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of the American Mathematical Society

April 2010

Volume 57, Number 4

Preventing boundary layer separation *(see page 516)*

Portland State UNIVERSITY

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DEPARTMENT OF
MATHEMATICS + STATISTICS

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About Fariborz Maseeh

A first-generation American born in Iran, Fariborz Maseeh received his B.S. in engineering and M.S. in mathematics from Portland State, an M.S. in engineering from the University of Texas at Austin, and a doctorate in science in engineering from the Massachusetts Institute of Technology. Maseeh founded and sold one of the world's first and fastest-growing companies specializing in the custom design, development and manufacture of micro-mechanical chips. He serves on the advisory boards of MIT, PSU, UCI and USC.

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According to Wim Wiewel, president of Portland State, "Dr. Maseeh's generosity shows the way to making PSU the internationally competitive urban research university that Portland needs."

For More Information Contact

Fariborz Maseeh
Department of Mathematics and Statistics
Portland State University
PO Box 751
Portland Oregon 97207-075
Tel: 503.725.3621
Fax: 503.725.3661
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PSEUDO-DIFFERENTIAL OPERATORS

Notices
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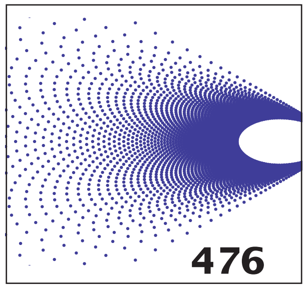
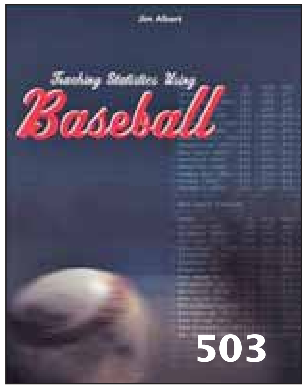
April 2010

Communications

Commentary





Since the time of the ancient Greeks, mathematics has helped us to understand sporting events. Today we use mathematics both to keep track of the statistics of the games and also to analyze the prowess of the athletes.

April is Mathematics Awareness Month, and the theme this year is "Math and Sports". Some of the articles that we feature in this issue explore different aspects of the interaction of math and sports. Other feature articles look into mathematics for its own sake, or the mathematics profession.

—Steven G. Krantz
Editor

Features

Notices

of the American Mathematical Society

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Departments

From the AMS Secretary

I thank Randi D. Ruden for her splendid editorial work, and for helping to assemble this issue. She is essential to everything that I do.

—*Steven G. Krantz*
Editor

ICM 2010

The next International Congress of Mathematicians will take place August 19–27, 2010, in Hyderabad, India. As the president of the International Mathematical Union, I have been and will be involved in virtually all aspects of this big event, and would like to share with you some thoughts on congresses.

The ICM is the single most important event in mathematics every four years. Its organization, from the work of the local organizers to the program committee to the prize committees to the publishers of the *Proceedings* (and many others), is the most important task for the IMU leadership and indeed for our whole community.

Often one hears skepticism about having such congresses at all. One of the objections people make is the exceptionally large size of it (at least for a mathematics meeting). Indeed, a single participant will only know a small fraction of the other participants, and you might walk down the crowded corridors for a long time without seeing a familiar face. Any participant will be able to follow only a small fraction of the section talks. A lot of effort has been made to make the invited talks accessible to a general mathematical audience; but it is still difficult to follow so many ideas from different parts of mathematics within such a short time. However, scientists working in physics, computer science, or many other branches of science are envious of the fact that we mathematicians have such an event.

While the first thing that comes to mind when speaking about math research is a mathematician sitting in a chair and chewing a pencil, or perhaps two of them standing at a blackboard trying to put together a new proof, the science of mathematics has many other important facets: How to apply mathematical results in other sciences, humanities, or in the economy, or how to distill from applications new problems or even theories? How to communicate mathematics most efficiently to other mathematicians? How to teach mathematics at all levels? How to popularize it, both to students (to inspire them to study mathematics) and to political and industrial leaders (to get support for research)? These questions are becoming more and more important, and I believe IMU has a duty to address all of them. Congresses are forums to learn about these issues and to discuss them.

As the backbone of the congress, carefully chosen speakers describe the latest developments in mathematics. I trust that the invited speakers will follow the trend observable at recent congresses and make their presentations as broadly accessible as at all possible.

We learn firsthand about the most important prizes in mathematics, and hear the recipients and/or experts describe their work. The Fields Medal and the Nevanlinna Prize themselves are unique in their scope. Most scientific prizes, like the Nobel Prize, are awarded to old people whose work is well known and well recognized. In contrast, these prizes of the IMU go to young people and new results. This way the whole community can learn about these breakthrough results and can meet these young mathematicians who are bound to become important personalities of our science in the near future.

