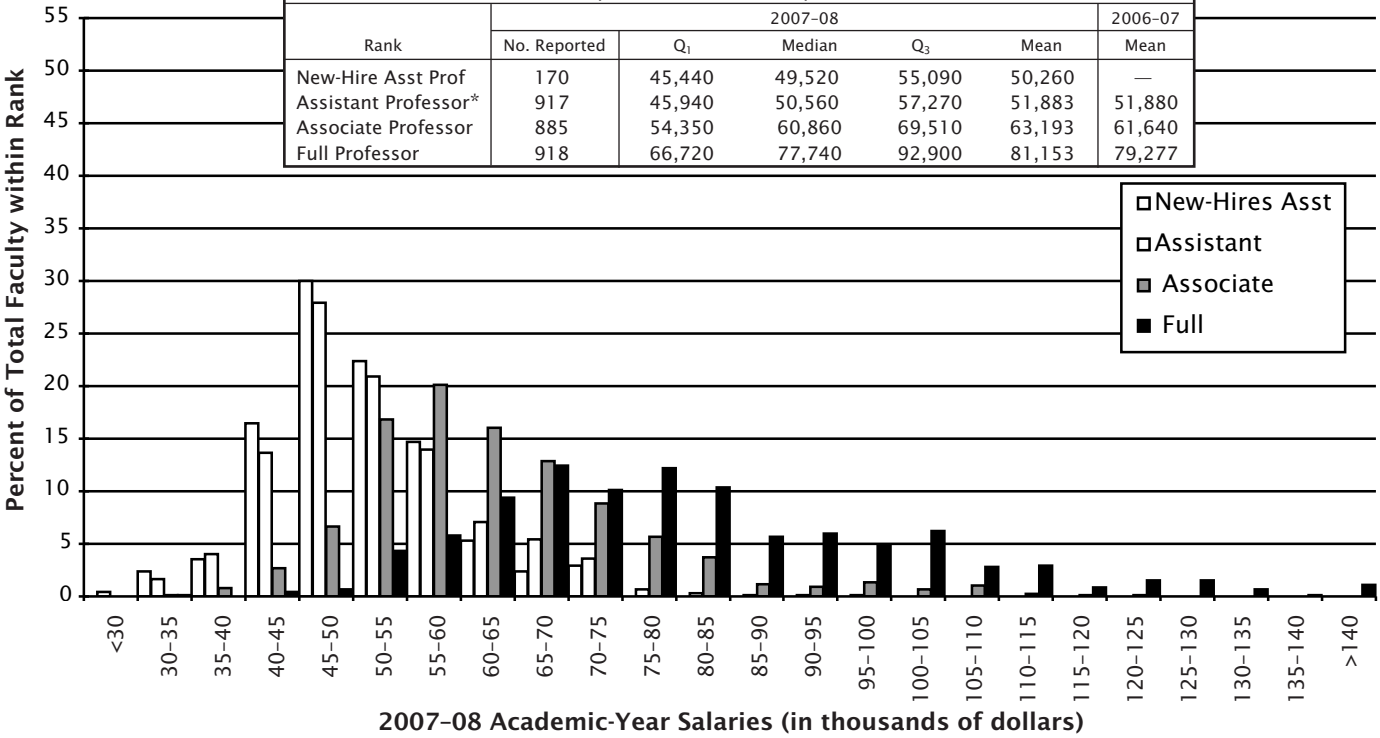


Group B Faculty Salaries

Bachelor's degree-granting departments of mathematics

330 responses out of 1035 departments (32%)

Rank	2007–08 No. Reported	Q_1	Median	Q_3	Mean	2006–07 Mean
New-Hire Asst Prof	170	45,440	49,520	55,090	50,260	—
Assistant Professor*	917	45,940	50,560	57,270	51,883	51,880
Associate Professor	885	54,350	60,860	69,510	63,193	61,640
Full Professor	918	66,720	77,740	92,900	81,153	79,277



*Includes new hires and is comparable to previous years' figures.

Commission on Professionals in Science and Technology, *Salaries of Scientists, Engineers, and Technicians: A Summary of Salary Surveys*, 22nd ed., CPST, Washington, DC, 2007.

_____, *Professional Women and Minorities,* 16th ed., CPST, Washington, DC, 2006.

National Research Council, *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.

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

Definitions of the Groups

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

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

Brief descriptions of the groupings are as follows:

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

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

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

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

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

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

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

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

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

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

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

Mathematics People

Borodin Receives 2008 CRM-Fields-PIMS Prize

ALLAN BORODIN of the University of Toronto has been awarded the 2008 CRM-Fields-PIMS Prize. The prize, awarded annually by the Centre de Recherches Mathématiques (CRM), the Fields Institute, and the Pacific Institute for the Mathematical Sciences (PIMS), recognizes exceptional contributions by a mathematician working in Canada. The prize carries a cash award of CA$10,000 (approximately US$9,800) and an invitation to give a lecture at each institute.

According to the prize citation, Borodin "is a world leader in the mathematical foundations of computer science. His influence on theoretical computer science has been enormous, and its scope is very broad." He has made fundamental contributions to many areas, including algebraic computations, resource trade-offs, routing in interconnection networks, parallel algorithms, online algorithms, and adversarial queuing theory.

Borodin received his bachelor's degree in mathematics from Rutgers University in 1963, his master's degree in electrical engineering and computer science in 1966 from Stevens Institute of Technology, and his Ph.D. in computer science from Cornell University in 1969. He was a systems programmer at Bell Laboratories from 1963 to 1966 and a research fellow at Cornell from 1966 to 1969. He has been a member of the computer science department at the University of Toronto since 1969 and served as chair of the department from 1980 to 1985. He has edited many journals, including *SIAM Journal of Computing, Algorithmica, Journal of Computer Algebra, Journal of Computational Complexity*, and *Journal of Applicable Algebra in Engineering, Communication, and Computing*. He is a fellow of the Royal Society of Canada.

The CRM and the Fields Institute established the CRM-Fields Prize in 1994 to recognize exceptional research in the mathematical sciences. In 2005, PIMS became an equal partner, and the name was changed to the CRM-Fields-PIMS Prize. Previous recipients of the prize are H.S.M. (Donald) Coxeter, George A. Elliott, James Arthur, Robert V. Moody, Stephen A. Cook, Israel Michael Sigal, William T. Tutte, John B. Friedlander, John McKay, Edwin Perkins, Donald A. Dawson, David Boyd, Nicole Tomczak-Jaegermann, and Joel S. Feldman.

—From a Fields Institute announcement

Devlin Awarded Sagan Prize

KEITH DEVLIN of Stanford University has been awarded the Carl Sagan Prize for Science Popularization. The prize is awarded by the Board of Trustees of Wonderfest to honor researchers in the San Francisco Bay Area who make science accessible. The award carries a cash prize of US$5,000.

Devlin is a senior researcher at and executive director of the Center for the Study of Language and Information (CSLI) at Stanford and a cofounder of the Stanford Media X research network and of the university's H-STAR institute. His current research focuses on applying mathematical logic to studying reasoning, communication, and human behavior. He has been an advisor to the television show *NUMB3RS* and appears on National Public Radio as "the Math Guy". He is a World Economic Forum fellow and a fellow of the American Association for the Advancement of Science.

The Sagan Prize is awarded annually to an individual who has contributed to the public understanding and appreciation of science, who is a legal resident of one of the nine San Francisco Bay Area counties, and who has a history of accomplishment in scientific research, at least half of which was conducted in the Bay Area.

—Elaine Kehoe

Prizes of the Mathematical Society of Japan

The Mathematical Society of Japan (MSJ) awarded a number of prizes in autumn 2007.

TADAHISA FUNAKI of the University of Tokyo was awarded the Autumn Prize for his contributions to stochastic analysis on large-scale interacting systems, in particular on the Ginzburg-Landau $\nabla\phi$ intersurface model and the low-temperature limit of interacting Brownian particles. The Autumn Prize is awarded to an individual who has made outstanding contributions within the preceding five years to mathematics in the highest and broadest sense.

SHIGEYUKI MORITA and KENICHI YOSHIKAWA, both of the University of Tokyo, were awarded the Geometry Prizes. Morita was recognized for his fundamental research work on mapping class groups, in particular his discovery of the Mumford-Morita-Miller characteristic classes, which resolves the structure of the stable cohomology algebra of mapping class groups. Yoshikawa was honored for his research work on the Ray-Singer analytic torsion and its behavior on various moduli spaces, which derives, for instance, a geometric construction of Borcherds modular forms for the moduli space of K3 surfaces.

The Analysis Prizes have been awarded to SHIGEKI AIDA of Osaka University, TOSHIAKI HISHIDA of Niigata University, and TAKESHI HIRAI of Kyoto University in recognition of their outstanding contributions to analysis. Aida was honored for his contributions to stochastic analysis in infinite-dimensional spaces, with special reference to his work on functional inequalities, symmetric diffusion processes, and semiclassical limits. Hishida was recognized for his contributions to the new developments in Fujita-Kato theory for the Navier-Stokes equations and, in particular, for his work on Navier-Stokes flows in aperture domains and around rotating bodies. Hirai was honored for his contributions to the representation theory of infinite symmetric groups, with special reference to his work on irreducible representations of infinite symmetric groups.

—From a Mathematical Society of Japan announcement

Venkatesh Receives Packard Fellowship

AKSHAY VENKATESH, a mathematician at the Courant Institute of Mathematical Sciences of New York University, has received a Fellowship for Science and Engineering from the David and Lucile Packard Foundation for the year 2007. He will conduct research in number theory, in particular developing a suite of techniques to study L-functions from the analytic viewpoint using ideas from various fields of mathematics, including nonabelian harmonic analysis and ergodic theory.

The Packard Fellowships are awarded to researchers in mathematics, natural sciences, computer science, and engineering who are in the first three years of a faculty appointment.

—From a Packard Foundation announcement

Professor of the Year Awards Announced

Two mathematicians have been selected as National Professors of the Year by the Carnegie Foundation for the Advancement of Teaching and the Council for Advancement and Support of Education (CASE), which cosponsor the awards, and another mathematician has received a State Professor of the Year award. The Professor of the Year Awards are intended to reward outstanding professors for their dedication to teaching, their commitment to students, and their innovative instructional methods.

ROSEMARY M. KARR of Collin County Community College was named Outstanding Community Colleges Professor for 2007. She developed Passport Mathematics, a holistic, self-paced program that cuts math anxiety and boosts self-confidence while providing a strong foundation in mathematics. Participants in the program also put their math skills to work in the community by tutoring at-risk young people and by writing about their experiences in journals.

CARLOS G. SPAHT of Louisiana State University, Shreveport, was selected as Outstanding Master's Universities and Colleges Professor for 2007. He created a two-year program that helps to prepare underserved middle and high school students for college programs in math, science, and engineering. He directs a tutoring program for inner-city youths in the Shreveport area and helped develop a financial literacy course for high school teachers and students. He is a past recipient of a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring.

FRANK JONES of Rice University in Texas was honored as a State Professor of the Year. The State Professors of the Year Award Program selects outstanding educators in all fifty states, the District of Columbia, Guam, Puerto Rico, and the U.S. Virgin Islands. Winners receive personalized award certificates and national and local media recognition.

—From a Carnegie Foundation announcement

Rhodes Scholarships Awarded

Two students in the mathematical sciences are among the thirty-two American men and women chosen as Rhodes Scholars by the Rhodes Scholarship Trust. The Rhodes Scholars were chosen from among 764 applicants who were endorsed by 294 different colleges and universities in a nationwide competition. The names and brief biographies of the mathematics scholars follow.

ADAM M. LEVINE of the Bronx, New York, is a senior at Dartmouth College, where he majors in anthropology, art history, and mathematics and social science. His undergraduate thesis in art history is an examination of canonical images of Christ. He is interested in the application of mathematical network analysis to art, historical, and anthropological studies. He is also a light heavyweight

boxer. He plans to study for a D.Phil. in classics at Oxford.

SHAYAK SARKAR of Edinburg, Texas, received both his bachelor of arts degree in applied mathematics and a master's degree in statistics from Harvard University in 2007. He was elected to Phi Beta Kappa as a junior and won a prize for his thesis on America's homeless children. He is interested in applying his analytical skills in mathematics, statistics, and economics to the problems of poverty, especially affordable housing and education reform. He intends to study for a doctorate in evidence-based social work at Oxford.

Rhodes Scholarships provide two or three years of study at the University of Oxford in England. The value of the Rhodes Scholarship varies depending on the academic field and the degree (bachelor's, master's, doctoral) and Oxford college chosen. The Rhodes Trust pays all college and university fees and provides a stipend to cover students' necessary expenses while they are in residence in Oxford, as well as during vacations, and transportation to and from England. The total value averages approximately US$45,000 per year.

—From a Rhodes Scholarship Trust announcement

Siemens Competition Prizes Announced

Three students in the mathematical sciences have won prizes in the Siemens Competition in Math, Science, and Technology. JACOB STEINHARDT of Vienna, Virginia, received a US$40,000 scholarship for his project, "Cayley Graphs Formed by Conjugate Generating Sets of S_n". Steinhardt is a senior at Thomas Jefferson High School for Science and Technology in Alexandria, Virginia. His mathematics project on algebraic graph theory can potentially help build custom-designed, highly efficient computer networks. He was mentored by John C. Dell, a physics teacher at Jefferson High School. Steinhardt is a member of the Boy Scouts of America, the senior computer team, and the varsity math and physics teams. He was also a winner in the 2007 U.S.A. Mathematics Olympiad. His hobbies include playing bridge, chess, soccer, and piano. He plans to study mathematics and to become a math professor.

AYON SEN of Austin, Texas, received a US$30,000 scholarship for his project, "Dissipation of Geostrophic Oceanic Flows by Quadratic Bottom Boundary Layer Drag". Sen is a senior at Westwood High School in Austin. His project studied the energy of geostrophic motions in the ocean that is dissipated by a variety of mechanisms, one of which is quadratic boundary layer drag at the ocean floor. He was mentored by Brian K. Arbic and Robert B. Scott of the Jackson School of Geosciences of the University of Texas. Sen is a member of Mu Alpha Theta, Junior Statesmen of America, and University Interscholastic League (UIL) Math. He enjoys playing the piano and violin and loves to read modernist/surrealist fiction. He won first place in both the Debose National Piano Competition, Solo Division, in 2006 and the U.S. International Duo Piano Competition in 2007. He speaks Bengali and Spanish fluently. He plans to study mathematics or physics and would like to become a professor of mathematics.

ALEXANDER C. HUANG of Plano, Texas, received a US$10,000 scholarship for his project, "Mathematical Modeling of a Eukaryotic Circadian Clock". Huang is a senior at Plano Senior High School. His biophysics research utilizes circadian-clock rhythms in bread mold to assist in the understanding of various biological cycles of living organisms and could ultimately produce better timing in chemotherapy delivery to the body. He was mentored by Karen Shepherd of Plano Senior High School, Yi Liu of the University of Texas Southwestern Medical Center, and Richard Haberman and Thomas Carr of Southern Methodist University. Huang is a member of the Academic Decathlon A-team and president of the Math Club. This year he was a national finalist in the U.S. National Chemistry Olympiad. He also volunteers at the Plano City Juvenile Court with the lead prosecutor. He is an accomplished musician who plays the violin and viola, and he speaks fluent Mandarin. He plans to study chemical engineering and would like to become a research scientist or a doctor.

—Elaine Kehoe

Mathematics Opportunities

NSF Support for Undergraduate Training in Biological and Mathematical Sciences

The National Science Foundation (NSF) offers opportunities for support through its Undergraduate Biology and Mathematics (UBM) program. The goal of the program is to enhance undergraduate education and training at the intersection of the biological and mathematical sciences and to better prepare undergraduate biology or mathematics students to pursue graduate study and careers in fields that integrate the mathematical and biological sciences.

The program will provide support for jointly conducted long-term research experiences for interdisciplinary balanced teams of at least two undergraduates from departments in the biological and the mathematical sciences. Projects should focus on research at the intersection of the mathematical and biological sciences and should provide students exposure to contemporary mathematics and biology addressed with modern research tools and methods. Projects must involve students from both areas in collaborative research experiences and include joint mentorship by faculty in both fields.

Between six and nine awards are expected to be made in 2008. The deadline for full proposals is **February 21, 2008**. For more information, see `http://www.nsf.gov/pubs/2008/nsf08510/nsf08510.htm`. The UBM program is a joint effort of the Education and Human Resources (EHR), Biological Sciences (BIO), and Mathematical and Physical Sciences (MPS) directorates of the NSF.

—From an NSF announcement

Call for Nominations for TWAS Prizes

The Academy of Sciences for the Developing World (TWAS) prizes will be awarded to individual scientists in developing countries in recognition of outstanding contributions to knowledge. Eight awards are given each year in the fields of mathematics, basic medical sciences, biology, chemistry, physics, agricultural sciences, earth sciences, and engineering sciences. Each award consists of US$10,000 and a plaque. Candidates for the awards must be nationals of developing countries and, as a rule, must be living and working in those countries.

The deadline for nominations for the 2008 prizes is **March 31, 2008**. Nomination forms should be sent to: TWAS Prizes, c/o The Abdus Salam International Centre for Theoretical Physics (ICTP), Strada Costiera 11, 1-34014 Trieste, Italy; fax: 39 040 2240-698. Further information is available on the World Wide Web at `http://www.twas.org/`.

—From a TWAS announcement

For Your Information

Everett Pitcher Lectures

The next series of Everett Pitcher Lectures will be held March 17–19, 2008, on the campus of Lehigh University in Bethlehem, Pennsylvania. The speaker will be Persi Diaconis of Stanford University. The lectures, which are open to the public, are held in honor of Everett Pitcher, who was secretary of the AMS from 1967 until 1988. Pitcher served in the mathematics department at Lehigh University from 1938 until 1978, when he retired as Distinguished Professor of Mathematics. He died in December 2006 at the age of ninety-four. For further information, contact the Everett Pitcher Lecture Series, Department of Mathematics, Lehigh University, Bethlehem, PA, 18015; telephone 610-758-3788; or see the website `http://www.lehigh.edu/~math/pitcher.html`.

—From a Lehigh University announcement

Program Director Positions at NSF

The Division of Mathematical Sciences (DMS) announces a nationwide search for a number of program director positions at the National Science Foundation (NSF).

NSF program directors bear the primary responsibility for carrying out the NSF's overall mission: to support innovative and merit-reviewed activities in basic research and education that contribute to the nation's technical strength, security, and welfare. To discharge this responsibility requires not only knowledge in the appropriate disciplines but also a commitment to high standards, a considerable breadth of interest and receptivity to new ideas, a strong sense of fairness, good judgment, and a high degree of personal integrity.

Applicants should have a Ph.D. or equivalent training in a field of the mathematical sciences, a broad knowledge of one of the relevant disciplinary areas of the DMS, some administrative experience, a knowledge of the general scientific community, skill in written communication and preparation of technical reports, an ability to communicate orally, and several years of successful independent research normally expected of the academic rank of associate professor or higher. Skills in multidisciplinary research are highly desirable.

Qualified individuals who are women, ethnic/racial minorities, and/or persons with disabilities are strongly urged to apply. No person shall be discriminated against on the basis of race, color, religion, sex, national origin, age, or disability in hiring by the National Science Foundation.

Program director positions recruited under this announcement may be filled under one of the following appointment options:

Visiting Scientist Appointment: Appointment to this position will be made under the Excepted Authority of the NSF Act. Visiting scientists are on unpaid leave status from their home institutions and appointed to NSF's payroll as federal employees. NSF withholds Social Security taxes and pays the home institution's contributions to maintain retirement and fringe benefits (i.e., health benefits and life insurance) either directly to the home institution or to the carrier. Appointments are usually made for up to one year and may be extended for an additional year by mutual agreement.

Intergovernmental Personnel Act (IPA) Assignment: Individuals eligible for an IPA assignment with a federal agency include employees of state and local government agencies or institutions of higher education, Indian tribal governments, and other eligible organizations in instances in which such assignments would be of mutual benefit to the organizations involved. Initial assignments under IPA provisions may be made for a period of up to two years, with a possible extension for up to an additional two-year period. The individual remains an employee of the home institution, and NSF provides funding toward the assignee's salary and benefits. Initial IPA assignments are made for a one-year period and may be extended by mutual agreement.

Temporary Excepted Service Appointment: Appointment to this position will be made under the Excepted Authority of the NSF Act. Candidates who do not have civil service status or reinstatement eligibility will not obtain civil service status if selected. Candidates currently in the competitive service will be required to waive competitive civil service rights if selected. Usual civil service benefits (retirement, health benefits, life insurance) are applicable for appointments of more than one year. Temporary appointments may not exceed three years.

For additional information on NSF's rotational programs, see "Programs for Scientists, Engineers and Educators" on the NSF website at `http://www.nsf.gov/about/career_opps`.

Applicants should send a letter of interest and vita (preferably via email) to Deborah F. Lockhart, Executive Officer, Division of Mathematical Sciences, National Science Foundation, 4201 Wilson Boulevard, Suite 1025, Arlington, Virginia 22230; phone: 703-292-4858; fax: 703-292-9032; email: `dlockhar@nsf.gov`.

NSF is an Equal Opportunity Employer committed to employing a highly qualified staff that reflects the diversity of our nation. This announcement can also be found at `http://www.nsf.gov/publications/pub_summ.jsp?ods_key=dms0601`.