It is a special pleasure to note that a new prize, the Chern Medal Award, will be given for the first time at the 2010 congress. This award, established in memory of the outstanding mathematician S. S. Chern, will be given for lifelong contribution to the field of mathematics.

We will have panel discussions about important issues such as education, applications, electronic publications, impact factors, and other topics that are in the forefront of interest at the time of the congress. There will be interesting exhibitions; over the years, there have been a variety of topics for these exhibitions, such as the history of the IMU, or the history of mathematics in the host country. There is always a book fair, there are meetings of special groups, poster sessions, satellite conferences, excursions, and many other events.

Just before the congress, the General Assembly will meet in Bangalore to decide on the site of the next congress, to elect the new leadership, and to discuss and make decisions about many other issues that are of interest to the mathematical community. The most important decisions will be announced at the opening ceremony of the congress.

Mathematics is a rather lonely science; most of our work is happening inside our heads. Therefore it is particularly good to have a big event bringing together our community every four years!

To choose the site of the congress is always a difficult decision. To have congresses in both developing countries and developed ones is important. In a developing country, the impact of such an event on the local community and on its position in the eyes of the general public may be much larger. But of course fewer mathematicians have firsthand experience with the site, and there are more concerns about the unknown, so people might hesitate to attend. A developed country, having a larger personal base and a longer experience, can often use the congress to promote mathematics in novel ways, and thereby provide example and experience for later congresses.

The site of the congress moves around in the world, and India, with its long tradition in mathematics and also with its attraction for tourists, is a fascinating congress venue. A year ago I visited India, the site of our 2010 congress in Hyderabad. Some friends wondered about such a trip, mentioning all sorts of dangers from snakes to malaria. If you recall, a few weeks earlier there had been terrorist attacks in Mumbai, and indeed, quite a few participants of the conference cancelled their trips. Needless to say, the terrorist attacks had no influence on my visit (except for some increased security at public buildings), and with some caution, it was easy to avoid infections (and snakes). India is a country where crime, especially violent crime, is rare.

I would like to invite you all to come to India and contribute to the success of the congress. See you at ICM 2010 in Hyderabad!

—László Lovász
Eötvös Loránd University
President, International Mathematical Union

(***Editor's note:*** *The ICM 2010 Second Announcement appears in this issue of the* Notices*, page 560.)*

Letters to the Editor

More on Mathematics and Patents

Bob Palais, in his letter of September 24, 2009, published in the January 2010 (Vol. 57, no. 1) issue of the *Notices*, encourages us to urge the United States Patent and Trademark Office (USPTO) to accept a mathematics degree as evidence of technical competence. I believe this is misguided, and the issue turns on the distinction between necessary and sufficient conditions.

Competence in mathematics is not a sufficient condition for working with technology specialists, which explains its omission from USPTO's list of sufficient bachelor's degrees. But it is necessary. Indeed Palais points out that USPTO recognizes the importance of mathematics in requiring mathematical competence in its own examiners. Palais deplores the mathematical ignorance of most patent attorneys; but the solution is not to make mathematics competence sufficient, but to make it necessary for admission to practice law before the USPTO.

—Jack Hirschfelder
University of Maryland University College
`jhirschfelder@faculty.umuc.edu`

(Received January 4, 2010)

Reply to Hirschfelder

Patents cover a wide range of technical and scientific areas of expertise. Neither mathematics nor any of the areas the USPTO accepts are sufficient to demonstrate proficiency in all areas of science and technology. But that was not my point, and I doubt it is the point of USPTO's requirements. It seems that the list of recognized subjects was intended not to certify every qualifying lawyer for general proficiency in science and technology, but rather to cover the range of material being patented, so that an inventor could always find some lawyer with the specialized training required for an understanding of their invention. Advanced mathematics has become the essential ingredient in many patents in bio- and information technologies in recent years. An undergraduate degree in mathematics is far more relevant to their content than any of the degrees USPTO currently accepts. With this in mind, it would seem that there is a need for SOME, not all, USPTO approved attorneys to have a much higher level of mathematical training in order for them to be able to assist with some of the significant number of important recent mathematics-based patents. Including a math major as evidence of scientific and technical proficiency would not diminish the number of lawyers with other capabilities, and could only add to the number with mathematical fluency that IS necessary for writing many modern patents.

—Robert Palais
Math Dept., Pathology Dept.
University of Utah

(Received January 5, 2010)

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.

Mathematics Awareness Month – April 2010

Mathematics and Sports

Can a jump shot be made with an initial angle of 30 degrees?