—DMS announcement

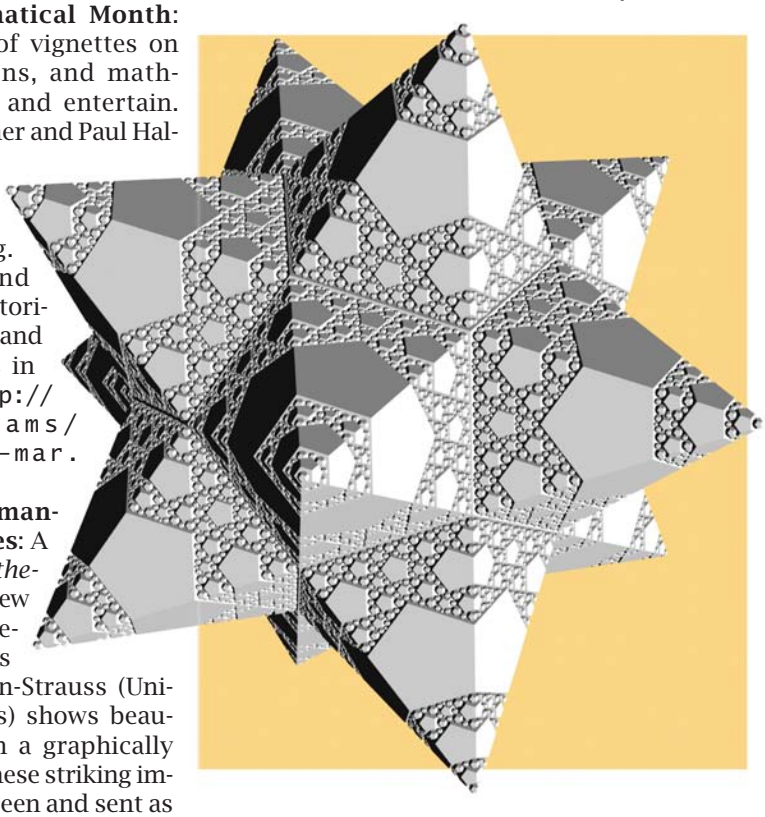
Inside the AMS

From the AMS Public Awareness Office

Recent developments and highlights from the AMS Public Awareness Office include:

• **Mathematics at the Annual AAAS Meeting.** Read a report about mathematics at the Annual Meeting of the American Association for the Advancement of Science (AAAS) held in Boston, February 15–18, 2008, at http://www.ams.org/ams/aaas2008.html.

• **This Mathematical Month**: Monthly postings of vignettes on people, publications, and mathematics to inform and entertain. March: Emmy Noether and Paul Halmos were born, and the AMS held its first-ever Congressional Briefing. Read anecdotes and descriptions of historical events in March and link to happenings in other months at http://www.ams.org/ams/thismathmonth-mar.html.



• **Chaim Goodman-Strauss: Symmetries**: A new album on *Mathematical Imagery*. A new collection of mathematical illustrations by Chaim Goodman-Strauss (University of Arkansas) shows beautiful symmetries in a graphically rigorous manner. These striking images, which can be seen and sent as e-postcards, are at http://www.ams.org/mathimagery/. (Pictured: "Dodecafoam I", by Chaim Goodman-Strauss, © Chaim Goodman-Strauss.)

• **Math in the Media**: AMS members may be surprised to see how often mathematics appears in the media: reports on research, stories about mathematicians and teachers, articles about applications of mathematics, etc. Our magazine, *Math in the Media*, provides monthly updates on press coverage of mathematics. *Math in the Media* includes "Tony's Take", in which Tony Phillips (Stony Brook University) offers his perspective on items involving mathematics that have appeared in the media, as well as "Math Digest", which provides summaries of media coverage of math. The summaries are written by Mike Breen (AMS), Claudia Clark (writer and editor), Lisa DeKeukelaere (2004 AMS Media Fellow), Annette Emerson (AMS), Brie Finegold (2006 Media Fellow, University of California, Santa Barbara), and Allyn Jackson (AMS, deputy editor of *Notices*); "Math Digest" is edited by Allyn Jackson. *Math in the Media* also includes "Reviews", links to hundreds of reviews of books, plays, and films. *Math in the Media* is freely available at http://www.ams.org/mathmedia/. The AMS Public Awareness Office invites members to send links to math-related articles in their local newspapers and on local radio programs to paoffice@ams.org.

—Annette Emerson and Mike Breen
AMS Public Awareness Officers

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

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

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

February 21, 2008: Full proposals for NSF Undergraduate Biology and Mathematics (UBM) program. See "Mathematics Opportunities" in this issue.

Where to Find It

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

AMS Bylaws—*November 2007, p. 1366*

AMS Email Addresses—*February 2008, p. 274*

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 2007, p. 1178*

Conference Board of the Mathematical Sciences—*September 2007, p. 1019*

IMU Executive Committee—*December 2007, p. 1526*

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

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

National Science Board—*January 2008, p. 69*

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

NRC Board on Mathematical Sciences and Their Applications—*March 2008, p. 401*

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

NSF Mathematical and Physical Sciences Advisory Committee—*February 2008, p. 276*

Program Officers for Federal Funding Agencies—*October 2007, p. 1173 (DoD, DoE); December 2007, p. 1359 (NSF), December 2007, p. 1526 (NSF Mathematics Education)*

Program Officers for NSF Division of Mathematical Sciences—*November 2007, p. 1358*

Stipends for Study and Travel—*September 2007, p. 1022*

February 29, 2008: Applications for the 2008 Summer Program for Women in Mathematics (SPWM2008). Contact the director, Murli M. Gupta, email: mmg@gwu.edu; telephone: 202-994-4857; or visit the program's website at http://www.gwu.edu/~spwm/.

March 1, 2008: Applications for Christine Mirzayan Science and Technology Policy Graduate Fellowship Summer Program. See http://www7.nationalacademies.org/policyfellows; or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 5th Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

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

March 31, 2008: Nominations for prizes of the Academy of Sciences for the Developing World (TWAS). See "Mathematics Opportunities" in this issue.

March 31, 2008: Nominations for 2008 Prize for Achievement in Information-Based Complexity. Contact Joseph Traub at traub@cs.columbia.edu.

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

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

May 1, 2008: Applications for May review for the National Academies Postdoctoral and Senior Research Associateship Programs. See http://www7.nationalacademies.org/rap/index.html or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.

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

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

August 1, 2008: Applications for August review for the National Academies Postdoctoral and Senior Research Associateship Programs. See http://www7.nationalacademies.org/rap/index.html or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.

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

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

November 1, 2008: Applications for November review for the National Academies Postdoctoral and Senior Research Associateship Programs. See http://www7.nationalacademies.org/rap/index.html or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email: rap@nas.edu.

Board on Mathematical Sciences and Their Applications, National Research Council

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

Massoud Amin, University of Minnesota

Tanya Styblo Beder, SB Consulting Corporation

Marsha Berger, New York University

Philip Bernstein, Microsoft Corporation

Patricia Brennan, University of Wisconsin

Gunnar Carlsson, Stanford University

Brenda Dietrich, IBM Thomas J. Watson Research Center

Debra Elkins, Allstate Insurance Company

John Geweke, University of Iowa

Darryll Hendricks, UBS Investment Bank

John E. Hopcroft, Cornell University

Karen Kafadar, University of Colorado, Denver

C. David Levermore, (Chair), University of Maryland

Charles M. Lucas, American International Companies

Jill P. Mesirov, Broad Institute

Andrew Odlyzko, Digital Technology Center

Donald Saari, University of California at Irvine

J. B. Silvers, Case Western Reserve University

George Sugihara, University of California, San Diego

Lai-Sang Young, Courant Institute of Mathematical Sciences

The postal address for BMSA is: Board on Mathematical Sciences and Their Applications, National Academy of Sciences, Room K974, 500 Fifth Street, NW, Washington, DC

20001; telephone: 202-334-2421; fax: 202-334-2422/2101; email: bms@nas.edu; website: http://www7.nationalacademies.org/bms/BMSA_Members.html.

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

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

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

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

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

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

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

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

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

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

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

A Certain Ambiguity: A Mathematical Novel, by Gaurav Suri and Hartosh Singh Bal. Princeton University Press, June 2007. ISBN-13: 978-0-691-12709-5. (Reviewed February 2008.)

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

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

**Does Measurement Measure Up?: How Numbers Reveal and Conceal the Truth*, by John Henshaw. Johns Hopkins University Press, March 2006. ISBN-13: 978-08018-8375-0.

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

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

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

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

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

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

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

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

**The Indian Clerk*, by David Leavitt. Bloomsbury USA, September 2007. ISBN-13: 978-15969-1040-9.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**Perfect Figures: The Lore of Numbers and How We Learned to Count*, by Bunny Crumpacker. Thomas Dunne Books, August 2007. ISBN-13: 978-03123-6005-4.

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

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

The Probability of God: A Simple Calculation That Proves the Ultimate Truth, by Stephen D. Unwin. Three Rivers Press (October 26, 2004). ISBN-13: 978-14000-5478-7. (Reviewed February 2008.)

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

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

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

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

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

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

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

Superior Beings: If They Exist, How Would We Know? Game-Theoretic Implications of Omnipotence, Omniscience, Immortality, and Incomprehensibility, by Steven Brams. Springer, second edition, November 2007. ISBN-13: 978-0-387-48065-7. (Reviewed February 2008.)

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

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

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

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

The Volterra Chronicles: The Life and Times of an Extraordinary Mathematician, by Judith R. Goodstein. AMS, February 2007. ISBN-13: 978-0-821-83969-0. (Reviewed in this issue.)

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

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

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

AMERICAN MATHEMATICAL SOCIETY

Leroy P. Steele Prizes

Call for Nominations

The selection committee for these prizes requests nominations for consideration for the 2009 awards. Further information about the prizes can be found in the November 2007 *Notices*, pp. 1372–1390 (also available at http://www.ams.org/prizes-awards).

Three Leroy P. Steele Prizes are awarded each year in the following categories: (1) the Steele Prize for Lifetime Achievement: for the cumulative influence of the total mathematical work of the recipient, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students; (2) the Steele Prize for Mathematical Exposition: for a book or substantial survey or expository-research paper; and (3) the Steele Prize for Seminal Contribution to Research: for a paper, whether recent or not, that has proved to be of fundamental or lasting importance in its field, or a model of important research. In 2009 the prize for Seminal Contribution to Research will be awarded for a paper in analysis.

Nominations with supporting information should be submitted to the Secretary, Robert J. Daverman, American Mathematical Society, 312D Ayres Hall, University of Tennessee, Knoxville, TN 37996-1330. Include a short description on the work that is the basis of the nomination, including complete bibliographic citations. A curriculum vitae should be included. The nominations will be forwarded by the Secretary to the prize selection committee, which will, as in the past, make final decisions on the awarding of prizes.

Deadline for nominations is March 31, 2008.

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Headlines & Deadlines

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Headlines

Fields Medalists
AMS Prizes and Awards
In Memory Of...
News from Math Institutes
AMS Sectional Meetings
Centennial Fellowships
Reports on Special Events
Annual List of Doctorates
Joint International Meetings
NSF Announcements
Links to News Releases on Mathematics
Math in the Media

&

Deadlines

Calls for Proposals
Meeting Registration Deadlines
Calls for Nominations
Application Deadlines

Twice-a-month email notifications of news, announcements about programs, publications, and events, as well as deadlines for fellowship and grant applications, calls for proposals, and meeting registrations.

AMS members can sign up for the service at

www.ams.org/enews

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Mathematics Calendar

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

March 2008

2–7 **IX International Conference "Approximation and Optimization in the Caribbean"**, Sunrise Beach Hotel, San Andres Island, Colombia. (Jun/Jul 2007, p. 782)

3–6 **The Third International Conference on Mathematical Sciences: ICM2008**, UAE University, Al-Ain, United Arab Emirates. (Jan. 2008, p. 75)

3–7 **IMA Workshop: Organization of Biological Networks**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

6–8 **Workshop on Secondary Teacher Preparation in Mathematics**, Institute for Mathematics and Education, University of Arizona, Tucson, Arizona. (Jan. 2008, p. 75)

* 8–11 **A Student Workshop on Mock Theta Functions**, University of Florida, Gainesville, Florida.
Topics: Combinatorics of Partitions and q-Series, q-Series and Special Functions, and Modular Forms.
Contacts: Sharon Garthwaite (Bucknell) will give the Student Workshop Lectures. Students wishing to attend the workshop or participate in the conference should contact either Krishnaswami Alladi (`alladi@math.ufl.edu`), Alex Berkovich (`alexb@math.ufl.edu`), or Frank Garvan (`frank@math.ufl.edu`). The conference will also include a Special Series of Lectures by Ken Ono (Wisconsin).
Information: `http://www.math.ufl.edu/~alladi/pqsmfconf.html`.

* 8–16 **Partitions, q-Series and Modular Forms Workshop and Conference**, University of Florida, Gainesville, Florida.
Topics: Combinatorics of Partitions and q-Series; q-Series and Special Functions; Modular Forms. A student workshop on Mock Theta Functions will take place March 8–11 and will precede the conference. A series of Lectures will be given by Sharon Garthwaite (Bucknell). The conference will also include a Special Series of Lectures by Ken Ono (Wisconsin).
Information: `http://www.math.ufl.edu/~alladi/pqsmfconf.html`.

9–12 **LUMS 2nd International Conference on Mathematics and its Applications in Information Technology 2008**, Lahore University of Management Sciences (LUMS), Lahore, Pakistan. (Sept. 2007, p. 1073)

10–June 13 **Optimal Transport (Long Program)**, UCLA, Los Angeles, California. (Jun/Jul 2007, p. 983)

11–14 **Optimal Transport Tutorials**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Feb. 2008, p. 305)

12–14 **International Workshop Moduli spaces of Vector Bundles: Algebro-Geometric Aspects**, Universitat de Barcelona, Barcelona, Spain. (Dec. 2007, p. 1532)

12–19 **Advanced Course on Geometric Flows and Hyperbolic Geometry**, Centre de Recerca Matemàtica, Bellaterra, Italy. (Oct. 2007, p. 1190)

13–15 **The 42nd Annual Spring Topology and Dynamical Systems**

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/`.

Conference, The University of Wisconsin Milwaukee, Milwaukee, Wisconsin. (Nov. 2007, p. 1403)

15–16 **AMS Eastern Section Meeting**, Courant Institute of New York University, New York, New York. (Jun/Jul 2007, p. 983)

15–18 **Maryland-Penn State Workshop on Dynamical Systems and Related Topics**, College Park, Maryland. (Jan. 2008, p. 75)

17–19 **DIMACS Workshop on Random Matrices**, DIMACS Center, CoRE Building, Rutgers University, Piscataway, New Jersey 08854-8018. (Jan. 2008, p. 75)

17–21 **Nonlinear PDEs of mixed type arising in mechanics and geometry**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2007, p. 983)

19–21 **The IAENG International Conference on Operations Research 2008**, Regal Kowloon Hotel, Kowloon, Hong Kong. (Jun/Jul 2007, p. 983)

20–22 **Mathematicians in Mathematics Education**, Institute for Mathematics and Education, University of Arizona, Tucson, Arizona. (Jan. 2008, p. 75)

* 24–28 **Classical and Quantum Information Theory**, La Posada de Santa Fe, Santa Fe, New Mexico.
Description: Over half a century ago, it was realized that quantum and statistical field theories are intimately related, both at the formal and physical levels. Quantum critical phenomena provide examples where quantum systems are frequently mapped onto classical systems, while non-equilibrium statistical mechanics provides an example of proceeding in the other direction via stochastic operator techniques. We are now witnessing a similar phenomenon in the areas of classical and quantum information theory, where methods and concepts of mathematical and statistical physics are found to be the common element for seemingly different problems such as quantum and classical spin glasses and quantum and classical error correcting codes. Our workshop will explore and exploit these developments, inviting leading experts to discuss the latest problems and techniques of interest.
Information: `http://cnls.lanl.gov/CQIT`.

25–30 **Spring School: Holomorphic symplectic manifolds and derived categories**, Palazzo Feltrinelli, Gargnano del Garda, Italy. (Jan. 2008, p. 75)

28–29 **The 34th Annual New York State Regional Graduate Mathematics Conference**, Syracuse University, Syracuse, New York. (Nov. 2007, p. 1403)

28–30 **AMS Southeastern Section Meeting**, Louisiana State University, Baton Rouge, Louisiana. (Jun/Jul 2007, p. 983)

* 30–April 5 **2008 Talbot Workshop: Affine Lie Algebras and Chiral Structures**, Plymouth, Massachusetts.
Description: The Talbot workshop will constitute a weeklong retreat, bringing together a small group of graduate students and junior faculty in an informal and collaborative environment to study geometric approaches to representations of affine Kac-Moody Lie algebras using Beilinson and Drinfeld's theory of chiral and factorization algebras.
Focus: A particular focus will be recent work of Gaitsgory and Lurie on the derived geometric Satake equivalence and a quantum formulation of the geometric Langlands conjecture.
Plenary Speaker: Dennis Gaitsgory.
Information: For more information about participating in the workshop, email Owen Gwilliam (`gwilliam@math.northwestern.edu`); `http://www-math.mit.edu/~jnkf/talbot`.

31–April 2 **SIAM International Conference on Numerical Combustion (NC08)**, Portola Plaza at Monterey Bay, Monterey, California. (Sept. 2007, p. 1074)

31–April 4 **Applications of universal algebra and logic to the constraint satisfaction problem**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2007, p. 783)

31–April 4 **Aspects of Optimal Transport in Geometry and Calculus of Variations**, Institute for Pure and Applied Mathematics, UCLA, Los Angeles, California. (Dec. 2007, p. 1533)

31–April 5 **International Workshop on Multi-Rate Processes and Hysteresis MURPHYS2008**, University College Cork, Cork, Ireland. (Nov. 2007, p. 1404)

April 2008

3–4 **Logic and the Simulation of Interaction and Reasoning (Symposium at the AISB 2008 Convention "Communication, Interaction and Social Intelligence")**, Aberdeen, Scotland. (Feb. 2008, p. 305)

4–6 **AMS Central Section Meeting**, Indiana University, Bloomington, Indiana. (Jun/Jul 2007, p. 783)

* 4–6 **Eleventh New Mexico Analysis Seminar: Mathematical models and analysis of liquid crystals and gels**, New Mexico State University, Las Cruces, New Mexico.
Keynote Speaker: Maria-Carme Calderer (University of Minnesota).
Supporting Speakers: Dmitry Golovaty (The University of Akron), Ming Chen (University of Minnesota).
Organizers: Cristina Pereyra (UNM), Tizian Giorgi, Joe Lakey, Robert Smits, Adam Sikora (NMSU)
Information: Time will be allocated for 20-minute contributed talks in all areas of analysis and applied mathematics. Partial travel support is available for attendees through an NSF grant; priority will be given to graduate students, postdoctoral fellows and junior faculty. Women and other underrepresented groups are especially encouraged to apply. The lectures intend to provide an overview of the field, and therefore of particular interest to people interested in working in the research area. Visit `http://www.math.nmsu.edu/~tgiorgi/nmas08/`.

7–8 **DIMACS Workshop on Climate and Disease**, DIMACS Center, CoRE Building, Rutgers University, Piscataway, New Jersey. (Feb. 2008, p. 305)

7–11 **Workshop on Spectrum and Dynamics**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 75)

10–12 **Partial Differential Equations in Conformal Geometry**, University of Arkansas, Fayetteville, Arkansas. (Jan. 2008, p. 75)

11–13 **The Eleventh Rivière-Fabes Symposium on Analysis and PDE**, University of Minnesota, Minneapolis, Minnesota. (Nov. 2007, p. 1404)

12–13 **MIT Women in Math**, Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts 02139. (Jan. 2008, p. 75)

14–18 **Numerics and Dynamics for Optimal Transport**, Institute for Pure and Applied Mathematics, UCLA, Los Angeles, California. (Dec. 2007, p. 1533)

16–27 **Workshop on Geometric Evolution Equations**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 76)

17–18 **IMA Workshop: Network Dynamics and Cell Physiology**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

20–25 **The International Conference on Group and Related Topics**, Xuzhou Normal University, Xuzhou, P. R. China. (Feb. 2008, p. 305)

21–25 **IMA Workshop: Design Principles in Biological Systems**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

24–26 **SIAM International Conference on Data Mining**, Hyatt Regency Hotel, Atlanta, Georgia. (Oct. 2007, p. 1190)

*25 **International Assessment of Research and Development in Simulation-based Engineering and Science (SBE&S)**, NSF, 4201 Wilson Boulevard, Arlington, VA, Room 375 (Stafford I).
Description: Learn about the current directions in Simulation-Based Engineering and Science (SBE&S)from a panel of experts who have completed a study initiated by the United States National Science Foundation (NSF) and other U.S. government agencies to examine the worldwide status and trends in this field. This FREE workshop will be held from 8:30am–4:00pm. Registration is required due to seating capacity and NSF security requirements.
Information: http://www.wtec.org/sbes/.

*28–30 **SCC 2008: First International Conference on Symbolic Computation and Cryptography**, Beijing, China.
Description: SCC 2008 is the first of a new series of conferences where research and development in symbolic computation and cryptography may be presented and discussed. It is organized in response to the growing interest in applying and developing methods, techniques, and software tools of symbolic computation for cryptography.
Invited Speakers: Bruno Buchberger (Johannes Kepler Universitaet Linz, Austria); Arjen K. Lenstra (Ecole Polytechnique Federale de Lausanne, Switzerland). To be confirmed: Adi Shamir (Weizmann Institute of Science, Israel); Xiaoyun Wang (Tsinghua University and Shandong University, China).
Important Dates: Deadline for extended abstract submission: February 17, 2008. Notification of acceptance or rejection: March 16, 2008. Conference taking place: April 28-30, 2008. Deadline for full paper submission: June 30, 2008.
Information: http://www.cc4cm.org/scc2008.

28–May 9 **NATO Advanced Study Institute, New Challenges in Digital Communications**, Vlora, Albania. (Sept. 2007, p. 1074)

May 2008

2–4 **CSMC International Curriculum Conference: Future Curricular Trends in School Algebra and Geometry**, The University of Chicago and The Field Museum, Chicago, Illinois. (Jan. 2008, p. 76)

3–4 **AMS Western Section Meeting**, Claremont McKenna College, Claremont, California. (Jun/Jul 2007, p. 783)

5–9 **Percolation on transitive graphs**, American Institute of Mathematics, Palo Alto, California.

5–9 **Topics in PDEs and Applications 2008**, Universitat Politènica de Catalunya, Barcelona, Spain. (Dec. 2007, p. 1533)

5–9 **Transport Systems in Geography, Geosciences, and Networks**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2008, p. 76)

5–June 27 **Mathematical Imaging and Digital Media**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Nov. 2007, p. 1404)

10–13 **SIAM Conference on Optimization**, Boston Park Plaza Hotel and Towers, Boston, Massachusetts. (Oct. 2007, p. 1190)

11–12 **Clay Research Conference 2008**, MIT, Cambridge, Massachusetts. (Feb. 2008, p. 305)

11–14 **SIAM Conference on Mathematical Aspects of Materials Science (MS08)**, Doubletree Hotel Philadelphia, Philadelphia, Pennsylvania. (Sept. 2007, p. 1074)

11–16 **CHT-08: Advances in Computational Heat Transfer**, Kenzi Farah Hotel, Marrakech, Morocco. (Jun/Jul 2007, p. 783)

12–16 **Ferroelectric Phenomena in Soft Matter Systems**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2007, p. 783)

12–16 **Singularities, Hamiltonian and Gradient Flows**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 76)

13–17 **Spectral geometry and related topics**, University of Potsdam, Germany. (Nov. 2007, p. 1404)

15–17 **GESTA 2008**, Universitat Politènica de Catalunya, Barcelona, Spain. (Dec. 2007, p. 1533)

15–17 **Twelfth International Conference Devoted to the Memory of Academician Mykhailo Kravchuk (Krawtchouk) (1892–1942)**, Kyiv, Ukraine. (Jun/Jul 2007, p. 783)

*16–18 **International Conference on Interdisciplinary Mathematical and Statistical Techniques**, Department of Mathematical Sciences, The University of Memphis, Memphis, Tennessee.
Description: Department of Mathematical Sciences, University of Memphis will be hosting the 16th annual conference of the Forum for Interdisciplinary Mathematics (FIM) titled "International Conference on Interdisciplinary Mathematical & Statistical Techniques" May 16–18, 2008 (Friday to Sunday).
Focus: The academic activities of the conference will primarily focus on the following areas of mathematical and statistical sciences: combinatorics, functional analysis, ergodic theory, partial differential equations, graph theory, number theory, Bayesian statistics, bioinformatics, biostatistics, design and analysis of experiments and multivariate analysis.
Information: We are expecting participation of around 250 leading researchers in Mathematics and Statistics from all over the world. The website of conference is: http://www.msci.memphis.edu/IMST2008-FIMXVI/.

16–18 **PhiMSAMP-3: "Is Mathematics Special"**, Universität Wien, Vienna, Austria. (Feb. 2008, p. 305)

18–21 **The 7th AIMS International Conference on Dynamical Systems, Differential Equations and Applications**, University of Texas at Arlington, Arlington, Texas. (May 2007, p. 666)

19–23 **Optimal Transport in the Human Body: Lungs and Blood**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2007, p. 1533)

19–24 **Lie Theory and Geometry: The Mathematical Legacy of Bertram Kostant**, Pacific Institute of Mathematical Sciences, Vancouver, Canada. (Nov. 2007, p. 1404)

19–24 **Workshop on Floer Theory and Symplectic Dynamics**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 76)

*21–23 **First Buea International Conference on the Mathematical Sciences**, University of Buea, Cameroon.
Description: The Department of Mathematics at the University of Buea, Cameroon, is organizing its first International Conference on Mathematical Sciences, with the aim of bringing together academicians and professionals with cross-disciplinary interests related to Mathematical Sciences, to demonstrate the vital role that mathematics plays in society, and to bridge as well as nuture understanding and collaboration between global and Cameroon regional mathematical scientists and practictioners.
Information: http://www.bueaconference.com.

26–30 **Congrès à la mémoire d'Adrien Douady**, Institute of Henri Poincaré, Paris, France. (Feb. 2008, p. 305)

26–30 **Discrete Groups and Geometric Structures, with Applications III**, K. U. Leuven Campus, Kortrijk, Belgium. (Jan. 2008, p. 76)

26–30 **ICCA8: 8th International Conference on Clifford Algebras and their Applications in Mathematical Physics**, UNICAMP, Campinas, Brazil. (Nov. 2007, p. 1404)

26–30 **IMA Workshop: Quantitative Approaches to Cell Motility and Chemotaxis**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

26–30 **Spring school in nonlinear partial differential equations**, Université catholique de louvain, Louvain-La-Neuve, Belgium. (Sept. 2007, p. 1074)

26–30 **The International Conferences: Inverse Problems: Modeling and Simulation**, Oludeniz–Fethiye, Turkey. (Dec. 2007, p. 1534)

*26–June 7 **International Conference "Analysis and Topology, Lviv -2008"**, Ivan Franko National University of Lviv, Ukraine.
Description: The conference will consist of two relatively independent parts: the first one May 26–31) is devoted to Complex Analysis and the second (June 2–7) to Topology and Topological Algebra.
Information: http://www.franko.lviv.ua/faculty/mechmat/Departments/conf/conf2008.html.

29–31 **Brownian Motion and Random Walks in Mathematics and in Physics**, Institut de Recherche Mathématique Avancée (Université Louis Pasteur), Strasbourg, France. (Dec. 2007, p. 1534)

June 2008

2–7 **Workshop on Mathematical Aspects of Quantum Chaos**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 76)

3–6 **Chaotic Modeling and Simulation International Conference (CHAOS2008)**, MAICh (Mediterranean Agronomic Institute of Chania) Conference Centre, Chania, Crete, Greece. (Feb. 2008, p. 306)

4–7 **First Joint International Meeting with the Sociedade Brasileira de Matematica**, Instituto Nacional de Matematica Pura e Aplicada (IMPA), Rio de Janeiro, Brazil. (Jun/Jul 2007, p. 784)

6–10 **International Conference on Discrete Mathematics-ICDM 2008**, University of Mysore, Mysore, India. (Dec. 2007, p. 1534)

*6–11 **Tenth International Conference on Geometry, Integrability and Quantization**, Varna, Bulgaria.
Description: This conference can be considered a continuation of previous meetings on Geometry and Mathematical Physics which took place in Bulgaria - Zlatograd (1995) and Varna (1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007). "Geometry" in the title refers to modern differential geometry of real and complex manifolds with some emphasis on curves, sigma models and minimal surface theory; "Integrability" to either the integrability of complex structures or classical dynamical systems of particles, soliton dynamics and hydrodynamical flows presented in geometrical form; and "Quantization" to the transition from classical to quantum mechanics expressed in geometrical terms.
Aim: The overall aim is to bring together experts in Classical and Modern Differential Geometry, Complex Analysis, Mathematical Physics and related fields to assess recent developments in these areas and to stimulate research in related topics.
Organizer: Ivaïlo M. Mladenov (Sofia), Gaetano Vilasi (Salerno) and Akira Yoshioka (Tokyo).
Information: http://www.bio21.bas.bg/conference/.

8–14 **34th International Conference "Applications of Mathematics in Engineering and Economics" (AMEE'08)**, The Black Sea resort of Sozopol, Bulgaria. (Feb. 2008, p. 306)

9–12 **International Cryptology Workshop and Conference 2008 (Cryptology2008)**, Putra World Trade Center (PWTC), Kuala Lumpur, Malaysia. (Jan. 2008, p. 76)

9–13 **Free Boundary Problems, Theory and Applications, 2008**, KTH, Stockholm, Sweden. (Dec. 2007, p. 1534)

9–13 **FVCA5 5th International Symposium on Finite Volumes for Complex Applications Problems and Perspectives**, Aussois, Savoiee, France. (Dec. 2007, p. 1534)

9–13 **12th International Conference on Hyperbolic Problems: Theory, Numerics, Applications**, University of Maryland, College Park, Maryland. (Jun/Jul 2007, p. 784)

9–19 **Advances in Set-Theoretic Topology: Conference in Honour of Tsugunori Nogura on his 60th Birthday**, Centre for Scientific Culture "Ettore Majorana", Erice, Sicily, Italy. (Jun/Jul 2007, p. 784)

9–20 **Parallel Numerical Methods for Partial Differential Equations**, University of Wyoming, Laramie, Wyoming. (Dec. 2007, p. 1534)

10–14 **Summer Symposium in Real Analysis XXXII**, Chicago State University, Chicago, Illinois. (Feb. 2008, p. 306)

15–28 **Aspects of Moduli**, de Giorgi Center; Scuola Normale Superiore, Pisa, Italy. (Feb. 2008, p. 306)

16–19 **SIAM Conference on Discrete Mathematics**, University of Vermont, Burlington, Vermont. (Jan. 2008, p. 76)

*16–20 **Conference on vector bundles in honour of S. Ramanan (on the occasion of his 70th birthday)**, Miraflores de la Sierra, Madrid, Spain.
Description: This conference is devoted to the broad area of research interests of Professor S. Ramanan (Chennai Mathematical Institute, India) in celebration of his 70th birthday.
Speakers: Sir Michael Atiyah* (Univ Edinburgh), V. Balaji (CMI, Chennai), A. Beauville (Univ Nice), D. Ben-Zvi (UT Austin), U. Bhosle (TIFR, Mumbai), R. Donagi (Univ Pennsylvania), E. Frenkel (UC Berkeley), N. Hitchin (Univ Oxford), K. Hulek (Leibniz Univ Hannover), J.-M. Hwang (KIAS, Seoul), J. N. Iyer (IMS, Chennai), S. Kumar (UNC Chapel Hill), M. S. Narasimhan (TIFR, Bangalore), N. Nitsure (TIFR, Mumbai), M. V. Nori (Univ Chicago), C. Pauly (Univ Montpellier 2), M. S. Raghunathan (TIFR, Mumbai), T. R. Ramadas (ICTP, Trieste), C. S. Seshadri (CMI, Chennai), C. Simpson (Univ Nice).
* To be confirmed.
Deadline to register: February 29, 2008.
Information: For on-line registration and updated information, please visit the website: http://www.mat.csic.es/webpages/moduli2008/ramanan/.

*16–21 **International Scientific Conference: "Differential Equations, Theory of Functions and their Applications" dedicated to 70th birthday of academician of NAS of Ukraine A. M. Samoilenko**, Tavriyskiy State Agrotechnological Universit, Melitopol, Ukraine.
Description: Plenary and sectional reports will be presented. Abstracts of reports will be published by beginning of the work of the Conference. Materials of plenary reports recommended by Organizing Committee will be published in "Ukrainian Mathematical Journal" or "Nonlinear Oscillations".
Topics: Qualitative and asymptotic methods in the theory of ordinary differential equations; Theory of functions of real and complex variable; Differential-functional, impulsive and stochastic equations; Approximation theory; Partial differential equations; Applied problems of theory.
Languages: Ukrainian, English, and Russian.
Information: All materials should be sent to Organizing Committee address: Institute of Mathematics of NAS of Ukraine, Tereshchenkivska Str., 3, Kyiv, 01004, Ukraine, Phone: (38044)2346526; email: conf2008@imath.kiev.ua. http://www.imath.kiev.ua/~funct/conf2008/.

16–22 **CRM-CIM Workshop GAP VI: Workshop on Geometry and Physics**, Universitat Politènica de Catalunya, Barcelona, Spain. (Dec. 2007, p. 1535)

17–20 **4th Croatian Mathematical Congress**, Department of Mathematics, University of Osijek, Osijek, Croatia. (Jun/Jul 2007, p. 784)

17–22 **Differential Equations and Topology**, Lomonosov Moscow State University, Moscow, Russia. (Nov. 2007, p. 1404)

18–21 **Conference on Algebra and its Applications, in honor of S. K. Jain's 70th birthday**, Ohio University, Athens, Ohio. (Nov. 2007, p. 1404)

*20–21 **Financial & Economic Engineering Symposium**, National School of Applied Sciences, Agadir, Morocco.
Description: Engineering, for long associated with technical problems, is in the middle of economy and finance today. Indeed, in front of the complexity of the economic behaviour problems and the diversity of the financial tools, important and concrete questions in economy, finance and organisation require a mathematical modelling of the phenomena and powerful tools for the implementation of the action policies.
Information: Contact: bouzahir@ensa-agadir.ac.ma or/and fees-2k8@ensa-agadir.ac.ma; http://www.ensa-agadir.ac.ma.

*22–27 **2008 USENIX Annual Technical Conference (USENIX '08)**, Sheraton Boston Hotel, 39 Dalton Street, Boston, Massachusetts
Description: The USENIX Annual Technical Conference has always been the place to present groundbreaking research and cutting-edge practices in a wide variety of technologies and environments and 2008 is no exception. There will be an extensive Training Program and Technical Sessions, featuring the Refereed Papers Track, Invited Talks, and a Poster Session. Join the community of programmers, developers, and systems professionals in sharing solutions and fresh ideas.
Information: http://www.usenix.org/events/usenix08/.

22–August 22 **Research in Industrial Projects for Students (RIPS)**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Feb. 2008, p. 306)

22–28 **Combinatorics 2008**, Costermano, Verona, Italy. (Sept. 2007, p. 1075)

22–28 **Symmetries and Integrability of Difference Equations/ SIDE8**, SIDE 8 will take place at Hotel Mont-Gabriel, in Ste-Adèle, Québec, Canada. (The Laurentian area near Montréal). (Jan. 2008, p. 76)

22–29 **46th International Symposium on Functional Equations**, Opava–Hradec and Moravici, Czech Republic. (Jan. 2008, p. 77)

23–27 **Conference on Differential and Difference Equations and Applications 2008(CDDEA 2008)**, Strečno (close to Žilina), Slovak Republic. (Feb. 2008, p. 306)

*23–27 **20th International Conference on "Formal Power Series and Algebraic Combinatorics"**, Valparaiso, Chile.
Information: http://inst-mat.utalca.cl/fpsac2008/.
Topics: All aspects of combinatorics and their relations with other parts of mathematics, physics, computer science, and biology. Conference Contents: Invited lectures, contributed presentations, poster session, problem session and software demonstrations. As usual, there will be no parallel sessions.
Invited Speakers: Marcelo Aguíar, Michael Albert, Jonathan Brundan, Dmitry Feichtner-Kozlov, Ian Grojnowski, Barry McCoy, Alexander Postnikov, María Ronco, Carla Savage.
Organizing Committee: Federico Ardila, Hélène Barcelo, María Ines Icaza, Christian Krattenthaler, Luc Lapointe, Jennifer Morse.

23–27 **Hermitian Symmetric Spaces, Jordan Algebras and Related Problems**, CIRM Luminy, Marseille, France. (Jun/Jul 2007, p. 784)

23–27 **Homotopical Group Theory and Topological Algebraic Geometry**, Max Planck Institute for Mathematics, Bonn, Germany. (Oct. 2007, p. 1190)

*23–27 **Workshop on Geometric Analysis, Elasticity, and PDE on the 60th Birthday of John Ball**, Maxwell Institute and Department of Mathematics, Heriot-Watt University, Edinburgh, Scotland.
Description: The workshop will concentrate on modern aspects of PDE using analytical and geometric methods, with applications to continuum mechanics, especially nonlinear elasticity and the structure of materials. The speakers at the workshop are of the highest international calibre, ranging from two Fields Medalists to outstanding young researchers.
Information: http://www.icms.org.uk/workshops/pde.

*23–28 **2008 Stochastic Networks Conference**, Ecole Normale Supérieure, Paris, France.
Description: Continuing a tradition of similar meetings held at irregular intervals over the last 20 years, this conference will bring together mathematicians and applied researchers who share an interest in stochastic network models. Like its predecessors, the 2008 Stochastic Networks Conference will emphasize new stochastic network models structures and new mathematical problems that are motivated by contemporary developments in wireless networks, Internet, biology, manufacturing, etc. There will be roughly twenty invited talks over a six-day period, with plenty of time in the interstices for informal discussions. In addition, there will be a poster session for contributed papers. Please visit the web site for the program of invited talks and for any information about this event.
Information: http://www.liafa.jussieu.fr/~gmerlet/StochasticNetworks/.

23–28 **Conference on Moment Maps**, Universitat Politènica de Catalunya, Barcelona, Spain. (Dec. 2007, p. 1535)

23–July 18 **Clay Mathematics Institute 2008 Summer School on Evolution Equations**, Swiss Federal Institute of Technology, ETH-Zurich, Switzerland. (Jan. 2008, p. 77)

*24–28 **Analysis and Geometry in Several Complex Variables**, Mathematics Institute of Romanian Academy (IMAR), Bucharest, Romania.
Description: Our intention is to bring together leading specialists and young researchers working in the following areas: Complex Analysis in Several Complex Variables and Applications, Complex Analytic and Algebraic Geometry, L2 estimates, Holomorphic Dynamics, Holomorphic Convexity. Scientific Committee: G. M. Henkin (Paris), Y.-T. Siu (Harvard).
Confirmed speakers: P. de Bartolomeis (Florence), F. Campana (Nancy), M. Coltoiu (Bucharest), D. Coman (Syracuse), J.-P. Demailly (Grenoble), K. Diederich (Wuppertal), T.-C. Dinh (Paris), J.E. Fornaess (Michigan), G.M. Henkin (Paris), J. Leiterer (Berlin), L. Lempert (Purdue), G. Marinescu (Frankfurt), N. Mok (Honk Kong), J. Noguchi (Tokyo), T. Ohsawa (Nagoya), M. Paun (Nancy), T. Peternell (Bayreuth), N. Sibony (Paris), Y.-T. Siu (Harvard), C. Voisin (Paris).
Organizing Committee: V. Brinzanescu (Bucharest), A. Iordan (Paris), C. Joita (Bucharest).
Information: http://www.imar.ro/~cjoita/scv2008.html.

25–27 **ICNPAA 2008: Mathematical Problems in Engineering, Aerospace and Sciences [Theory, Methods (includes Experimental, Computational) and Applications]**, University of Genoa, Italy. (Jun/Jul 2007, p. 784)

29–July 4 **IWASAWA 2008**, Kloster Irsee, Germany. (Jun/Jul 2007, p. 784)

30–July 3 **Analysis, PDEs and Applications. On the occasion of the 70th birthday of Vladimir Maz'ya**, INDAM (Istituto Nazionale di Alta Matematcia "Francesco Severi") - Università degli Studi di Roma "La Sapienza", Roma, Italy. (Dec. 2007, p. 1535)

30–July 3 **10th International Conference on P-Adic and Non-Archimedean Analysis**, Michigan State University, East Lansing, Michigan. (Jan. 2008, p. 77)

30–July 4 **ICMI/IASE Study: Statistics Education in School Mathematics: Challenges for Teaching and Teacher Education**, ITESM, Monterrey, Mexico. (Dec. 2006, p. 1381)

30–July 5 **HOCAT 2008: Homotopy Structures in Geometry and Algebra; Derived Categories, Higher Categories**, Universitat Politènica de Catalunya, Barcelona, Spain. (Dec. 2007, p. 1535)

30–July 5 **Workshop on Integrable Quantum Systems and Solvable Statistical Mechanical Models**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 77)

* 30–July 25 **UA VIGRE: Arizona Summer Program 2008 on Computational Group Theory**, Department of Mathematics, University of Arizona, Tucson, Arizona.
Description: The 2008 Arizona Summer Program will be an exciting 4-week research experience for undergraduates interested in Computational Group Theory and its applications. There will be several lecture series given by experts covering the various areas of computational group theory accompanied by hands-on lab sessions using the Computer Algebra system GAP. Students will work in teams of 3 or 4 on projects inspired by current problems in the area of computational group theory and its applications.
Information: http://math.arizona.edu/~klux/2008Info.html.

July 2008

2–4 **The 2008 International Conference of Applied and Engineering Mathematics (ICAEM 2008)**, Imperial College London, London, United Kingdom. (Nov. 2007, p. 1404)

2–11 **S3CM: Soria Summer School on Computational Mathematics: "Algebraic Coding Theory"**, Campus "Duques de Soria", Universidad de Valladolid, Soria, Spain. (Feb. 2008, p. 306)

3–5 **8th Conference on Logic and the Foundations of Game and Decision Theory (LOFT 2008)**, Universiteit van Amsterdam, Amsterdam, The Netherlands. (Feb. 2008, p. 306)

3–8 **22nd International Conference on Operator Theory**, West University of Timisoara, Timisoara, Romania. (Jan. 2008, p. 77)

6–19 **38th International Probability Summer School**, Saint-Flour, France. (Feb. 2008, p. 306)

* 7–9 **I Latin-American Workshop on Optimization and Control**, Escuela Politécnica Nacional, Quito, Ecuador.
Description: The first Latin American Workshop on Optimization and Control will take place in Quito, Ecuador, from the 7th to the 9th of July 2008. The event will host leading latin american researchers in the areas of optimization and control. Invited talks from outstanding international scientists and contributing presentations will be held. One aim of the workshop is to present latin american scientific contributions to these areas of knowledge and enhance the scientific collaboration among the participants.
Information: http://www.math.epn.edu.ec/workshop/eng/.

7–9 **SIAM Conference on Imaging Science (IS08)**, Town & Country Resort and Convention Center, San Diego, California. (Nov. 2007, p. 1405)

7–10 **The 2008 International Conference on Bioinformatics, Computational Biology, Genomics and Chemoinformatics (BCBGC-08)**, Orlando, Florida. (Jan. 2008, p. 77)

7–11 **Poisson 2008: Poisson Geometry in Mathematics and Physics**, Centre Interfacultaire Bernoulli (CIB) EPFL École Polytechnique Fédérale de Lausanne, Switzerland. (Jan. 2008, p. 77)

7–11 **Spring Meeting of the Swiss Mathematical Society: Conference on Complex Analysis 2008–In honour of Linda Rothschild**, University of Fribourg, Switzerland. (Nov. 2007, p. 1405)

7–11 **VIII International Colloquium on Differential Geometry (E. Vidal Abascal Centennial Congress)** (Sept. 2007, p. 1076), Santiago de Compostela, Spain.

7–12 **Conference on "Modules and Representation Theory"**, Babes-bolyai University, Cluj-napoca, Romania. (Jan. 2008, p. 77)

* 8–11 **Algebraic Aspects of Association Schemes and Scheme Rings**, University of Regina, Regina, Saskatchewan, Canada.
Description: The main objective of this conference is to bring together researchers who study association schemes and scheme rings from both the representation-theoretic and combinatorial perspectives.
Information: http://www.math.uregina.ca/~schemes.

* 8–11 **Riemannian Geometry and Applications—RIGA 2008**, University Transilvania of Brasov, Brasov, Romania.
Description: Dedicated to Bang-Yen Chen (Michigan State University) on his 65th birthday.
Organizing Committee: Ion Mihai, Emil Stoica, Gh. Munteanu, Bogdan Suceava, Adela Mihai, Valentin Ghisoiu.
Scientific Committee (preliminary): Radu Miron, Leopold Verstraelen, Stere Ianus, Gheorghe Pitis.
Information: http://www.unitbv.ro.