Mathematics can answer this question and many others.
www.mathaware.org

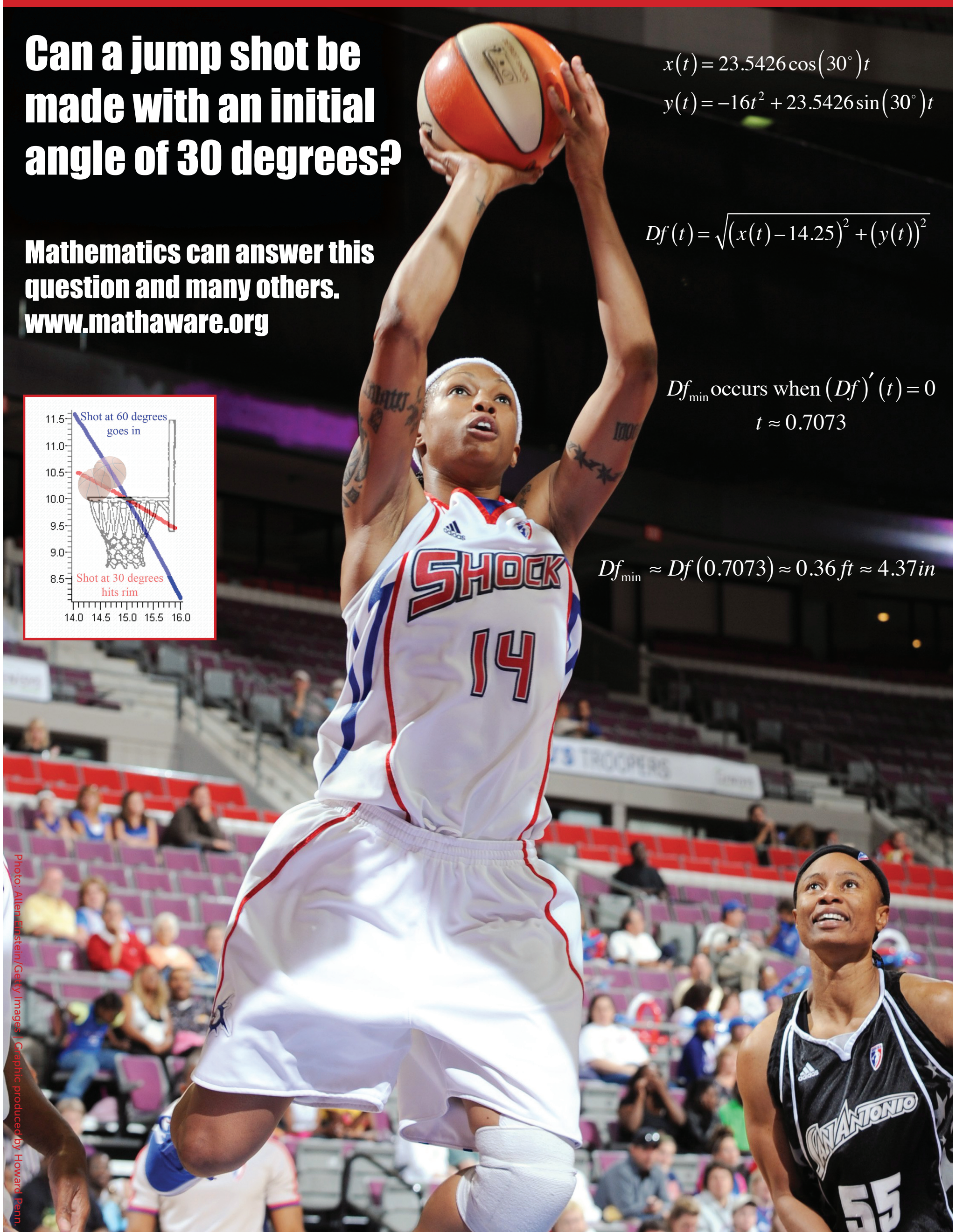
$$x(t) = 23.5426\cos(30^\circ)t$$
$$y(t) = -16t^2 + 23.5426\sin(30^\circ)t$$

$$Df(t) = \sqrt{(x(t) - 14.25)^2 + (y(t))^2}$$

$Df_{\min}$ occurs when $(Df)'(t) = 0$

$t \approx 0.7073$

$$Df_{\min} \approx Df(0.7073) \approx 0.36\,ft \approx 4.37\,in$$



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Life on the Mathematical Frontier: Legendary Figures and Their Adventures

Roger Cooke

How many fairy tales circulate as "universally known truths"!