9–13 **NSF-CBMS Conference: Knots and Topological Quantum Computing**, University of Central Oklahoma, Edmond, Oklahoma. (Feb. 2008, p. 307)

13–16 **CTAC08: The 14th Biennial Computational Techniques and Applications Conference**, Australian National University, Canberra, ACT, Australia. (Nov. 2007, p. 1405)

14–17 **Random Matrix Theory and Wireless Communication**, Boulder, Colorado. (Dec. 2007, p. 1535)

14–18 **5th European Congress of Mathematics**, Amsterdam, the Netherlands. (Feb. 2007, p. 308)

14–18 **Efficient Monte Carlo: From Variance Reduction to Combinatorial Optimization. A Conference on the Occasion of R. Y. Rubinstein's 70th Birthday**, Sandbjerg Estate, Sønderborg, Denmark. (Feb. 2008, p. 307)

14–25 **IPAM/CCB Summer School: Mathematics in Brain Imaging**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Feb. 2008, p. 307)

14–December 19 **Mathematics and Physics of Anderson Localization: 50 Years After**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Jun/Jul. 2006, p. 714)

16–18 **60 Miles: A meeting to celebrate Miles Reid's sixtieth birthday**, LMS and University College, London, United Kingdom. (Jan. 2008, p. 77)

21–25 **Fourteenth International Conference of Difference Equations and Applications**, Besiktas Campus of Bahcesehir University on the European shore of the Bosporus in Istanbul, Turkey. (Feb. 2008, p. 307)

* 21–25 **Operator Structures and Dynamical Systems**, Lorentz Center, Leiden, The Netherlands.
Description: This conference is an official satellite of the Fifth European Congress of Mathematics in Amsterdam in the preceding week. The theme is the relationship between dynamical systems (topological as well as abstract) and associated operator structures in a broad sense. We intend to cover the hotel costs for invited participants, hence people interested should contact Marcel de Jeu first before registering. Young researchers are especially encouraged to participate.
Information: http://www.lorentzcenter.nl/lc/web/2008/288/info.php3?wsid=288.

22–26 **International Workshop on Operator Theory and its Applications (IWOTA)**, College of William and Mary, Williamsburg, Virginia. (Feb. 2007, p. 308)

22–26 **Noncommutative Structures in Mathematics and Physics**, Brussels, Belgium. (Dec. 2007, p. 1535)

24–26 **Current Trends and Challenges in Model Selection and Related Areas**, University of Vienna, Vienna, Austria. (Dec. 2007, p. 1535)

August 2008

4 **Workshop on Stochastic Loewner Evolution and Scaling Limits**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 77)

4–7 **SIAM Conference on the Life Sciences**, Hyatt Regency Montreal, Montreal, Quebec, Canada. (Jan. 2008, p. 78)

4–15 **20th European Summer School for Logic, Language and Information (ESSLLI 2008)**, Universität Hamburg, Freie und Hansestadt, Hamburg, Germany. (Feb. 2008, p. 307)

4–18 **ESSLLI 2008 Student Session**, Hamburg, Germany. (Feb. 2008, p. 307)

5–9 **Building Bridges**, Renyi Institute of Mathematics, Budapest, Hungary. (Feb. 2008, p. 307)

11–15 **Fete of Combinatorics and Computer Science**, Keszthely, Lake Balaton, Hungary. (Feb. 2008, p. 307)

18–22 **International Conference on Ring and Module Theory**, Hacettepe University, Ankara, Turkey. (Feb. 2008, p. 308)

18–23 **Workshop on Laplacian Growth and Related Topics**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

19–22 **Duality and Involutions in Representation Theory**, National University of Ireland, Maynooth, Co. Kildare, Ireland. (Nov. 2007, p. 1405)

* 21–26 **6th Bolyai-Gauss-Lobachevsky Conference: International conference on the non-euclidean geometry and its applications in modern physics**, University of Debrecen, Debrecen, Hungary.
Description: The scientific program of the Conference is planned to include talks on the following topics: non-euclidean geometry, tranformation groups, homogeneous spaces, Lie theory, non-euclidean mechanics, integrable systems, ergodic theory of dynamical systems, quantum mechanics, quantum dynamical and integrable systems, quantum field theory, quantum gravity, strings and superstrings.
Organizing Committee: István Lovas, Department of Theoretical Physics, Debrecen, Hungary (chairman); László Jenkovszky, Bogolyubov Institute for Theoretical Physics, Kiev, Ukraine (co-chairman); Péter T. Nagy, Institute of Mathematics, Debrecen, Hungary (co-chairman).
Information: http://www.math.unideb.hu/~bgl6.

25–29 **Dynamics Days Europe 2008**, TU Delft, The Netherlands. (Feb. 2008, p. 308)

25–29 **Geometry and Analysis**, Royal Institute of Technology, Stockholm, Sweden. (Dec. 2007, p. 1536)

25–29 **International Conference Approximation & Computation**, Faculty of Electronic Engineering, University of Nis, Nis, Serbia. (Feb. 2008, p. 308)

25–30 **Workshop on Random Matrices, Related Topics and Applications**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

26–December 19 **The Nature of High Reynolds Number Turbulence**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Jun/Jul. 2006, p. 714)

September 2008

1–5 **Conference in Numerical Analysis (NumAn 2008) recent approaches to numerical analysis: Theory, methods and applications honoring Richard S. Varga on his 80th birthday**, Kalamata, Greece. (Feb. 2008, p. 308)

1–6 **Workshop on Random Tilings, Random Partitions and Stochastic Growth Processes**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

2–5 **X Spanish Meeting on Cryptology and Information Security (X RECSI)**, Hospederia Fonseca, Salamanca, Spain. (Dec. 2007, p. 1536)

* 8–12 **International Workshop on Orthogonal Polynomials and Approximation Theory 2008. Conference in honor of Professor Guillermo López Lagomasino in his 60th Anniversary**, Universidad Carlos III de Madrid, Madrid, Spain.
Description: It is well known the increasing attention paid in the last decades to the theory of Orthogonal Polynomials. Numerous applications of these mathematical objects in different areas of Mathematics like numerical integration, spectral methods, interpolation, combinatorics, mathematical physics, quantum physics, and approximation theory among others have been particularly relevant.
Topics: The topics to be considered are: Approximation theory; Numerical analysis, in particular quadrature formulas; orthogonal polynomials and special functions; analytic properties and applications; integrable systems.
Information: http://www.uc3m.es/iwopa08.

* 8–11 **Logic, Algebra and Truth Degrees**, College Santa Chiara, Siena, Italy.
Description: This is the first official meeting of the working group on Mathematical Fuzzy Logic (http://www.cs.cas.cz/mathfuzzlog/). Mathematical Fuzzy Logic is a subdiscipline of Mathematical Logic which studies the notion of comparative truth. The assumption that "truth comes in degrees" has revealed very useful in many, both theoretical and applied, areas of Mathematics, Computer Science and Philosophy. The main goal of this meeting is to foster collaboration between researchers in the area of Mathematical Fuzzy Logic, and to promote communication and cooperation with members of neighbouring fields.
Programme Committee: Franco Montagna (chair), Roberto Cignoli, Petr Cintula, Francesc Esteva, Hiroakira Ono.
Invited speakers: Stefano Aguzzoli, Matthias Baaz, Xavier Caicedo, Christian Fermüller, Lluís Godo, Petr Hájek, Kazushige Terui, Constantine Tsinakis.
Information: http://www.mat.unisi.it/~latd2008/.

8–12 **Long Program: Internet Multi-Resolution Analysis: Foundations, Applications and Practice**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Feb. 2008, p. 308)

* 10 **Nonlinear Differential Equations, A Tribute to the work of Patrick Habets & Jean Mawhin on the occasion of their 65th birthdays**, Académie Royale de Belgique, Brussels, Belgium.
Speakers: Antonio Ambrosetti, Cristian Bereanu, Denis Bonheure, Haïm Brezis, Colette De Coster, Thierry De Pauw, Jean-Pierre Gossez, Jean-Pierre Kahane, Louis Nirenberg, Pierpaolo Omari, Rafael Ortega, Miguel Ramos, Luis Sanchez, Didier Smets, James Serrin, Michel Willem, Fabio Zanolin.
Organizing committee: D. Bonheure (Université catholique de Louvain) J. P. Gossez (Université libre de Bruxelles) J. Van Schaftingen (Université catholique de Louvain) M. Willem (Université catholique de Louvain).
Information: http://www.uclouvain.be/node2008.html.

* 15–18 **Information Security Conference 2008 (ISC 2008)**, Taipei, Taiwan.
Description: Information Security Conference (ISC 2008) is an annual international conference covering research in theory and applications of Information Security. ISC aims to attract high quality papers in all technical aspects of information security. It was first initiated as a workshop in Japan in 1997 (ISW'97, LNCS 1396). ISC 2008 will be held in Taipei, a beautiful city with a vibrant blend of traditional culture and cosmopolitan life. For more information, please see http://isc08.twisc.org/.
Information: http://isc08.twisc.org.

16–19 **Conference on Boundary Value Problems: Mathematical Models in Engineering, Biology and Medicine**, University of Santiago de Compostela, Santiago de Compostela, Spain. (Feb. 2008, p. 308)

*16–20 **International Conference of Numerical Analysis and Applied Mathematics 2008 (ICNAAM 2008)–Honoring John Butcher on the occasion of his 75th birthday**, Hotel Kypriotis Village-Kypriotis Panorama-Kypriotis International Conference Center, Psalidi, Kos, Greece.

Description: The aim of ICNAAM 2008 is to bring together leading scientists of the International Numerical & Applied Mathematics community and to attract original research papers of very high quality.

Invited Speakers so far: John Butcher, New Zealand; Gotz Alefeld, Germany; Uri Ascher, Canada; Martin Berzins, USA; Peter Deuflhard, Germany; Adrian Hill, United Kingdom; Zdzislaw Jackiewicz, USA; Rolf Jeltsch, Switzerland; Daniel W. Lozier, USA; Christian Lubich, Germany; Brynjulf Owren, Norway; Stefan Vandewalle, Belgium.

Information: http://www.icnaam.org/.

22–28 **A joint conference of 5th Annual International Conference on Voronoi Diagrams in Science and Engineering and 4th International Kyiv Conference on Analytic Number Theory and Spatial Tessellations**, Drahomanov National Pedagogical University, Kyiv, Ukraine. (Feb. 2008, p. 308)

24–27 (REVISED INFORMATION) **Vector Measures, Integration and Applications**, Katholische Universitaet Eichstaett-Ingolstadt, Eichstaett, Germany. (Feb. 2007, p. 308)

29–October 4 **Workshop on Quantum Many-Body Systems, Bose-Einstein Condensation**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

October 2008

4–5 **AMS Western Section Meeting**, University of British Columbia and the Pacific Institute of Mathematical Sciences, Vancouver, Canada. (Jun/Jul 2007, p. 784)

6–10 **Conference on Arithmetic Algebraic Geometry on the occasion of Michael Rapoport's 60th birthday**, Universitaet Bonn, Bonn, Germany. (Feb. 2008, p. 308)

11–12 **AMS Eastern Section Meeting**, Wesleyan University, Middletown, Connecticut. (Jun/Jul 2007, p. 784)

*11–13 **International Conference on Applied Mathematics and Approximation Theory 2008**, University of Memphis, Memphis, Tennessee.

Description: Honoring 80th Birthday of P. L. Butzer (AMAT08).

Plenary Speakers: C. Bardaro, J. Bona, B. Berndt, F. Deutsch, K. Diethelm, S. Dragomir, J. Goldstein, M. Ismail, M. J. Lai, H. Mhaskar, J. Prestin, S. Samko, R. Stens, A. Zayed.

Organizer: George Anastassiou.

Information: http://www.msci.memphis.edu/AMAT2008/.

17–19 **AMS Central Section Meeting**, Western Michigan University, Kalamazoo, Michigan. (Jun/Jul 2007, p. 784)

24–26 **AMS Southeastern Section Meeting**, University of Alabama, Huntsville, Alambama. (Jun/Jul 2007, p. 784)

November 2008

*3–4 **International Workshop on New Trends in Science and Technology**, Cankaya University, Ankara, Turkey.

Description: This workshop will provide a place to exchange recent developments and progresses on nanoscience and nanotechnology, nonlinear science and complexity in mathematics, physics and engineering as well as on symmetries, supersymmetries and integrable systems. The applications of the nanotechnology in the renewable energy production and storage as well as the nanostructured materials for nanoelectronics, energy and sensing will be discussed. The experimental details of detection of cancer cell, the development of censors and the multi purpose thin films are going to be presented in the perspectives of the nanoscience point of view.

Purpose: The purpose of the workshop is to bring together scientists whose common interests are the nanoscience, nonlinear science and complexity, the symmetries, supersymmetries and integrability.

Information: http://ntst08.cankaya.edu.tr/index.html.

*5–7 **Fractional Differentiation and its Applications**, Ankara, Turkey.

Description: The scope of the workshop is to present the state of the art on fractional systems, both on theoretical and application aspects. The growing research and development on fractional calculus in the areas of mathematics, physics and engineering, both from university and industry, motivates this international event gathering and unifying the whole community. Main Areas: Representation tools; modeling vibration insulation; analysis tools; identification filtering synthesis tools; observation pattern recognition simulation tools; control edge detection.

Deadlines: For submission of proposals: April 15, 2008. Notification for acceptance of proposals: June 6, 2008.

Information: http://www.cankaya.edu.tr/fda08/.

December 2008

*15–19 **The 13th Asian Technology Conference in Mathematics (ATCM 2008)**, Suan Sunandha Rajabhat University, Bangkok, Thailand.

Description: The ATCM 2008 is an international conference held in Thailand that will continue addressing technology-based issues in all Mathematical Sciences. Thanks to advanced technological tools such as computer algebra systems CAS), interactive and dynamic geometry, and hand-held devices, the effectiveness of our teaching and learning, and the horizon of our research in mathematics and its applications continue to grow rapidly.

Aim: To provide a forum for educators, researchers, teachers and experts in exchanging information regarding enhancing technology to enrich mathematics learning, teaching and research at all levels.

Language: English is the official language of the conference. There will be over 300 participants coming from over 26 countries around the world.

Deadline: Submitting abstracts: June 15, 2008. Submitting full papers: July 30, 2008.

Information: http://atcm.mathandtech.org.

17–21 **First Joint International Meeting with the Shanghai Mathematical Society**, Shanghai, China. (Jun/Jul 2007, p. 784)

*23–26 **International Conference on Computer Analysis of Science and Technology problems**, Tajik State National University (TSNU), Dushanbe, Tajikistan.

Description: The Second International Conference on Computer Analysis and its applications in Information Technology will be held on the beautiful campus of TSNU in December 2008 over four days.

Topics: Computer analysis of economical and ecological systems; Computer analysis of singular problems of science and technology; Theoretical problems of Computer analysis; Problems of Computer and Information Security.

Scientific Committee: Mahmadyusuf Yunusi, Dmitrii Logofet, Zafar Usmanov, Zahra Afsharnejat, Aleksandr Uspensky, Tasleem Mustafa.

Deadlines: Submission of one full page abstract: September 1, 2008. Notification of Acceptance of Abstract: October 1, 2008. Registration: September 1, 2008. Abstracts could be written in: WORD. Not to exceed one page, and can be sent by email to: icca2008@mail.tj.

Information: http://www.yunusi.com/conference; email: myu@yunusi.com.

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Mathematics Calendar

January 2009

4–9 **Workshop on Random Functions and Random Surfaces and Interfaces**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

May 2009

18–23 **Workshop on Interacting Stochastic Particle Systems**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

June 2009

8–13 **Workshop on Disordered Systems: Spin Glasses**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

22–26 (NEW DATE) **5th Asian Mathematical Conference (AMC 2009)**, Penang /Kulalumpur, Malaysia. (Oct. 2007, p. 1190)

September 2009

12–18 (NEW DATE) **Models in Developing Mathematics Education**, Dresden University of Applied Sciences, Dresden, Germany. (Apr. 2007, p. 498)

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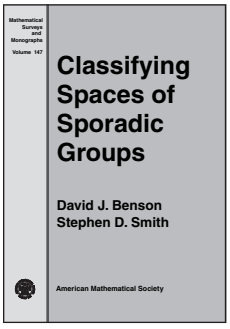
Algebra and Algebraic Geometry



Classifying Spaces of Sporadic Groups

David J. Benson, *University of Aberdeen, Scotland, United Kingdom*, and **Stephen D. Smith**, *University of Illinois at Chicago, IL*

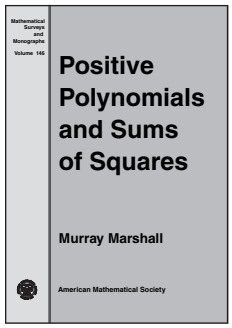
For each of the 26 sporadic finite simple groups, the authors construct a 2-completed classifying space using a homotopy decomposition in terms of classifying spaces of suitable 2-local subgroups. This construction leads to an additive decomposition of the mod 2 group cohomology. The authors also summarize the current status of knowledge in the literature about the ring structure of the mod 2 cohomology of sporadic simple groups.

This book begins with a fairly extensive initial exposition, intended for non-experts, of background material on the relevant constructions from algebraic topology, and on local geometries from group theory. The subsequent chapters then use those structures to develop the main results on individual sporadic groups.

Contents: Overview of our main results; *Exposition of background material:* Review of selected aspects of group cohomology; Simplicial sets and their equivalence with topological spaces; Bousfield-Kan completions and homotopy colimits; Decompositions and ample collections of p-subgroups; 2-local geometries for simple groups; *Main results on sporadic groups:* Decompositions for the individual sporadic groups; Details of proofs for individual groups; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 147

March 2008, 289 pages, Hardcover, ISBN: 978-0-8218-4474-8, LC 2007060587, 2000 *Mathematics Subject Classification:* 20D08, 20J06, 55R35; 20B25, 20J05, 55R40, **AMS members US$68**, List US$85, Order code SURV/147



Positive Polynomials and Sums of Squares

Murray Marshall, *University of Saskatchewan, Saskatoon, SK, Canada*

The study of positive polynomials brings together algebra, geometry and analysis. The subject is of fundamental importance in real algebraic geometry, when studying the properties of objects defined by polynomial inequalities. Hilbert's 17th problem and its solution in the first half of the 20th century were landmarks in the early days of the subject. More recently, new connections to the moment problem and to polynomial optimization have been discovered. The moment problem relates linear maps on the multidimensional polynomial ring to positive Borel measures.

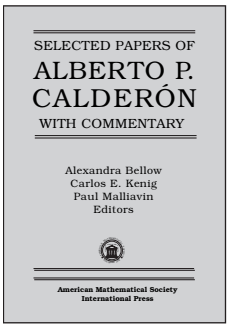
This book provides an elementary introduction to positive polynomials and sums of squares, the relationship to the moment problem, and the application to polynomial optimization. The focus is on the exciting new developments that have taken place in the last 15 years, arising out of Schmüdgen's solution to the moment problem in the compact case in 1991. The book is accessible to a well-motivated student at the beginning graduate level. The objects being dealt with are concrete and down-to-earth, namely polynomials in n variables with real coefficients, and many examples are included. Proofs are presented as clearly and as simply as possible. Various new, simpler proofs appear in the book for the first time. Abstraction is employed only when it serves a useful purpose, but, at the same time, enough abstraction is included to allow the reader easy access to the literature. The book should be essential reading for any beginning student in the area.

Contents: Preliminaries; Positive polynomials and sums of squares; Krivine's Positivstellensatz; The moment problem; Non-compact case; Archimedean T-modules; Schmüdgen's Positivstellensatz; Putinar's question; Weak isotropy of quadratic forms; Scheiderer's local-global principle; Semidefinite programming and optimization; Appendix 1: Tarski-Seidenberg theorem; Appendix 2: Algebraic sets; Bibliography.

Mathematical Surveys and Monographs, Volume 146

April 2008, 187 pages, Hardcover, ISBN: 978-0-8218-4402-1, LC 2007060573, 2000 *Mathematics Subject Classification:* 13J30, 14P10, 44A60, **AMS members US$52**, List US$65, Order code SURV/146

Analysis



Selected Papers of Alberto P. Calderón with Commentary

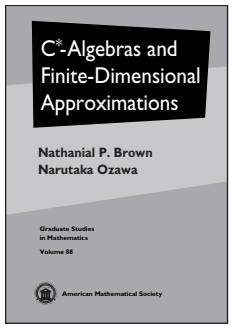
Alexandra Bellow, *Northwestern University, Evanston, IL*, **Carlos E. Kenig**, *University of Chicago, IL*, and **Paul Malliavin**, Editors

Alberto Calderón was one of the leading mathematicians of the twentieth century. His fundamental, pioneering work reshaped the landscape of mathematical analysis. This volume presents a wide selection from some of Calderón's most influential papers. They range from singular integrals to partial differential equations, from interpolation theory to Cauchy integrals on Lipschitz curves, from inverse problems to ergodic theory. The depth, originality, and historical impact of these works are vividly illustrated by the accompanying commentaries by some of today's leading figures in analysis. In addition, two biographical chapters preface the volume. They discuss Alberto Calderón's early life and his mathematical career.

Contents: **A. B. Calderón**, On becoming a mathematician: Markers and decisive moments in Alberto P. Calderón's early life; **M. Christ**, **C. E. Kenig**, and **C. Sadosky**, Alberto P. Calderón the mathematician, his life and works; *Calderon selecta papers:* **A. P. Calderón**, On theorems of M. Riesz and A. Zygmund; **A. P. Calderón**, On the behaviour of harmonic functions at the boundary; **A. P. Calderón**, On a theorem of Marcinkiewicz and Zygmund; **A. P. Calderón** and **A. Zygmund**, On the existence of certain singular integrals; **A. P. Calderon**, A general ergodic theorem; **A. P. Calderón** and **A. Zygmund**, Singular integrals and periodic functions; **R. Arens** and **A. P. Calderón**, Analytic functions of several Banach algebra elements; **A. P. Calderón**, On singular integrals; **A. P. Calderón** and **A. Zygmund**, Algebras of certain singular operators; **A. P. Calderón** and **A. Zygmund**, Singular integral operators and differential equations; **A. P. Calderón**, Uniqueness in the Cauchy problem for partial differential equations; **A. P. Calderón**, Lebesgue spaces of differentiable functions and distributions; **A. P. Calderón**, Existence and uniqueness theorems for systems of a partial differential equations; **A. Benedek**, **A. P. Calderón**, and **R. Panzone**, Convolution operators on Banach space valued functions; **A. P. Calderón**, Boundary value problems for elliptic equations; **A. P. Calderón**, Intermediate spaces and interpolation, the complex method; **A. P. Calderón**, Commutators of singular integral operators; **A. P. Calderón**, Spaces between L^1 and L^∞ and the theorem of Marcinkiewicz; **A. P. Calderón**, Singular integrals; **A. P. Calderón**, Algebras of singular integral operators; **A. P. Calderón**, The analytic calculation of the index of elliptic equations; **A. P. Calderón**, Ergodic theory and translation-invariant operators; **A. P. Calderón** and **R. Vaillancourt**, On the boundedness of pseudo-differential operators; **A. P. Calderón** and **R. Vaillancourt**, A class of bounded pseudo-differential operators; **A. P. Calderón**, Cauchy integrals on Lipschitz curves and related operators; **A. P. Calderon**, An atomic decomposition of distributions in parabolic H^p spaces; **A. P. Calderón**, **C. P. Calderon**, **E. Fabes**, **M. Jodeit**, and **N. M. Riviere**, Applications of the Cauchy integral on Lipschitz curves; **A. P. Calderón**, Commutators, singular integrals on Lipschitz curves and applications; **A. P. Calderón**, On an inverse boundary value problem; **A. Bellow**, **A. P. Calderón**, and **U. Krengel**, Hopf's ergodic theorem for particles with different velocities and the "strong sweeping out property"; **M. Christ**, **C. E. Kenig**, and **C. Sadosky**, Harmonic analysis and partial differential equations–Essays in honor of alberto P. Calderón; **A. P. Calderon** and **C. P. Calderon**, A representation formula and its applications to singular integrals; *Calderon selecta commentary:* **D. L. Burkholder**, Comments on (5), (14), (22), (30), and (31); **M. Christ**, Commentary on two papers of A. P. Calderón; **C. Fefferman** and **E. M. Stein**, Commentary on Calderón's papers on interpolation; **C. Fefferman** and **E. M. Stein**, Comments on several papers of A. P. Calderón; **P. Malliavin**, On the analytical side of the proof of the index theorem, some personal recollections; **Y. Meyer**, Complex analysis and operator theory in Alberto Calderón's work; **L. Nirenberg**, Comments on some papers of Alberto P. Calderón; **G. Uhlmann**, Commentary on Calderón's paper (29), On an inverse boundary value problem.

Collected Works, Volume 21

May 2008, 640 pages, Hardcover, ISBN: 978-0-8218-4297-3, LC 2007060595, 2000 *Mathematics Subject Classification:* 42B20, 42B25, 42B35, 37A30, 37A45, 35G05, 35L30, 58J20, **AMS members US$95**, List US$119, Order code CWORKS/21



C*-Algebras and Finite-Dimensional Approximations

Nathanial P. Brown, *Pennsylvania State University, State College, PA*, and **Narutaka Ozawa**, *University of California, Los Angeles, CA*

C*-approximation theory has provided the foundation for many of the most important conceptual breakthroughs and applications of operator algebras. This book systematically studies (most of) the numerous types of approximation properties that have been important in recent years: nuclearity, exactness, quasidiagonality, local reflexivity, and others. Moreover, it contains user-friendly proofs, insofar as that is possible, of many fundamental results that were previously quite hard to extract from the literature. Indeed, perhaps the most important novelty of the first ten chapters is an earnest attempt to explain some fundamental, but difficult and technical, results as painlessly as possible. The latter half of the book presents related topics and applications—written with researchers and advanced, well-trained students in mind. The authors have tried to meet the needs both of students wishing to learn the basics of an important area of research as well as researchers who desire a fairly comprehensive reference for the theory and applications of C*-approximation theory.

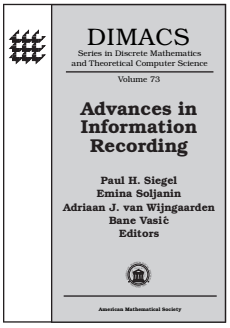
Contents: Fundamental facts; *Basic theory:* Nuclear and exact C*-algebras: Definitions, basic facts and examples; Tensor products; Constructions; Exact groups and related topics; Amenable traces and Kirchberg's factorization property; Quasidiagonal C*-algebras; AF embeddability; Local reflexivity and other tensor product conditions; Summary and open problems; *Special topics:* Simple C*-algebras; Approximation properties for groups; Weak expectation property and local lifting property; Weakly exact von Neumann algebras; *Applications:* Classification of group von Neumann algebras; Herrero's approximation problem; Counterexamples in K-homology and K-theory; *Appendices:*

Ultrafilters and ultraproducts; Operator spaces, completely bounded maps and duality; Lifting theorems; Positive definite functions, cocycles and Schoenberg's Theorem; Groups and graphs; Bimodules over von Neumann algebras; Bibliography; Notation index; Subject index.

Graduate Studies in Mathematics, Volume 88

April 2008, 509 pages, Hardcover, ISBN: 978-0-8218-4381-9, LC 2007060566, 2000 *Mathematics Subject Classification:* 46L05, 46L06, 46L07, 46L10, 46L35, 46L55, 05C25, 22D25, 43A07, **AMS members US$63**, List US$79, Order code GSM/88

Applications



Advances in Information Recording

Paul H. Siegel, *University of California, San Diego, La Jolla, CA*, **Emina Soljanin** and **Adriaan J. van Wijngaarden**, *Bell Laboratories, Murray Hill, NJ*, and **Bane Vasić**, *University of Arizona, Tucson, AZ*, Editors

This book comprises a collection of articles stemming from a DIMACS Working Group and DIMACS Workshop on Theoretical Advances in Information Recording held at Rutgers University, Piscataway, NJ. Written by leading researchers in information theory and data storage technology, the articles address problems related to the efficient and reliable storage of information in devices based upon novel optical, magnetic, and biological recording mechanisms.

The primary focus of the articles is on signal processing and coding techniques applicable to exploratory technologies being considered for future generations of storage devices, including two-dimensional optical storage (TwoDOS), heat-assisted magnetic recording (HAMR), and volumetric macro-molecular data storage. Specific topics addressed include channel equalization, timing recovery, data detection, modulation coding, and error control coding. Several articles explore the emerging connections between data storage, information theory, and the storage and processing of genetic information in living cells. Articles in the volume also illustrate the broader applicability of fundamental advances in information theory that have arisen in the context of information storage technology.

The volume is suitable for graduate students and research scientists interested in applications of information theory, communication theory, and coding theory to man-made and natural data storage systems.

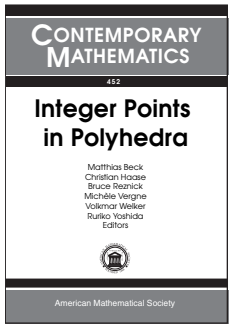
Co-published with the Center for Discrete Mathematics and Theoretical Computer Science beginning with Volume 8. Volumes 1–7 were co-published with the Association for Computer Machinery (ACM).

Contents: W. M. J. Coene and **A. H. J. Immink**, Modulation coding for a two-dimensional optical storage channel; **R. Radhakrishnan**, **B. Vasić**, **F. Erden**, and **C. He**, Characterization of heat-assisted magnetic recording channels; **A. R. Nayak**, **J. R. Barry**, and **S. W. McLaughlin**, Cramér-Rao bound for timing recovery on channels with inter-symbol interference; **M. Mansuripur** and **P. Khulbe**, Macro-molecular data storage with petabyte/cm^3 density, highly parallel read/write operations, and genuine 3D storage capability; **G. Battail**, Can we explain the faithful communication of genetic information?; **O. Milenkovic**, Data storage and processing in cells: An information theoretic approach; **N. Kashyap** and **P. H. Siegel**, Ghostbusting: Coding for optical communications.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 73

February 2008, 165 pages, Hardcover, ISBN: 978-0-8218-3752-8, LC 2007060569, 2000 *Mathematics Subject Classification:* 68P20, 68P30, 92D20; 37B10, 93E10, 94A14, 94A15, 94A17, 94A40, 94B12, **AMS members US$63**, List US$79, Order code DIMACS/73

Discrete Mathematics and Combinatorics



Integer Points in Polyhedra

Matthias Beck, *San Francisco State University, CA*, **Christian Haase**, *Freie Universität Berlin, Germany*, **Bruce Reznick**, *University of Illinois at Urbana-Champaign, IL*, **Michèle Vergne**, *Ecole Polytechnique, Palaiseau, France*, **Volkmar Welker**, *Phillips-Universität Marburg, Germany*, and **Ruriko Yoshida**, *University of Kentucky, Lexington, KY*, Editors

The AMS-IMS-SIAM Joint Summer Research Conference "Integer Points in Polyhedra" was held in Snowbird, Utah in June 2006. This proceedings volume contains research and survey articles originating from the conference.

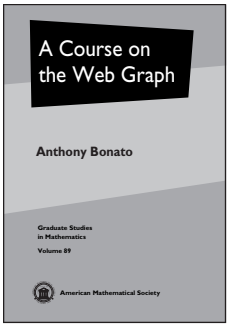
The volume is a cross section of recent advances connected to lattice-point questions. Similar to the talks given at the conference, topics range from commutative algebra to optimization, from discrete geometry to statistics, from mirror symmetry to geometry of numbers. The book is suitable for researchers and graduate students interested in combinatorial aspects of the above fields.

Contents: K. Aardal, Lattice reformulation of integer programming problems; **V. Baldoni**, **N. Berline**, and **M. Vergne**, Local Euler-Maclaurin expansion of Barvinok valuations and Ehrhart coefficients of a rational polytope; **V. Batyrev** and **B. Nill**, Combinatorial aspects of mirror symmetry; **B. Braun** and **M. Develin**, Ehrhart polynomial roots and Stanley's non-negativity theorem; **J. W. Davis**, **E. D'Souza**, **S. Lee**, and **C. D. Savage**, Enumeration of integer solutions to linear inequalities defined by digraphs; **R. Erdahl**, **A. Ordine**, and **K. Rybnikov**, Perfect Delaunay polytopes and perfect quadratic functions on lattices; **C. Haase** and **T. B. McAllister**, Quasi-period collapse and $GL_n(\mathbb{Z})$-scissors congruence in rational polytopes; **H. Ohsugi** and **T. Hibi**, Quadratic Gröbner bases arising from combinatorics; **K. Karu**, Ehrhart analogue of the h-vector; **A. Takemura** and **R. Yoshida**, Saturation

points on faces of a rational polyhedral cone; **Z. Xu**, An explicit formulation for two dimensional vector partition functions; **M. Beck**, **B. Nill**, **B. Reznick**, **C. Savage**, **I. Soprunov**, and **Z. Xu**, Let me tell you my favorite lattice-point problem ….

Contemporary Mathematics, Volume 452

April 2008, approximately 193 pages, Softcover, ISBN: 978-0-8218-4173-0, 2000 *Mathematics Subject Classification:* 52B20; 05A15, 11D04, 11H06, 11P21, 13P10, 14M25, 14J32, 52C07, 90C10, **AMS members US$47**, List US$59, Order code CONM/452



A Course on the Web Graph

Anthony Bonato, *Wilfrid Laurier University, Waterloo, ON, Canada*

A Course on the Web Graph provides a comprehensive introduction to state-of-the-art research on the applications of graph theory to real-world networks such as the web graph. It is the first mathematically rigorous textbook discussing both models of the web graph and algorithms for searching the web.

After introducing key tools required for the study of web graph mathematics, an overview is given of the most widely studied models for the web graph. A discussion of popular web search algorithms, e.g. PageRank, is followed by additional topics, such as applications of infinite graph theory to the web graph, spectral properties of power law graphs, domination in the web graph, and the spread of viruses in networks.

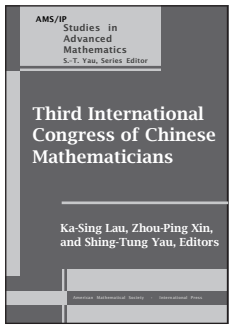
The book is based on a graduate course taught at the AARMS 2006 Summer School at Dalhousie University. As such it is self-contained and includes over 100 exercises. The reader of the book will gain a working knowledge of current research in graph theory and its modern applications. In addition, the reader will learn first-hand about models of the web, and the mathematics underlying modern search engines.

Contents: Graphs and probability; The web graph; Random graphs; Models for the web graph; Searching the web; The infinite web; New directions in internet mathematics; Bibliography; Index.

Graduate Studies in Mathematics, Volume 89

April 2008, approximately 196 pages, Hardcover, ISBN: 978-0-8218-4467-0, LC 2007060579, 2000 *Mathematics Subject Classification:* 05C90, 05C80, 68R10, 94C15, **AMS members US$36**, List US$45, Order code GSM/89

General and Interdisciplinary



Third International Congress of Chinese Mathematicians

Ka-Sing Lau and **Zhou-Ping Xin**, *The Chinese University of Hong Kong, China*, and **Shing-Tung Yau**, *Harvard University, Cambridge, MA*, Editors

These volumes consist of the proceedings of the Third International Congress of Chinese Mathematicians, held at the Chinese University of Hong Kong in December 2004. The congress brought together eminent Chinese and overseas mathematicians to discuss the latest developments in pure and applied mathematics.

This two-part proceedings contains the contents of lectures given by the plenary speakers and the invited speakers—the major portion comprising new results—together with some expository and survey articles. Eleven major topics are treated: algebra, number theory and cryptography; algebraic geometry and algebraic topology; geometric analysis; complex analysis and complex geometry; harmonic analysis and functional analysis; applied mathematics; dynamical systems, fractals and wavelets; numerical analysis; PDE; probability, statistics, and financial mathematics; and education.

Titles in this series are co-published with International Press, Cambridge, MA.

Contents: Part 1: J. A. Smoller and **J. B. Temple**, Shock waves and cosmology; **C.-Q. Cheng** and **J. Yan**, Variational construction of diffusion orbits in convex Hamiltonian systems with multiple degrees of freedom; **T. L. Lai**, Saddlepoint approximations and boundary crossing probabilities for random fields and their applications; **N. Mok**, Recognizing certain rational homogeneous manifolds of Picard number 1 from their varieties of minimal rational tangents; **C.-W. Shu**, Discontinuous Galerkin methods for convection dominated partial differential equations; **X.-J. Wang**, Singularity behavior of the mean curvature flow; **J. Zhou**, Localization and duality; **B.-L. Chen** and **X.-P. Zhu**, Surgical Ricci flow on four-manifolds with positive isotropic curvature; **E. Viehweg** and **K. Zuo**, Special subvarieties of $\mathcal{A}_g$; **L. Fu** and **D. Wan**, Local monodromy of the Kloosterman sheaf at ∞; **T. Yang**, Hilbert modular functions and their CM values; **Y. Hu**, Geometric invariant theory and birational geometry; **X. Sun**, Remarks on Gieseker's degeneration and its normalization; **W.-S. Cheung** and **B. Wong**, Bundle rigidity of complex surfaces; **S. S.-T. Yau**, CR equivalence problem of strongly pseudoconvex CR manifolds; **L. Weiming** and **X.-Y. Zhou**, Vector bundles on non-primary Hopf manifolds with abelian fundamental group; **D.-C. Chang** and **P. Greiner**, Subelliptic PDE's and subRiemannian geometry; **S.-C. Chang**, The Q-curvature flow on a closed 3-manifold of positive Q-curvature; **T.-J. Li**, The space of symplectic structures on closed 4-manifolds; **L. Ni**, Ancient solutions to Kähler-Ricci flow; **M.-T. Wang**, A convergence result of the Lagrangian mean curvature flow; **R.-H. Wang**, On piecewise algebraic variety; **B. H. Lian**, An introduction to chiral equivariant cohomology; **L. Ji**, Large scale geometry, compactifications and the integral Novikov conjectures for arithmetic groups; **M.-D. Choi**, Normal dilations; **L. Ge** and **J. Shen**, On the generator problem of von Neumann algebras;

M. K. Kwong, A survey of results on the ground state of semilinear elliptic equations; **E. Kaniuth** and **A. T. Lau**, Separating and extending subgroups of a locally compact group; **N.-C. Wong**, The triangle of operators, topologies, bornologies; **X. Zhang**, The positive mass theorem near null infinity; **Part 2: C.-H. Chu** and **Z. Qian**, Dirichlet forms and Markov semigroups on non-associative vector bundles; **A. H. Fan** and **J.P. Kahane**, Decomposition principle and random cascades; **Y. Jiang**, Holomorphic motions and normal forms in complex analysis; **S.-Y. Li**, On pseudo-Hermitian CR manifolds; **Z. Shen**, Recent progress on the Dirichlet problem in Lipschitz domains; **X.-R. Dai**, **D.-J. Feng**, and **Y. Wang**, Refinable functions with non-integer Dilations; **Z.-Y. Wen** and **L.-F. Xi**, On Whitney's critical sets; **P.-M. Wong**, Applications of Nevanlinna theory to geometric problems; **Y. Wang**, Some results on Smale's mean value conjecture; **J. Deng**, **T. Y. Hou**, and **X. Yu**, Localized non-blowup conditions for the 3D incompressible Euler equations; **T.-C. Lin** and **Y.-W. Hsu**, Separation of bound state solutions of systems of nonlinear Schrödinger equations; **Z. Liqun**, The C^{α} regularity of a class of ultraparabolic equations; **T. Yang** and **H.-J. Zhao**, Stability of basic wave patterns for gas motions; **Z. Lin**, On strong near-epoch dependence; **P. Mörters** and **N.-R. Shieh**, Multifractal analysis of branching measure on a Galton-Watson tree; **J. Xia** and **J.-A. Yan**, Convex duality theory for optimal investment; **J. Yong**, Backward stochastic Volterra integral equations; **M.-C. Chang**, Set addition and set multiplication; **C. Y. Ho**, Collineation groups of translation planes; **Q. Du**, Intelligent and informative scientific computing, trends and examples; **Z. Shen** and **S. Waldron**, Scattered data interpolation by box splines; **Z. Wu**, Piecewise function generated by the solutions of linear ordinary differential equation; **Y.-X. Yuan**, Step-sizes for the gradient method; **K.-T. Fang** and **Y. Wang**, Number-theoretic methods in experimental designs; **J. Xin**, Ear modeling and sound signal processing; **X. Liao** and **K. Zhang**, The mathematical problem of inertial waves in rapidly rotating planets and stars; **S. M. Keung**, Mathematics, mathematics education and the mouse.

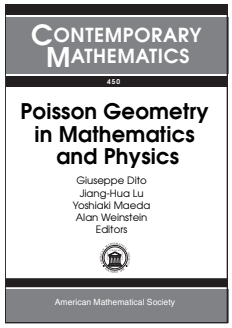
AMS/IP Studies in Advanced Mathematics, Volume 42

Part 1: May 2008, approximately 475 pages, Softcover, ISBN: 978-0-8218-4454-0, 2000 *Mathematics Subject Classification:* 05-XX, 08-XX, 11-XX, 14-XX, 22-XX, 35-XX, 37-XX, 80-XX, **AMS members US$79**, List US$99, Order code AMSIP/42.1

Part 2: May 2008, approximately 489 pages, Softcover, ISBN: 978-0-8218-4452-6, 2000 *Mathematics Subject Classification:* 05-XX, 08-XX, 11-XX, 14-XX, 22-XX, 35-XX, 37-XX, 80-XX, **AMS members US$79**, List US$99, Order code AMSIP/42.2

Set: May 2008, Softcover, ISBN: 978-0-8218-4416-8, 2000 *Mathematics Subject Classification:* 05-XX, 08-XX, 11-XX, 14-XX, 22-XX, 35-XX, 37-XX, 80-XX, **AMS members US$127**, List US$159, Order code AMSIP/42

Geometry and Topology



Poisson Geometry in Mathematics and Physics

Giuseppe Dito, *University of Bourgogne, Dijon, France*, **Jiang-Hua Lu**, *Hong Kong University of Science and Technology, Kowloon, Hong Kong, China*, **Yoshiaki Maeda**, *Keio University, Yokohama, Japan*, and **Alan Weinstein**, *University of California, Berkeley, CA*, Editors

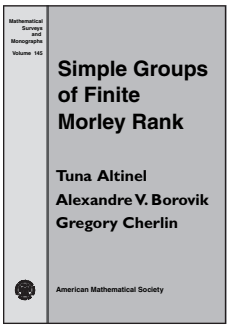
This volume is a collection of articles by speakers at the conference "Poisson 2006: Poisson Geometry in Mathematics and Physics", which was held June 5–9, 2006, in Tokyo, Japan. Poisson 2006 was the fifth in a series of international conferences on Poisson geometry that are held once every two years. The aim of these conferences is to bring together mathematicians and mathematical physicists who work in diverse areas but have common interests in Poisson geometry. The program for Poisson 2006 was remarkable for the overlap of topics that included deformation quantization, generalized complex structures, differentiable stacks, normal forms, and group-valued moment maps and reduction. The articles represent current research in Poisson geometry and should be valuable to anyone interested in Poisson geometry, symplectic geometry, and mathematical physics. This volume also contains lectures by the principal speakers of the three-day school held at Keio University that preceded Poisson 2006.

Contents: P. Bieliavsky, **L. Claessens**, **D. Sternheimer**, and **Y. Voglaire**, Quantized anti de Sitter spaces and non-formal deformation quantizations of symplectic symmetric spaces; **C. Blohmann** and **A. Weinstein**, Group-like objects in Poisson geometry and algebra; **O. Brahic** and **R. L. Fernandes**, Poisson fibrations and fibered symplectic groupoids; **H. Bursztyn**, **G. R. Cavalcanti**, and **M. Gualtieri**, Generalized Kähler and hyper-Kähler quotients; **A. S. Cattaneo**, Deformation quantization and reduction; **J.-P. Dufour**, Examples of higher order stable singularities of Poisson structures; **F. Gay-Balmaz** and **T. S. Ratiu**, Poisson reduction and the Hamiltonian structure of the Euler-Yang-Mills equations; **T. S. Holm**, Orbifold cohomology of abelian symplectic reductions and the case of weighted projective spaces; **N. IKEDA**, Deformation of graded Poisson (Batalin-Vilkovisky) structures; **A. V. Karabegov**, Deformation quantization of a Kähler-Poisson structure vanishing on a Levi nondegenerate hypersurface; **J.-H. Lu**, A note on Poisson homogeneous spaces; **E. Meinrenken**, Lectures on pure spinors and moment maps; **S. A. Merkulov**, Lectures on props, Poisson geometry and deformation quantization; **P. Schapira**, Deformation quantization modules on complex symplectic manifolds; **M. Van den Bergh**, Non-commutative quasi-Hamiltonian spaces; **S. Waldmann**, Locally noncommutative space-times.

Contemporary Mathematics, Volume 450

March 2008, 311 pages, Softcover, ISBN: 978-0-8218-4423-6, LC 2007060575, 2000 *Mathematics Subject Classification:* 53D17, 53D55, 19L10, 58B34, 81T70, 14A22, 22A22, 47G30, **AMS members US$71**, List US$89, Order code CONM/450

Logic and Foundations



Simple Groups of Finite Morley Rank

Tuna Altinel, *Université de Lyon 1, Villeurbanne, France*, **Alexandre V. Borovik**, *Manchester University, England*, and **Gregory Cherlin**, *Rutgers University, Piscataway, NJ*

The book gives a detailed presentation of the classification of the simple groups of finite Morley rank which contain a nontrivial unipotent 2-subgroup. They are linear algebraic groups over algebraically closed fields of characteristic 2. Although the story told in the book is inspired by the classification of the finite simple groups, it goes well beyond this source of inspiration. Not only do the techniques adapted from finite group theory cover, in a peculiar way, various portions of the three generations of approaches to finite simple groups but model theoretic methods also play an unexpected role. The book contains a complete account of all this material, part of which has not been published. In addition, almost every general result about groups of finite Morley rank is exposed in detail and the book ends with a chapter where the authors provide a list of open problems in the relevant fields of mathematics. As a result, the book provides food for thought to finite group theorists, model theorists, and algebraic geometers who are interested in group theoretic problems.

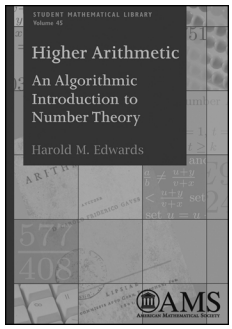
This item will also be of interest to those working in algebra and algebraic geometry.

Contents: *Part A. Methods:* Tools; K-groups and L-groups; Specialized topics; Generic covering and conjugacy theorems; *Part B. Mixed type groups:* Mixed type; *Part C. Even type groups:* Strong embedding and weak embedding; Standard components of type SL_2; The $C(G,T)$ theorem and a plan of attack; Quasithin groups; Conclusion; Bibliography; Index of notation; Index of terminology; Index.

Mathematical Surveys and Monographs, Volume 145

March 2008, approximately 556 pages, Hardcover, ISBN: 978-0-8218-4305-5, LC 2007060551, 2000 *Mathematics Subject Classification:* 32G15, 03C98, 03C45, 20G05, 20G10, 20G20, 20G40, 17B20, 17B25, 17B45, 20A15, 20B07, 20B15, 20B20, 20B22, 20B25, 20B27, 20D05, 20E42, 51E12, 51E24, 20P05, 19C20, **AMS members US$87**, List US$109, Order code SURV/145

Number Theory



Higher Arithmetic

An Algorithmic Introduction to Number Theory

Harold M. Edwards, *New York University, NY*

Although number theorists have sometimes shunned and even disparaged computation in the past, today's applications of number theory to cryptography and computer security demand vast arithmetical computations. These demands have shifted the focus of studies in number theory and have changed attitudes toward computation itself.

The important new applications have attracted a great many students to number theory, but the best reason for studying the subject remains what it was when Gauss published his classic *Disquisitiones Arithmeticae* in 1801: Number theory is the equal of Euclidean geometry—some would say it is superior to Euclidean geometry—as a model of pure, logical, deductive thinking. An arithmetical computation, after all, is the purest form of deductive argument.

Higher Arithmetic explains number theory in a way that gives deductive reasoning, including algorithms and computations, the central role. Hands-on experience with the application of algorithms to computational examples enables students to master the fundamental ideas of basic number theory. This is a worthwhile goal for any student of mathematics and an essential one for students interested in the modern applications of number theory.

Harold M. Edwards is Emeritus Professor of Mathematics at New York University. His previous books are *Advanced Calculus* (1969, 1980, 1993), *Riemann's Zeta Function* (1974, 2001), *Fermat's Last Theorem* (1977), *Galois Theory* (1984), *Divisor Theory* (1990), *Linear Algebra* (1995), and *Essays in Constructive Mathematics* (2005). For his masterly mathematical exposition he was awarded a Steele Prize as well as a Whiteman Prize by the American Mathematical Society.

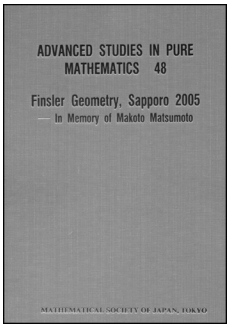
Contents: Numbers; The problem $A\square + B = \square$; Congruences; Double congruences and the Euclidean algorithm; The augmented Euclidean algorithm; Simultaneous congruences; The fundamental theorem of arithmetic; Exponentiation and orders; Euler's ϕ-function; Finding the order of a mod c; Primality testing; The RSA cipher system; Primitive roots mod p; Polynomials; Tables of indices mod p; Brahmagupta's formula and hypernumbers; Modules of hypernumbers; A canonical form for modules of hypernumbers; Solution of $A\square + B = \square$; Proof of the theorem of Chapter 19; Euler's remarkable discovery; Stable modules; Equivalence of modules; Signatures of equivalence classes; The main theorem; Which modules become principal when squared?; The possible signatures for certain values of A; The law of quadratic reciprocity; Proof of the Main Theorem; The theory of binary quadratic forms; Composition of binary quadratic forms; Cycles of stable modules; Answers to exercises; Bibliography; Index.

Student Mathematical Library, Volume 45

April 2008, approximately 212 pages, Softcover, ISBN: 978-0-8218-4439-7, LC 2007060578, 2000 *Mathematics Subject Classification:* 11-01, **AMS members US$31**, List US$39, Order code STML/45

New AMS-Distributed Publications

Analysis



Finsler Geometry, Sapporo 2005

In Memory of Makoto Matsumoto

Sorin V. Sabau and **Hideo Shimada**, *Hokkaido Tokai University, Sapporo, Japan*

This volume contains surveys and original articles based on the talks given at the 40th Finsler Symposium on Finsler Geometry, held on September 9–10, 2005 at Hokkaido Tokai University, Sapporo, Japan. The symposium was not only a meeting of the Finsler geometers from Japan and abroad but also a commemoration of the late Professor Makoto Matsumoto. The papers included in this volume contain fundamental topics of modern Riemann-Finsler geometry, interesting for specialists in Finsler geometry as well as researchers in Riemannian geometry or other fields of differential geometry and its applications.

This item will also be of interest to those working in geometry and topology.

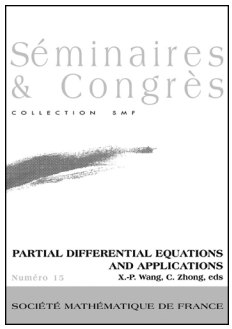
Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Contents: *Part I. Professor Makoto Matsumoto:* Photos of Makoto Matsumoto; **H. Shimada** and **S. V. Sabau**, Matsumoto's legacy. The life and work of Professor Makoto Matsumoto; *Part II. Hunting Unicorns and Other Topics of Global Finsler Geometry:* **D. Bao**, On two curvature-driven problems in Riemann-Finsler geometry; **S. Bácsó**, **X. Cheng**, and **Z. Shen**, Curvature properties of (α, β)-metrics; **I. R. Peter**, A connectedness principle in positively curved Finsler manifolds; **S. V. Sabau** and **H. Shimada**, Riemann-Finsler surfaces; **L. Tamássy**, Finsler geometry in the tangent bundle; *Part III. Finslerian Inspired Differential Geometry:* **P. L. Antonelli** and **S. F. Rutz**, Perturbations of constant connection Wagner spaces; **M. Crampin** and **D. J. Saunders**, Path geometries and almost Grassmann structures; **R. L. Lovas**, **J. Pék**, and **J. Szilasi**, Ehresmann connections, metrics and good metric derivatives; **R. Miron**, Dynamical systems of the Lagrangian and Hamiltonian mechanical systems; *Part IV. Complex Finsler Geometry:* **T. Aikou**, The Chern-Finsler connection and Finsler-Kähler manifolds; **P.-M. Wong**, A survey of complex Finsler geometry.

Advanced Studies in Pure Mathematics, Volume 48

November 2007, 433 pages, Hardcover, ISBN: 978-4-931469-42-6, 2000 *Mathematics Subject Classification:* 58B20; 53C60, 58J60, **AMS members US$57**, List US$71, Order code ASPM/48

Differential Equations



Partial Differential Equations and Applications

Proceedings of the CIMPA School Held in Lanzhou (2004)

Xue Ping Wang, *Université de Nantes, France*, and **Chengkui Zhong**, *Lanzhou University, China*

This volume contains expanded versions of lecture notes of CIMPA's school held in Lanzhou in July 2004. These texts offer a detailed survey, including the most recent advances, of some topics in analysis of partial differential equations arising from physics, mechanics and geometry such as Korteweg-de Vries equation, harmonic maps, Birkhoff normal form and KAM theorem for infinite dimensional dynamical systems, vorticity of Euler equation, semi-classical analysis of Schrödinger and Dirac equations, and limiting situations of semilinear elliptic equations. They are mainly aimed at students and young researchers interested in these subjects.

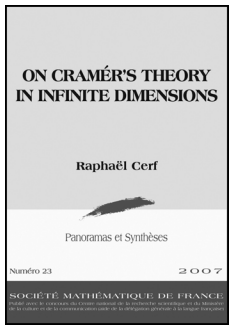
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: B. Grébert, Birkhoff normal form and Hamiltonian PDEs; **F. Hélein**, Four lambda stories, an introduction to completely integrable systems; **D. Iftimie**, Large time behavior in perfect incompressible flows; **D. Robert**, Propagation of coherent states in quantum mechanics and applications; **W.-M. Wang**, Stability of quantum harmonic oscillator under time quasi-periodic perturbation; **X. P. Wang**, Microlocal estimates of the stationary Schrödinger equation in semi-classical limit; **D. Ye**, Some limiting situations for semilinear elliptic equations.

Séminaires et Congrès, Number 15

November 2007, 332 pages, Softcover, ISBN: 978-2-85629-237-2, 2000 *Mathematics Subject Classification:* 34A12, 35B34, 35B35, 35B40, 35J60, 35P25, 35Q30, 35Q35, 37K10, 37K45, 37K55, 76B47, 76D05, 81Q10, **Individual member US$86**, List US$96, Order code SECO/15

Probability



On Cramér's Theory in Infinite Dimensions

Raphaël Cerf, *Université Paris Sud, Orsay, France*

This text is a self-contained account of Cramér's theory in infinite dimensions. The point of view is slightly different from the classical texts of Azencott, Bahadur and Zabell, Dembo and Zeitouni, and Deuschel and Stroock. The authors have been trying to understand the relevance of the topological hypotheses necessary to carry out the core of the theory. They have also drawn some inspiration from the analogy between the large deviation proofs in statistical mechanics and for i.i.d. random variables.

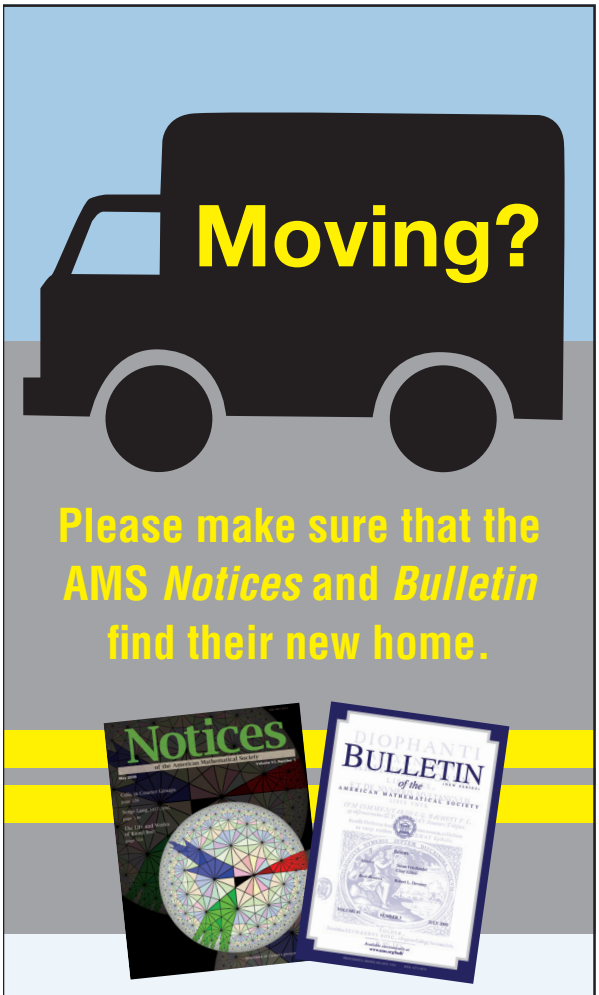
This item will also be of interest to those working in analysis.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Large deviation theory; Topological vector spaces; The model; The weak large deviation principle; The measurability hypotheses; Subadditivity; Proof of Theorem 5.2; Convex regularity; Enhanced upper bound; The Cramér transform $I(\mu, A)$ as a function of μ; The Cramér transform and the Log–Laplace; $I = \Lambda^*$: the discrete case; $I = \Lambda^*$: the smooth case; $I = \Lambda^*$: the finite dimensional case; $I = \Lambda^*$: the infinite dimensions; Exponential tightness; Cramér's theorem in $\mathbb{R}$; Cramér's theorem in $\mathbb{R}^d$; Cramér's theorem in the weak topology; Cramér's theorem in a Banach space; Gaussian measures; Sanov's theorem: autonomous derivation; Cramér's theorem implies Sanov's theorem; Sanov's theorem implies the compact Cramér theorem; Mosco convergence; A. Lusin's theorem; B. The mean of a probability measure; C. Ky Fan's proof of the minimax theorem; Index; Bibliography.

Panoramas et Synthèses, Number 23

November 2007, 159 pages, Softcover, ISBN: 978-2-85629-235-8, 2000 *Mathematics Subject Classification:* 60F10, 46A03, 49J35, **Individual member US$48**, List US$53, Order code PASY/23



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MISSISSIPPI

UNIVERSITY OF MISSISSIPPI
Department of Mathematics

The Department of Mathematics at the University of Mississippi invites applications for three tenure-track positions at the assistant professor level beginning Fall 2008. All candidates should have a Ph.D. (or equivalent) by August 2008 in mathematics or statistics, and outstanding potential in both research and teaching. The department seeks two candidates specializing in number theory or algebra, and one candidate specializing in analysis. Outstanding candidates in other areas complementing our existing strengths, including probability theory, partial differential equations, and knot theory, will also be considered. The successful applicant will teach 6 hours per semester and is also expected to conduct a vigorous research program.

Applicants should complete the application form, cover letter, and curriculum vitae online at `http://jobs.olemiss.edu`. At least one page of a statement on the applicant's research interest, three letters of recommendation about the applicant's research, and at least one letter of recommendation about the applicant's's teaching must be sent to:

University of Mississippi
Department of Mathematics
Chairman of Tenure-Track Search Committee
305 Hume Hall
University, MS 38677

The letters of recommendation must be submitted directly by the referees. Inquiries about this position may be sent to `mdepart@pop.olemiss.edu`. Screening of applications will begin immediately and will continue until the position is filled. For information about the department please visit `http://www.olemiss.edu/depts/mathematics/` and for information about the University of Mississippi see `http://www.olemiss.edu`.

The University of Mississippi is an EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA employer.

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CHILE

PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE
Departamento de Matemáticas

The Department of Mathematics invites applications for two tenure-track positions at the assistant professor level beginning either March or August 2009. Applicants should have a Ph.D. in mathematics, proven research potential either in pure or applied mathematics, and a strong commitment to teaching and research. The regular teaching load for assistant professors consists of three one-semester courses per year, reduced to two during the first two years. The annual salary will be US$36,000. Please send a letter indicating your main research interests, potential collaborators in our department (`http://www.mat.puc.cl`), detailed curriculum vitae, and three letters of recommendation to:

Director
Departamento de Matemáticas
Pontificia Universidad Católica de Chile
Av. Vicuña Mackenna 4860
Santiago, Chile;
fax: (56-2) 552-5916;
email: `mchuaqui@mat.puc.cl`

For full consideration, complete application materials must arrive by May 31, 2008.

000022

SOUTH KOREA

NATIONAL INSTITUTE FOR MATHEMATICAL SCIENCES

National Institute for Mathematical Sciences (NIMS) invites applications for several postdoctorals and full-time researchers beginning in Jan. 2008, or until suitable applicants are found. We seek strong potential researchers in any field of pure and applied mathematics. The salary will be ranged from 31,000,000–39,000,000 Korean won (approx. US$33,000–43,000) for a postdoctoral and 49,000,000–69,000,000 Korean won (approx. US$53,000–75,000) for a full-time researcher. Benefits include health insurance, a family allowance, etc. and housing may be provided at no rental cost. For more information, please visit our webpage `http://www.nims.re.kr`.

NIMS, founded in Oct 2005, promotes interdisciplinary studies and joint research with industries as well as fundamental mathematics, aiming to contribute to our scientific technologies and industrial economic developments.

Applications should include a curriculum vitae, a publication list, and two letters of recommendation. Application materials can be submitted via email `recruit@nims.re.kr` or directly sent to:

Search Committee
National Institute for Mathematical Sciences
628 Daeduk-daero(385-16 Doryong-dong), 3F Tower Koreana,
Yuseong-gu, Daejeon 305-340

000012

Suggested uses for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The 2007 rate is $110 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified ads.

Upcoming deadlines for classified advertising are as follows: April 2008 issue–January 28, 2008; May 2008–February 28, 2008; June/July 2008 issue–April 28, 2008; August 2008 issue–May 28, 2008; September 2008 issue–June 30, 2008; October 2008 issue–July 29, 2008.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

AMS PRESIDENTS

A TIMELINE

AMS presidents play a key role in leading the Society and representing the profession. Browse through the timeline to see each AMS president's page, which includes the institution and date of his/her doctoral degree, a brief note about his/her academic career and honors, and links to more extensive biographical information.

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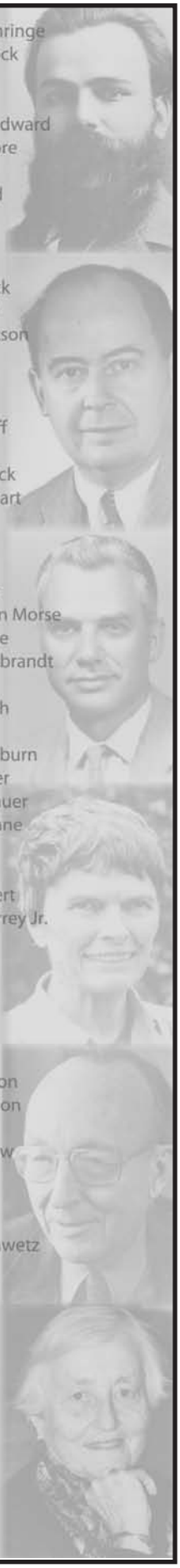

www.ams.org/ams/amspresidents.html

AMERICAN MATHEMATICAL SOCIETY

Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices.* However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

New York, New York

Courant Institute of New York University

March 15–16, 2008

Saturday – Sunday

Meeting #1036

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: January 2008
Program first available on AMS website: January 31, 2008
Program issue of electronic *Notices*: March 2008
Issue of *Abstracts*: Volume 29, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Weinan E, Princeton University, *The density functional theory of electronic structure.*

William Timothy Gowers, University of Cambridge, *Decomposing bounded functions* (Erdős Memorial Lecture).

Ilya Kapovich, University of Illinois at Urbana-Champaign, *Algebraic rigidity and randomness in geometric group theory.*

Ovidiu Savin, Columbia University, *Are solutions to elliptic PDEs always nice?*

Ravi Vakil, Stanford University, *Murphy's Law in algebraic geometry: Badly-behaved moduli spaces.*

Special Sessions

Algebraic Combinatorial Geometry, **Julianna Tymoczko**, University of Iowa, and **Linda Chen**, Ohio State University.

Buckminster Fuller's Synergetics and Mathematics, **Christopher J. Fearnley** and **Joe Clinton**, Synergetics Collaborative.

Computational Fluid Dynamics, **Daljit S. Ahluwalia**, New Jersey Institute of Technology, **James G. Glimm**, State University of New York at Stony Brook, and **Jean E. Taylor**, NYU-Courant Institute.

Difference Equations and Applications, **Michael A. Radin**, Rochester Institute of Technology.

Geometric Topology, **Marco Varisco**, Binghamton University, SUNY, and **David Rosenthal**, St. John's University.

Isoperimetric Problems and PDE, **Bernd Kawohl**, University of Cologne, and **Marcello Lucia**, City University of New York.

L-Functions and Automorphic Forms, **Alina Bucur**, Massachusetts Institute of Technology, **Ashay Venkatesh**, Courant Institute of Mathematical Sciences, **Stephen D. Miller**, Rutgers University, and **Steven J. Miller**, Brown University.

Mathematics of Multiscale Phenomena, **Peter McCoy** and **Reza Malek-Madani**, U.S. Naval Academy.

Nonlinear Elliptic Equations and Geometric Inequalities, **Fengbo Hang**, Princeton University, and **Xiaodong Wang**, Michigan State University.

Nonlinear Waves and their Applications, **Edward D. Farnum**, Kean University, and **Roy Goodman**, New Jersey Institute of Technology.

Northeast Hyperbolic Geometry, **Ara Basmajian**, Hunter College and Graduate Center of the City University of New York, and **Ed Taylor**, Wesleyan University.

Baton Rouge, Louisiana

Louisiana State University, Baton Rouge

March 28–30, 2008

Friday – Sunday

Meeting #1037

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: February 2008
Program first available on AMS website: February 14, 2008
Program issue of electronic *Notices*: March 2008
Issue of *Abstracts*: Volume 29, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Maria Chudnovsky, Columbia University, *Even pairs in perfect graphs*.

Soren Galatius, Stanford University, *Stable homology of automorphism groups of free groups*.

Zhongwei Shen, University of Kentucky, *The celebrated Calderon-Zygmund Lemma revisited*.

Mark Shimozono, Virginia Polytechnic Institute & State University, *Schubert calculus for the affine Grassmannian*.

Special Sessions

Actions of Quantum Algebras, **Lars Kadison**, University of Pennsylvania, and **Alexander Stolin**, University of Gothenburg/Chalmers University of Technology.

Algebraic Geometry of Matrices and Determinants, **Zachariah C. Teitler**, Texas A&M University, and **Kent M. Neuerburg**, Southeastern Louisiana University.

Arrangements and Related Topics, **Daniel C. Cohen**, Louisiana State University.

Current Challenges in Financial Mathematics, **Arkadev Chatterjea**, Kenan-Flagler Business School, The University of North Carolina at Chapel Hill, and **Ambar Sengupta**, Louisiana State University.

Elementary Mathematics from an Advanced Perspective, **James J. Madden**, Louisiana State University, and **Kristin L. Umland**, University of New Mexico.

Gauge Theory in Smooth and Symplectic Topology, **Scott J. Baldridge** and **Brendan E. Owens**, Louisiana State University.

Geometric Group Theory, **Noel Brady**, University of Oklahoma, **Tara E. Brendle**, Louisiana State University, and **Pallavi Dani**, University of Oklahoma.

Geometric and Combinatorial Representation Theory, **Pramod N. Achar** and **Daniel S. Sage**, Louisiana State University.

Harmonic Analysis and Partial Differential Equations in Real and Complex Domains, **Loredana Lanzani**, University of Arkansas, and **Zhongwei Shen**, University of Kentucky.

Knot and 3-Manifold Invariants, **Oliver T. Dasbach** and **Patrick M. Gilmer**, Louisiana State University.

Lie Groups and Holomorphic Function Spaces: Analysis, Geometry, and Mathematical Physics, **Brian C. Hall**, University of Notre Dame, and **Jeffrey J. Mitchell**, Robert Morris University.

Lie Groups, Lie Algebras, and Their Representations, **Mark C. Davidson**, Louisiana State University, and **Ronald Stanke**, Baylor University.

Mathematical Modeling in Biology, **Hongyu He**, Louisiana State University, **Sergei S. Pilyugin**, University of Florida, and **Jianjun Tian**, College of William and Mary.

Matroid Theory, **Bogdan S. Oporowski** and **James G. Oxley**, Louisiana State University.

Nonlinear Evolution Equations of Mathematical Physics, **Jerry L. Bona**, University of Illinois at Chicago, and **Michael M. Tom**, Louisiana State University.

Number Theory and Applications in Other Fields, **Jorge Morales**, Louisiana State University, **Robert Osburn**, University College Dublin, and **Robert V. Perlis** and **Helena Verrill**, Louisiana State University.

Radon Transforms, Tomography, and Related Geometric Analysis, **Fulton B. Gonzalez**, Tufts University, **Isaac Pesenson**, Temple University, **Todd Quinto**, Tufts University, and **Boris S. Rubin**, Louisiana State University.

Recent Advances in Knot Theory: Quandle Theory and Categorified Knot Invariants, **Sam Nelson**, Pomona College, and **Alissa S. Crans**, Loyola Marymount University.

Recent Trends in Partial Differential Equations, **Wai Yuen Chan**, Southeast Missouri State University.

Structural Graph Theory, **Maria Chudnovsky**, Columbia University.

Wavelets, Frames, and Multi-Scale Constructions, **Palle E. T. Jorgensen**, University of Iowa, **David R. Larson**, Texas A&M University, **Gestur Olafsson**, Louisiana State University, and **Darrin Speegle**, Saint Louis University.

White Noise Distribution Theory and Orthogonal Polynomials, **Jeremy J. Becnel**, Stephen F. Austin State University, and **Aurel I. Stan**, The Ohio State University at Marion.

Bloomington, Indiana

Indiana University

April 5–6, 2008

Saturday – Sunday

Meeting #1038

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2008
Program first available on AMS website: February 21, 2008
Program issue of electronic *Notices*: April 2008
Issue of *Abstracts*: Volume 29, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: February 12, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Shi Jin, University of Wisconsin, *Title to be announced.*

Michael J. Larsen, Indiana University, *Solving equations in finite groups.*

Mircea Mustata, University of Michigan, *Title to be announced.*

Margaret H. Wright, Courant Institute, NYU, *Nonderivative optimization: Mathematics, heuristics, or hack?*

Special Sessions

Algebraic Aspects of Coding Theory (Code: SS 5A), **Heide Gluesing-Luerssen**, University of Kentucky, and **Roxana Smarandache**, San Diego State University.

Algebraic K-theory and Nil groups in Algebra and Topology (Code: SS 20A), **James F. Davis**, Indiana University, and **Christian Haesemeyer**, University of Illinois at Chicago.

Applications of Ring Spectra (Code: SS 16A), **Randy McCarthy**, University of Illinois at Urbana-Champaign, and **Ayelet Lindenstrauss**, Indiana University.

Birational Algebraic Geometry (Code: SS 3A), **Mircea I. Mustata**, University of Michigan, and **Mihnea Popa**, University of Illinois at Chicago.

Combinatorial Representation Theory, Topological Combinatorics, and Interactions Between Them (Code: SS 13A), **Patricia Hersh**, Indiana University, **Cristian P. Lenart**, State University of New York at Albany, and **Michelle Wachs**, University of Miami.

Combinatorial and Geometric Aspects of Commutative Algebra (Code: SS 1A), **Juan Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

D-modules (Code: SS 14A), **Mathias Schulze**, Oklahoma State University, and **Hans Ulrich Walther**, Purdue University.

Discrete Structures in Conformal Dynamics and Geometry (Code: SS 11A), **Kevin M. Pilgrim**, Indiana University, and **William J. Floyd**, Virginia Polytech Institute & State University.

Financial Mathematics (Code: SS 22A), **Victor Goodman**, Indiana University, and **Kiseop Lee**, University of Louisville.

Finite Element Methods and Applications (Code: SS 9A), **Nicolae Tarfulea**, Purdue University Calumet, and **Sheng Zhang**, Wayne State University.

Geometry and Dynamics (Code: SS 7A), **Chris Connell**, **David M. Fisher**, and **Marlies Gerber**, Indiana University.

Graph Theory (Code: SS 17A), **Jozsef Balogh**, University of Illinois at Urbana-Champaign, **Hemanshu Kaul**, Illinois Institute of Technology, and **Tao Jiang**, Miami University.

Harmonic Analysis Methods in Mathematical Fluid Dynamics (Code: SS 21A), **Zoran Grujic** and **Irina Mitrea**, University of Virginia.

Harmonic Analysis and Related Topics (Code: SS 8A), **Ciprian Demeter**, Institute for Advance Study, and **Nets Katz**, Indiana University.

Hyperbolic and Kinetic Equations (Code: SS 2A), **Shi Jin** and **Marshall Slemrod**, University of Wisconsin.

Mathematical Modeling of Cell Motility: From Molecular Events to Mechanical Movement (Code: SS 18A), **Anastasios Matzavinos**, Ohio State University, and **Nicoleta Eugenia Tarfulea**, Purdue University Calumet.

Minimal and CMC Surfaces (Code: SS 19A), **Bruce Michael Solomon** and **Matthias Weber**, Indiana University, and **Adam Weyhaupt**, Southern Illinois University.

Operator Algebras and Applications (Code: SS 12A), **Hari Bercovici**, Indiana University, **Marius Dadarlat**, Purdue University, and **Mihai Popa**, Indiana University.

Probability and Spatial Systems (Code: SS 10A), **Russell D. Lyons**, Indiana University, and **Alexander Holroyd**, University of British Columbia.

Recent Advances in Classical and Geophysical Fluid (Code: SS 15A), **Roger Temam** and **Shouhong Wang**, Indiana University.

Some Mathematical Problems in Biology, from Macromolecules to Ecosystems (Code: SS 6A), **Santiago David Schnell** and **Roger Temam**, Indiana University.

Weak Dependence in Probability and Statistics (Code: SS 4A), **Richard C. Bradley** and **Lahn T. Tran**, Indiana University.

Claremont, California

Claremont McKenna College

May 3–4, 2008
Saturday – Sunday

Meeting #1039
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: March 2008
Program first available on AMS website: March 20, 2008
Program issue of electronic *Notices*: May 2008
Issue of *Abstracts*: Volume 29, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: March 11, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Michael Bennett, University of British Columbia, *Title to be announced*.

Chandrashekhar Khare, University of Utah, *Title to be announced*.

Huaxin Lin, University of Oregon, *Title to be announced*.

Anne Schilling, University of California Davis, *Title to be announced*.

Special Sessions

Algebraic Combinatorics (Code: SS 9A), **Anne Schilling**, University of California Davis, and **Michael Zabrocki**, York University.

Applications of Delay-Differential Equations to Models of Disease (Code: SS 8A), **Ami Radunskaya**, Pomona College.

Combinatorics of Partially Ordered Sets (Code: SS 6A), **Timothy M. Hsu**, San Jose State University, **Mark J. Logan**, University of Minnesota-Morris, and **Shahriar Shahriari**, Pomona College.

Diophantine Problems and Discrete Geometry (Code: SS 3A), **Matthias Beck**, San Francisco State University, and **Lenny Fukshansky**, Texas A&M University.

Dynamical Systems and Differential Equations (Code: SS 1A), **Adolfo Rumbos**, Pomona College, **Mario Martelli**, Claremont McKenna College, and **Alfonso Castro**, Harvey Mudd College.

Hopf Algebras and Quantum Groups (Code: SS 5A), **Gizem Karaali**, Pomona College, **M. Susan Montgomery**, University of Southern California, and **Serban Raianu**, California State University Dominguez Hills.

Knot Theory and the Topology of 3-manifolds (Code: SS 7A), **Sam Nelson**, Pomona College, **David Bachman**, Pitzer College, **Erica Flapan**, Pomona College, **Jim Hoste**, Pitzer College, and **Patrick Shanahan**, Loyola Marymount University.

Operators, Functions and Linear Spaces (Code: SS 2A), **Asuman G. Aksoy**, Claremont McKenna College, **Stephan R. Garcia**, Pomona College, **Michael Davlin O'Neill**, Claremont McKenna College, and **Winston C. Ou**, Scripps College.

Recent Developments in Riemannian and Kaehlerian Geometry (Code: SS 4A), **Hao Fang**, University of Iowa, **Zhiqin Lu**, University of California, Irvine, **Dragos-Bogdan Suceava**, California State University Fullerton, and **Mihaela B. Vajiac**, Chapman University.

Accommodations

Participants should make their own arrangements directly with a hotel of their choice as early as possible. Special rates (rates do not include any applicable taxes) 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) meeting**. Cancellation and early checkout penalties may apply; be sure to check the policy when you make your reservations. **All rooms will be on a space available basis after the deadline given**.

Doubletree Hotel Claremont, 555 West Foothill Blvd, Claremont, CA, 91711; 909-626-2411, fax: 909-624 0756; US$189 per night, single/double. This is the only hotel within walking distance to the meeting. **Deadline for reservations is April 1, 2008**.

Due to other events taking place at the Claremont Colleges other hotels closest to campus (within walking distance) were unable to guarantee rooms for our group. The hotels listed below are near the Ontario International Airport and are not within walking distance to the meeting. The airport is approximately ten miles from the campus.

Best Western, 209 N. Vineyard Avenue, Ontario, CA 91764; 909-937-6800 or toll free 800-780-7234; US$84 per night, single/double and includes a daily complimentary continental breakfast and airport shuttle (Ontario Airport). **Deadline for reservations is April 14, 2008**.

Doubletree Hotel Ontario Airport, 222 North Vineyard Ave, Ontario, CA 91764-4431; 909-937-0900, fax: 909-937-1999; US$84 single/double, complimentary airport shuttle to/from Ontario Airport. **Deadline for reservations is April 2, 2008**.

Marriott Ontario Airport, 2200 E. Holt Boulevard, Ontario, CA 91761; 909-975-5000 or toll-free: 800-284-8811; US$95 per night, single/double, complimentary airport shuttle to/from Ontario Airport. Reservations can also be made at https://resweb.passkey.com/go/AmericanMath. **Deadline for reservations is April 3, 2008**.

A list of additional hotels in the area for those interested can be found at: http://www.claremontmckenna.edu/about/claremont-guide/lodging.php.

Food Service

Collins Dining Hall on CMC campus (see the campus map) should be open for brunch (10:30 a.m.–12:30 p.m.) and dinner (4:45 p.m.–6:15 p.m.) on both Saturday and Sunday, and accessible to meeting participants. The dining hall only accepts cash as a form of payment. There is also a variety of restaurants in the center of Claremont, called The Village (Yale and Harvard Avenues between First Street and Bonita Avenue, as well as the adjacent "Packing House" area across the Indian Hill Boulevard), which is a 15-minute walk, or a very short drive away from campus. A list of local restaurants can be found at: http://www.claremontmckenna.edu/about/claremont-guide/restaurants.php.

Local Information

For further information please consult the websites maintained by Claremont McKenna: http://www.mckenna.edu and http://www.claremontmckenna.edu/about/. A detailed printable campus map can be found at: http://www.claremontmckenna.edu/about/campusmaps/print/printmap.php. For additional area maps, see: http://www.claremontmckenna.edu/about/maps-guides.php. For campus maps of other Claremont Colleges, see: http://www.claremontmckenna.edu/about/campusmaps/.

Other Activities

AMS Book Sale (Founders Room, Bauer North): 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

Conference participants will be able to use the two parking lots adjacent to Bauer North and South buildings on the east side, the entrances to both of which are from Ninth Street (see the campus map). Parking should be free for conference participants, and the two lots should have sufficient space to accommodate everyone. There is additional street parking available along Mills Avenue, Columbia Avenue, and other local streets, especially west of campus.

Registration and Meeting Information

The meeting will be held at Claremont McKenna College (CMC). All of the activities for the meeting, including registration, invited lectures, special sessions, and book exhibit will take place in the adjacent buildings called Bauer North and Bauer South. All lecture rooms will be equipped with computer projectors and overhead projectors, screens, blackboards and/or white boards.

The registration desk will be in the lobby of Bauer North and will be open 7:30 a.m.–4:00 p.m. on Saturday, May 3, and 8:00 a.m.–noon on Sunday, May 5. Fees are US$40 for AMS or CMS members, US$60 for nonmembers; and US$5 for students/unemployed/emeritus, payable on site by cash, check or credit card.

Travel

Los Angeles International Airport (LAX) is located approximately 40 miles from Claremont and is served by all major airlines. Shuttle service is available from LAX to the campus for approximately US$104 round-trip. For reservations/information visit http://www.supershuttle.com/. Ontario International Airport is located approximately 10 miles from the Claremont McKenna campus. Taxi service is available and most hotels offer free shuttle service. Taxis in Claremont include: Byrd Limousine Service, 909-621-3502, http://www.byrdlimo.com, and Yellow Cab, 909-621-0699.

Driving

I-10 WESTBOUND (from San Bernardino)

Stay on I-10 West (toward Los Angeles) until you reach the **Indian Hill/Claremont** exit. Turn right (north) off the exit. You will be on Indian Hill; continue north on Indian Hill for 2 miles until you reach **Foothill Blvd.** Turn right onto Foothill Blvd. and follow it until you reach **Claremont Blvd.** Turn right on Claremont Blvd.—after a quarter of a mile you will see a sign which reads **"Claremont McKenna College/Pitzer College"**. Turn right at the entrance. Continue west past the parking lot for a couple of blocks; you will see Bauer Center (500 East 9th Street), a large three story building, on your left.

I-10 EASTBOUND (from Los Angeles)

Stay on I-10 East (toward San Bernardino) until you reach the **Indian Hill/Claremont** exit. Turn left (north) off the exit. You will be on Indian Hill; continue north on Indian Hill for 2 miles until you reach **Foothill Blvd.** Turn right onto Foothill Blvd. and follow it until you reach **Claremont Blvd.** Turn right on Claremont Blvd.—after a quarter of a mile you will see a sign which reads **"Claremont McKenna College/Pitzer College"**. Turn right at the entrance. Continue west past the parking lot for a couple of blocks; you will see Bauer Center (500 East 9th Street), a large three story building, on your left.

I-210 WESTBOUND (from San Bernardino)

Stay on the I-210 West (towards Pasadena) until you reach the **Towne Avenue** exit. Turn left off the exit. You will be on Towne; continue south for about one mile until you reach **Foothill Blvd**. Turn left on **Foothill Blvd**. Continue east on Foothill for about one and a quarter miles until you reach **Claremont Blvd**. Turn right on Claremont Blvd—after a quarter of a mile you will see a sign which reads **"Claremont McKenna College/Pitzer College"**. Turn right at the entrance. Continue west past the parking lot for a couple of blocks; you will see Bauer Center (500 East 9th Street), a large three story building, on your left.

I-210 EASTBOUND (from Pasadena)

Stay on the I-210 East (towards San Bernardino) until you reach the **Towne Avenue** exit. Turn right off the exit. You will be on Towne; continue south for about one mile until you reach **Foothill Blvd**. Turn left on **Foothill Blvd**. Continue east on Foothill for about one and a quarter miles until you reach **Claremont Blvd**. Turn right on Claremont Blvd—after a quarter of a mile you will see a sign which reads **"Claremont McKenna College/Pitzer College".** Turn right at the entrance. Continue west past the parking lot for a couple of blocks; you will see Bauer Center (500 East 9th Street), a large three story building, on your left.

Car Rental

Avis is the official car rental company for the sectional meeting in Claremont. All rates include unlimited free mileage. Weekend daily rates are available from noon Thursday–Monday at 11:59 p.m. and start at US$21.00 per day. Rates for this meeting are effective April 26, 2008–May 11, 2008. 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 **J098887**.

Weather

Claremont's climate is semi-desert and in early October the days are warm and the nights are cool. The probability of precipitation is low.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at `http://www7.nationalacademies.org/visas/Traveling_to_US.html` and `http://travel.state.gov/visa/index.html`. If you need a preliminary conference invitation in order to secure a visa, please send your request to `dls@ams.org`.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

*Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

– family ties in home country or country of legal permanent residence

– property ownership

– bank accounts

– employment contract or statement from employer stating that the position will continue when the employee returns;

*Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

*Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

*Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

*If travel plans will depend on early approval of the visa application, specify this at the time of the application;

*Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the websites above for the most up-to-date information.

Rio de Janeiro, Brazil

Instituto Nacional de Matemática Pura e Aplicada (IMPA)

June 4–7, 2008

Wednesday – Saturday

Meeting #1040

Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: February 2008
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: January 31, 2008
For abstracts: January 31, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

AMS Invited Addresses

Ruy Exel, Universidade Federal de Santa Catarina, *Noncommutative dynamics*.

Velimir Jurdjevic, University of Toronto, *Intergrable Hamiltionian systems on symmetric spaces*.

Andre Nachbin, IMPA, *Wave dynamics: Asymptotics with differential operators and solutions*.

Richard M. Schoen, Stanford University, *Riemannian manifolds of positive curvature*.

Ivan P. Shestakov, University of Sao Paulo, *Automorphisms of free algebras*.

Amie Wilkinson, Northwestern University, *Partially hyperbolic dynamics*.

Special Sessions

Commutative Algebra and Algebraic Geometry, **Izzet Coskun**, University of Illinois at Chicago, and **Israel Vainsencher**, UFMG.

Complexity, **Gregorio Malajovich**, Universidade Federal do Rio de Janeiro, and **J. Maurice Rojas**, Texas A&M University.

Control and Related Topics, **Jair Koiller**, FGV, and **Velimir Jurdgevic**, University of Toronto.

Extremal and Probablistic Combinatorics, **Bela Bollobas**, The University of Memphis, and **Yoshiharu Kohayakawa**, University of Sao Paulo.

Geometry, Representation Theory, and Mathematical Physics, **Henrique Bursztyn**, IMPA, **Anthony Licata**, Stanford University, and **Alistair Savage**, University of Ottawa.

Group Theory, **Rostislav I. Grigorchuk**, **Volodymyr Nekrashevych**, and **Zoran Sunic**, Texas A&M University, and **Said N. Sidki** and **Pavel Zalesskii**, University of Brasilia.

History and Philosophy of Mathematics, **Sergio Nobre**, Universidade Estadual Paulista-Rio Claro, and **James J. Tattersall**, Providence College.

Lie and Jordan Algebras and Their Applications, **Ivan K. Dimitrov**, Queen's University, **Vyacheslav Futorny**, University of Sao Paulo, and **Vera Serganova**, University of California Berkeley.

Low Dimensional Dynamics, **Andre de Carvalho**, University of Sao Paulo, and **Misha Lyubich** and **Marco Martens**, SUNY at Stony Brook.

Low Dimensional Topology, **Louis H. Kauffman**, University of Illinois at Chicago, and **Pedro M. Lopes**, Instituto Superior Tecnico, Technical University of Lisbon.

Mathematical Fluid Dynamics, **Susan J. Friedlander**, University of Southern California, **Milton Lopes Filho** and **Helena Nussenzveig Lopes**, University of Campinus, and **Maria Elena Schonbek**, University of California Santa Cruz.

Mathematical Methods in Biology, **Julie C. Mitchell**, University of Wisconsin-Madison, and **Max O. Souza**, Universidade Federal Fluminense.

Mathematical Methods in Image Processing, **Stacey Levine**, Duquesne University, and **Celia A. Zorzo Barcelos**, Federal University of Uberlândia.

Nonlinear Dispersive Equations, **Felipe Linares**, Institute for Pure-Applied Mathematics, and **Gustave A. Ponce**, University of California Santa Barbara.

Partial Differential Equations, Harmonic Analysis, and Related Questions, **Haroldo R. Clark**, Universidade Federal Fluminense, **Michael Stessin**, University at Albany, and **Geraldo Soares de Souza**, Auburn University.

Several Complex Variables and Partial Differential Equations, **Shiferaw Berhanu**, Temple University, and **Jorge Hounie**, Federal University of San Carlos.

Vancouver, Canada

University of British Columbia and the Pacific Institute of Mathematical Sciences (PIMS)

October 4–5, 2008

Saturday – Sunday

Meeting #1041

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2008
Program first available on AMS website: August 21, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines

For organizers: March 9, 2008
For consideration of contributed papers in Special Sessions: June 17, 2008
For abstracts: August 12, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Freeman Dyson, Institute for Advanced Study, *Birds and Frogs* (Einstein Public Lecture in Mathematics).

Richard Kenyon, Brown University, *Title to be announced.*

Alexander S. Kleshchev, University of Oregon, *Title to be announced.*

Mark Lewis, University of Alberta, *Title to be announced.*

Audrey A. Terras, University of California San Diego, *Title to be announced.*

Special Sessions

Algebraic Topology and Related Topics (Code: SS 3A), **Alejandro Adem**, University of British Columbia, and **Stephen Ames Mitchell**, University of Washington.

Combinatorial Representation Theory (Code: SS 1A), **Sara C. Billey**, University of Washington, **Alexander S. Kleshchev**, University of Oregon, and **Stephanie Jane Van Willigenburg**, University of British Columbia.

Hilbert Functions and Free Resolutions (Code: SS 4A), **Susan Cooper**, California Polytechnic State University, **Christopher A. Francisco**, Oklahoma State University, and **Benjamin P. Richert**, California Polytechnic State University.

Noncommutative Algebra and Geometry (Code: SS 6A), **Jason Bell**, Simon Fraser University, and **James Zhang**, University of Washington.

Probability and Statistical Mechanics (Code: SS 7A), **David Brydges**, University of British Columbia, and **Richard Kenyon**, Brown University.

Special Functions and Orthogonal Polynomials (Code: SS 2A), **Mizanur Rahman**, Carleton University, and **Diego Dominici**, State University of New York New Paltz.

Wavelets, Fractals, Tilings and Spectral Measures (Code: SS 5A), **Dorin Ervin Dutkay**, University of Central Florida, **Palle E. T. Jorgensen**, University of Iowa, and **Ozgur Yilmaz**, University of British Columbia.

Middletown, Connecticut

Wesleyan University

October 11–12, 2008

Saturday – Sunday

Meeting #1042

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2008
Program first available on AMS website: August 28, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines

For organizers: March 11, 2008
For consideration of contributed papers in Special Sessions: June 24, 2008
For abstracts: August 19, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Pekka Koskela, University of Jyväskylä, *Title to be announced.*

Monika Ludwig, Polytechnic University New York, *Title to be announced.*

Duong Hong Phong, Columbia University, *Title to be announced.*

Thomas W. Scanlon, University of California, Berkeley, *Title to be announced.*

Special Sessions

Algebraic Geometry (Code: SS 1A), **Eyal Markman** and **Jenia Tevelev**, University of Massachusetts, Amherst.

Complex geometry and partial differential equations. (Code: SS 3A), **Jacob Sturm**, Rutgers University.

Number Theory (Code: SS 4A), **Wai Kiu Chan** and **David Pollack**, Wesleyan University.

Riemannian and Lorentzian Geometries (Code: SS 2A), **Ramesh Sharma**, University of New Haven, and **Philippe Rukimbira**, Florida International University.

Kalamazoo, Michigan

Western Michigan University

October 17–19, 2008

Friday – Sunday

Meeting #1043

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2008
Program first available on AMS website: September 4, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines

For organizers: March 17, 2008
For consideration of contributed papers in Special Sessions: July 1, 2008
For abstracts: August 26, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

M. Carme Calderer, University of Minnesota, *Title to be announced.*

Alexandru Ionescu, University of Wisconsin, *Title to be announced.*

Boris S. Mordukhovich, Wayne State University, *Title to be announced.*

David Nadler, Northwestern University, *Title to be announced.*

Special Sessions

Affine Algebraic Geometry (Code: SS 9A), **Shreeram Abhyankar**, Purdue University, **Anthony J. Crachiola**, Saginaw Valley State University, and **Leonid G. Makar-Limanov**, Wayne State University.

Computation in Modular Representation Theory and Cohomology (Code: SS 2A), **Christopher P. Bendel**, University of Wisconsin-Stout, **Terrell L. Hodge**, Western Michigan University, **Brian J. Parshall**, University of Virginia, and **Cornelius Pillen**, University of South Alabama.

Graph Labeling, Graph Coloring, and Topological Graph Theory (Code: SS 5A), **Arthur T. White**, Western Michigan University, and **David L. Craft**, Muskingum College.

Homotopy Theory (Code: SS 8A), **Michele Intermont**, Kalamazoo College, and **John R. Martino** and **Jeffrey A. Strom**, Western Michigan University.

Mathematical Finance (Code: SS 3A), **Qiji J. Zhu**, Western Michigan University, and **George Yin**, Wayne State University.

Mathematical Knowledge for Teaching (Code: SS 7A), **Kate Kline** and **Christine Browning**, Western Michigan University.

Nonlinear Analysis and Applications (Code: SS 1A), **S. P. Singh**, University of Western Ontario, and **Bruce B. Watson**, Memorial University.

Optimization/Midwest Optimization Seminar (Code: SS 6A), **Jay S. Treiman** and **Yuri Ledyaev**, Western Michigan University, and **Ilya Shvartsman**, Penn State Harrisburg.

Variational Analysis and its Applications (Code: SS 4A), **Yuri Ledyaev** and **Jay S. Treiman**, Western Michigan University, **Ilya Shvartsman**, Penn State Harrisburg, and **Qiji J. Zhu**, Western Michigan University.

Huntsville, Alabama

University of Alabama, Huntsville

October 24–26, 2008

Friday – Sunday

Meeting #1044

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: August 2008
Program first available on AMS website: September 11, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines

For organizers: March 24, 2008
For consideration of contributed papers in Special Sessions: July 8, 2008
For abstracts: September 2, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Mark Behrens, Massachusetts Institute of Technology, *Title to be announced.*

Anthony Michael Bloch, University of Michigan, Ann Arbor, *Title to be announced.*

Roberto Camassa, University of North Carolina, Chapel Hill, *Title to be announced.*

Mark V. Sapir, Vanderbilt University, *Title to be announced.*

Special Sessions

Mathematical Biology: Modeling, Analysis, and Simulations (Code: SS 1A), **Jia Li**, University of Alabama in Huntsville, **Azmy S. Ackleh**, University of Louisiana at Lafayette, and **Maia Martcheva**, University of Florida.

Shanghai, People's Republic of China

Fudan University

December 17–21, 2008

Wednesday – Sunday

Meeting #1045

First Joint International Meeting Between the AMS and the Shanghai Mathematical Society
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: June 2008
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: 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

L. Craig Evans, University of California Berkeley, *Title to be announced.*

Zhi-Ming Ma, Chinese Academy of Sciences, *Title to be announced.*

Richard Schoen, Stanford University, *Title to be announced.*

Richard Taylor, Harvard University, *Title to be announced.*

Xiaoping Yuan, Fudan University, *Title to be announced.*

Weiping Zhang, Chern Institute, *Title to be announced.*

Special Sessions

Biomathematics: Newly Developed Applied Mathematics and New Mathematics Arising from Biosciences, **Banghe Li**, Chinese Academy of Sciences, **Reinhard C. Laubenbacher**, Virginia Bioinformatics Institute, and **Jianju Tian**, College of William and Mary.

Combinatorics and Discrete Dynamical Systems, **Reinhard C. Laubenbacher**, Virginia Bioinformatics Institute, **Klaus Sutner**, Carnegie Mellon University, and **Yaokun Wu**, Shanghai Jiao Tong University.

Dynamical Systems Arising in Ecology and Biology, **Qishao Lu**, Beijing University of Aeronautics & Astronautics, and **Zhaosheng Feng**, University of Texas-Pan American.

Harmonic Analysis and Partial Differential Equations with Applications, **Yong Ding**, Beijing Normal University, and **Guo-Zhen Lu**, Wayne State University.

Integrable System and Its Applications, **En-Gui Fan**, Fudan University, **Sen-Yue Lou**, Shanghai Jiao Tong University and Ningbo University, and **Zhi-Jun Qiao**, University of Texas-Pan American.

Integral and Convex Geometric Analysis, **Deane Yang**, Polytechnic University, and **Jiazu Zhou**, Southwest University.

Nonlinear Systems of Conservation Laws and Related Topics, **Gui-Qiang Chen**, Northwestern University, and **Shuxing Chen** and **Yi Zhou**, Fudan University.

Quantum Algebras and Related Topics, **Naihuan N. Jing**, North Carolina State University, **Quanshui Wu**, Fudan University, and **James J. Zhang**, University of Washington.

Recent Developments in Nonlinear Dispersive Wave Theory, **Jerry Bona**, University of Illinois at Chicago, **Bo Ling Guo**, Institute of Applied Physics and Computational Mathematics, **Shu Ming Sun**, Virginia Polytech Institute and State University, and **Bingyu Zhang**, University of Cincinnati.

Several Topics in Banach Space Theory, **Gerard J. Buskes** and **Qingying Bu**, University of Mississippi, and **Lixin Cheng**, Xiamen University.

Stochastic Analysis and its Application, **Jiangang Ying**, Fudan University, and **Zhenqing Chen**, University of Washington.

Washington, District of Columbia

Marriott Wardman Park Hotel and Omni Shoreham Hotel

January 5–8, 2009

Monday – Thursday

Meeting #1046

Joint Mathematics Meetings, including the 115th Annual Meeting of the AMS, 92nd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Bernard Russo
Announcement issue of *Notices*: October 2008
Program first available on AMS website: November 1, 2008
Program issue of electronic *Notices*: January 2009
Issue of *Abstracts*: Volume 30, Issue 1

Deadlines

For organizers: April 1, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Urbana, Illinois

University of Illinois at Urbana-Champaign

March 27–29, 2009

Friday – Sunday
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 29, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Special Sessions

Geometric Group Theory (Code: SS 2A), **Sergei V. Ivanov**, **Ilya Kapovich**, **Igor Mineyev**, and **Paul E. Schupp**, University of Illinois at Urbana-Champaign.

q-Series and Partitions (Code: SS 1A), **Bruce Berndt**, University of Illinois at Urbana-Champaign.

Raleigh, North Carolina

North Carolina State University

April 4–5, 2009

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 4, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

San Francisco State University

April 25–26, 2009
Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: September 25, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Worcester, Massachusetts

Worcester Polytechnic Institute

April 25–26, 2009
Saturday – Sunday
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: September 25, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Waco, Texas

Baylor University

October 16–18, 2009
Friday – Sunday
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: March 17, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Boca Raton, Florida

Florida Atlantic University

October 30 – November 1, 2009
Friday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: March 30, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Riverside, California

University of California

November 7–8, 2009
Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: April 6, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 6–9, 2010

Wednesday – Saturday
Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society of Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2009
Program first available on AMS website: November 1, 2009
Program issue of electronic *Notices*: January 2010
Issue of *Abstracts*: Volume 31, Issue 1

Deadlines

For organizers: April 1, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lexington, Kentucky

University of Kentucky

March 27–28, 2010

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 28, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

St. Paul, Minnesota

Macalester College

April 10–11, 2010

Saturday – 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: September 10, 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

MATHEMATICAL MOMENTS

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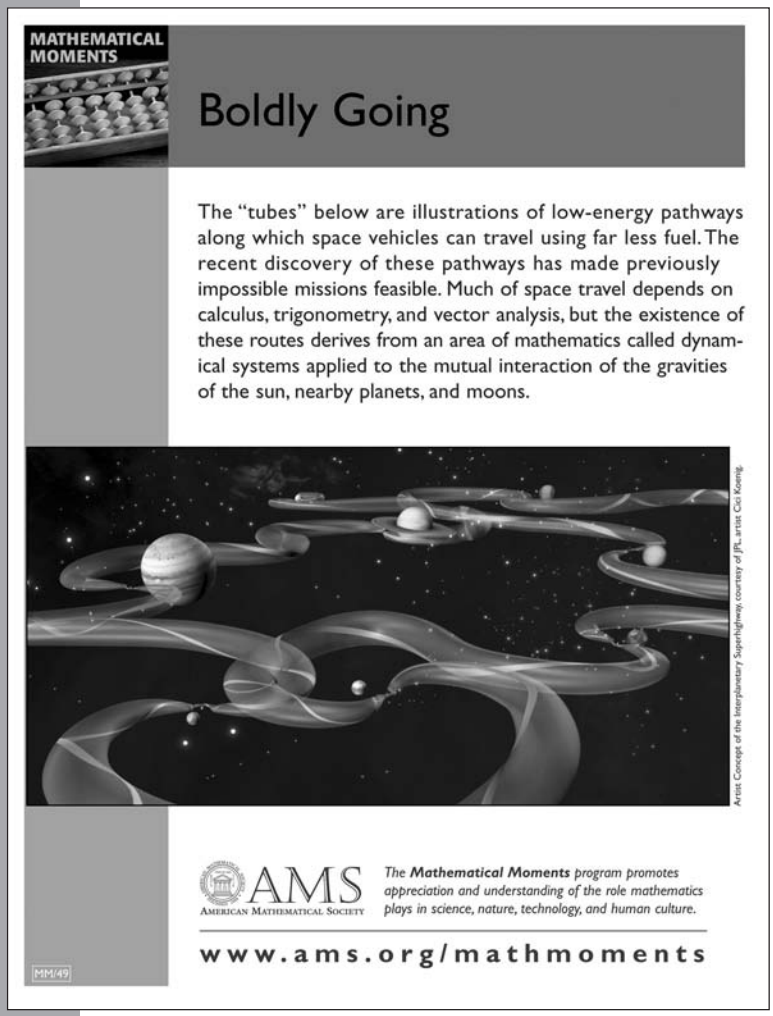

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Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: susan@math.nwu.edu; telephone: 312-996-3041.

Eastern Section: Lesley M. Sibner, Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@duke.poly.edu; telephone: 718-260-3505.

Southeastern Section: Matthew Miller, Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001, e-mail: miller@math.sc.edu; telephone: 803-777-3690.

2009 Washington, DC, Meeting: Bernard Russo, Department of Mathematics, University of California, Irvine, CA 92697-3875, e-mail: brusso@math.uci.edu; telephone: 949-824-5505.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at** www.ams.org/meetings/.

Meetings:

2008

March 15–16	New York, New York	p. 425
March 28–30	Baton Rouge, Louisiana	p. 426
April 4–6	Bloomington, Indiana	p. 427
May 3–4	Claremont, California	p. 428
June 4–7	Rio de Janeiro, Brazil	p. 430
October 4–5	Vancouver, Canada	p. 431
October 11–12	Middletown, Connecticut	p. 432
October 17–19	Kalamazoo, Michigan	p. 432
October 24–26	Huntsville, Alabama	p. 433
December 17–21	Shanghai, People's Republic of China	p. 433

2009

January 5–8	Washington, DC Annual Meeting	p. 434
March 27–29	Urbana, Illinois	p. 434
April 4–5	Raleigh, North Carolina	p. 434
April 25–26	San Francisco, California	p. 435
Oct. 30–Nov. 1	Worcester, Massachusetts	p. 435
Oct. 16–18	Waco, Texas	p. 435
Oct. 30–Nov. 1	Boca Raton, Florida	p. 435
Nov. 7–8	Riverside, California	p. 435

2010

January 6–9	San Francisco, California Annual Meeting	p. 436
March 27–29	Lexington, Kentucky	p. 436
March April 10–11	St. Paul, Minnesota	p. 436

2011

January 5–8	New Orleans, Louisiana Annual Meeting	p. 436

2012

January 4–7	Boston, Massachusetts Annual Meeting	p. 437

2013

January 9–12	San Diego, California Annual Meeting	p. 437

2014

January 15–18	Baltimore, Maryland Annual Meeting	p. 437

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 95 in the January 2008 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarly coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)
Co-sponsored conferences:
February 14–18, 2008: AAAS Meeting, Boston MA.
June 30–July 3, 2008: Tenth Conference on p-adic and Non-Archimedean Analysis, Michigan State University. See http://bt.pa.msu.edu/NA08/ for more information.

CAMBRIDGE

New Mathematics Titles
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J-Contractive Matrix Valued Functions and Related Topics
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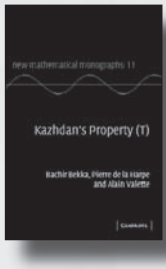
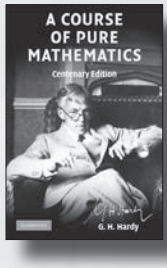


A Course of Pure Mathematics, Centenary edition
Tenth Edition
G.H. Hardy, Foreword by T.W. Körner
Cambridge Mathematical Library
$45.00: Paperback: 978-0-521-72055-7: 520 pp.



An Introduction to Involutive Structures
Shiferaw Berhanu, Paulo D. Cordaro, and Jorge Hounie
New Mathematical Monographs
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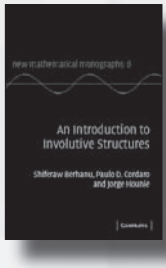

Asymptotic Analysis of Random Walks
Heavy-Tailed Distributions
A. A. Borovkov and K. A. Borovkov
Encyclopedia of Mathematics and its Applications
$190.00: Hardback: 978-0-521-88117-3: 656 pp.

Harmonic Analysis on Finite Groups
Representation Theory, Gelfand Pairs and Markov Chains
Tullio Ceccherini-Silberstein, Fabio Scarabotti, and Filippo Tolli
Cambridge Studies in Advanced Mathematics
$80.00: Hardback: 978-0-521-88336-8: 448 pp.

Generalized Linear Models for Insurance Data
Piet de Jong and Gillian Z. Heller
International Series on Actuarial Science
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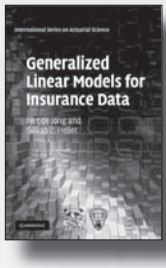
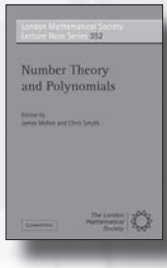


Number Theory and Polynomials
Edited by James McKee and Chris Smyth
London Mathematical Society Lecture Note Series
$75.00: Paperback: 978-0-521-71467-9: 360 pp.



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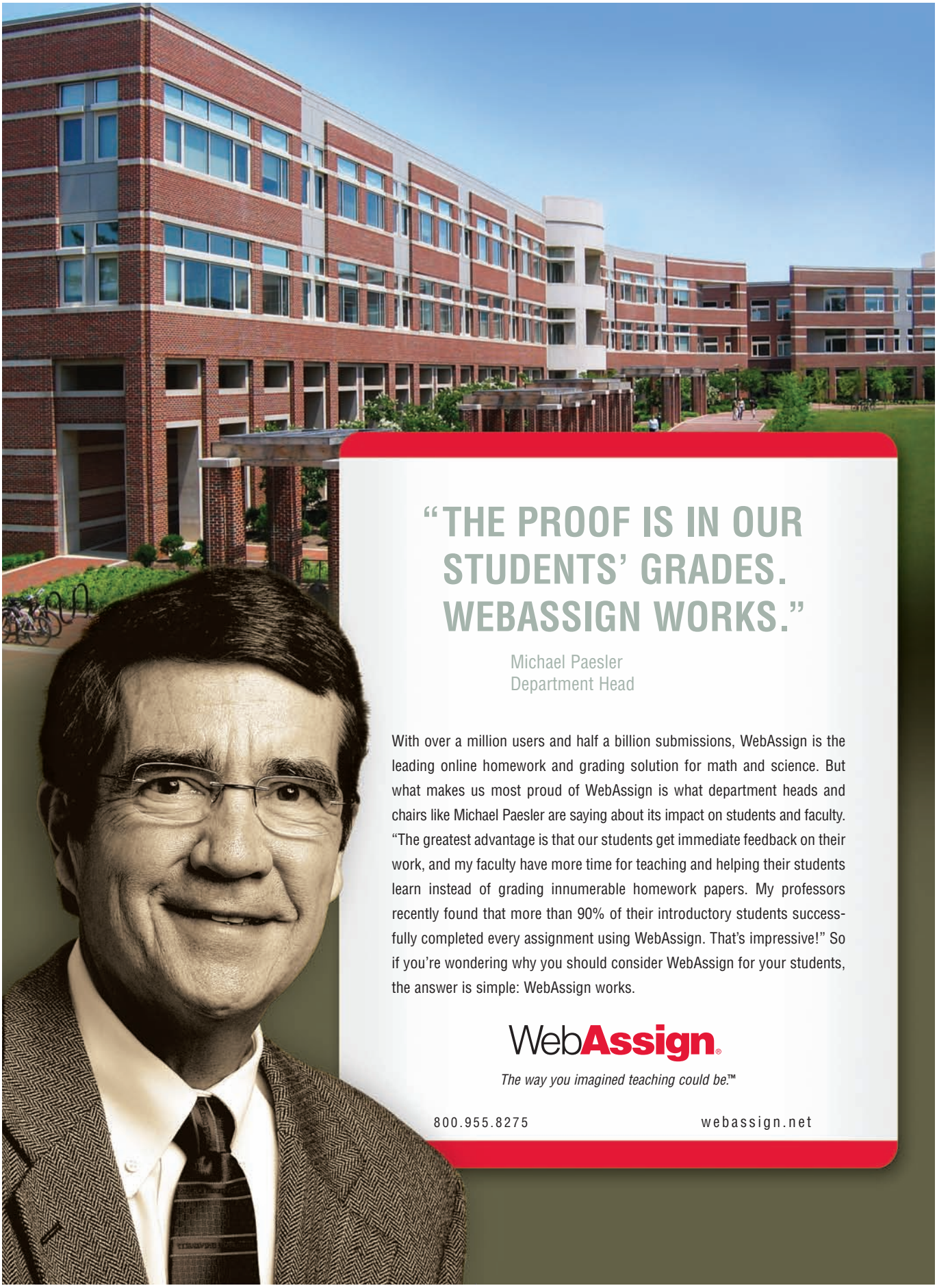

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A. Bain, BNP Paribas, London, UK
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The objective of stochastic filtering is to determine the best estimate for the state of a stochastic dynamical system from partial observations. The solution of this problem in the linear case is the well known Kalman-Bucy filter which has found widespread practical application. The purpose of this book is to provide a rigorous mathematical treatment of the non-linear stochastic filtering problem using modern methods. Particular emphasis is placed on the theoretical analysis of numerical methods for the solution of the filtering problem via particle methods.
The book should provide sufficient background to enable study of the recent literature. While no prior knowledge of stochastic filtering is required, readers are assumed to be familiar with measure theory, probability theory and the basics of stochastic processes.

2008. Approx. 380 pp. (Stochastic Modelling and Applied Probability, Volume 60)
ISBN 978-0-387-76895-3 ► **approx. $59.95**

Atlas of Functions

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K. B. Oldham, **J. Myland**, Trent University, Peterborough, ON, Canada; **J. Spanier**, University of California, Irvine, CA

Appropriate for researchers and students in the science, technology and mathematics disciplines, from mathematics to chemistry, biology, physics and computer science, this book provides comprehensive information on several hundred functions or function families. Beginning with simple integer-valued functions, the book progresses to polynomials, exponential, trigonometric, Bessel, and hypergeometric functions, and more. In addition to providing definitions and simple properties for every function, each chapter catalogs interrelationships as well as other characteristics of the function. Many chapters close with a concise exposition on a topic in applied mathematics associated with the particular function or function family. The book is packed with Equator, a CD which eliminates the need for tables or programming to find numerical values.

2nd ed. 2008. XX, 700 p. 330 illus., 70 in color. With CD-ROM. Hardcover
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C. A. Floudas, Princeton University, NJ, USA; **P. M. Pardalos**, University of Florida, Gainesville, USA (Eds.)

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The first edition (2001) was acclaimed by J. B. Rosen as "an indispensable resource," and by Ding-Zhu Du who announced it as "the standard most important reference in this very dynamic research field."

2nd ed. 2008. Springer Reference
Print (Hardcover), Approx. 4000 p.
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All prepublication prices valid until November 30, 2008

Braid Groups

C. Kassel, **V. Turaev**, Université Louis Pasteur - CNRS, Strasbourg, France

Motivated by numberous examples and problems, the authors introduce the basic theory of braid groups, highlighting several definitions that show their equivalence; this is followed by a treatment of the relationship between braids, knots and links. Important results then treat the linearity and orderability of the subject. Relevant additional material is included in five large appendices.

2008. Approx. 340 p. 60 illus. (Graduate Texts in Mathematics, Volume) Hardcover
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