B. L. van der Waerden, Preface to *Science Awakening*

A mathematical legend begins as an anecdote about a mathematician or a theorem, reported by someone at second hand. After many repetitions, usually with some variations, it solidifies into a legend. Thus a legend is characterized by two properties: 1) it is not attested by any primary documents or anyone claiming to have been an eyewitness; 2) it becomes widely known and cited. As the examples below will illustrate, a mathematical legend may be cited in more than one context to add color to a mathematical achievement. It often arises as a way of explaining how results were achieved when there is no paper trail showing the way, just as the legend of the Trojan horse, according to some classicists, explains how the Greeks were able to take Troy after the death of the great warrior Achilles when they could not do so with his help.

Any legend, mathematical or historical, may "migrate" from one person to another, just as the legends of the American frontiersmen Daniel Boone (1734–1820) and David Crockett (1786–1836) have become commingled through hagiography. A famous legend about Boone relates that he killed a wildcat as a boy, and according to another, he later killed a bear and carved a memorial of his feat into a nearby tree. (In the version I heard as a child, he showed his ignorance of spelling by writing "D. Boon cilled a bar this yre 1775.") The popular song that accompanied the Disney-promoted legend of Crockett said he "killed him a b'ar, when he was only three." It is more than coincidental that the same actor, Fess Parker, portrayed the two men as essentially identical in two popular American television series during the 1950s and 1960s.

The durability of a mathematical legend depends more on its resonance with the mathematical community than on its plausibility. If it illuminates some feature of a mathematician or a theory, it deserves a place in the history of the subject. For example, did Archimedes suddenly leap from his bath shouting "Eureka!" when he thought of the idea of measuring specific mass using the displacement of water? As the legend tells it, Archimedes had been ordered to do a forensic investigation for the King of Syracuse, who suspected that some of the gold he had provided to make a crown had been replaced with an equal weight of silver. It's an interesting story and seems plausible at first sight. But is there any eyewitness testimony to it? The oldest source for this story is the introduction to Book IX of *De architectura* by the first-century Roman architect Vitruvius, who lived two full centuries after Archimedes. Vitruvius cites no earlier source, and so we are left to conjecture whether the story is true and how it might have arisen if it isn't. What is valuable in the story is the picture of the sudden flash of inspiration that mathematicians sometimes experience. Whether true or not, this story will continue to be told

Roger Cooke is professor of mathematics at the University of Vermont. His email address is cooke@cems.uvm.edu.
He gratefully acknowledges Mike Wilson, Jeremy Gray, and Greg Buzzard for many helpful comments; Sergei Demidov for checking a reference in Moscow; and John Milnor for replying to an email inquiry. Several referees provided not only helpful comments and corrections but also references that he was unaware of.

because it amuses people and because it expresses some folklore concerning a legendary figure.

How much should one be willing to bet on the historical truth of this story? It seems doubtful that Archimedes could have weighed gold and silver and measured the amount of water they displace so precisely as to solve the problem he had been challenged with. The difference in the amount of water displaced must have been very small. Moreover, Vitruvius claims that Archimedes performed a quantitative analysis of the crown, determining the exact amount of silver that had been used to replace the gold. That would have been unnecessary if his only task had been to determine whether the gold had been alloyed with silver, which is probably all the king would have wished to know. And again, although the physical principle involved in the analysis is correct, the practical application of it appears to be much more challenging.

As is the case with other stories told of Archimedes by Vitruvius' contemporary Plutarch, such as the story that he designed a claw to be attached to a crane that could snatch Roman ships out of the water during the siege of Syracuse (*Life of Marcellus*, Ch. 15, § 3), there seem to be some practical difficulties. Although engineers working with both the BBC and the *Discovery Channel* have constructed machines that are capable of upending a Roman ship from shore, it is difficult to believe the ships could not have maneuvered out of reach. It has been conjectured that the claw was used at night, when the sailors could not see it approaching. But perhaps the main purpose of the claw was to keep the ships from attempting to land at all. In that case, it would indeed have been a practical defensive weapon that needed only to be demonstrated once, not regularly used. The same explanation would apply to Archimedes' supposed use of burning mirrors to set the Roman ships on fire. Revolved conic sections were well enough understood in his day to allow the design of such mirrors. Modern experimenters have found it difficult to set wood on fire in this way, but it is not necessary to set a ship on fire to make it unbearably hot for its human occupants. Thus, these two stories merit a somewhat higher degree of confidence than the story of the crown. If indeed these stories are only legends and not true reports, one can imagine how they may have arisen, since Archimedes wrote treatises on floating bodies, the lever, and the parabola.

Anecdotes reported by people who do not claim to have been eyewitnesses need to be used with caution when reconstructing serious history, precisely because mathematics is a logical subject, but mathematicians do not always discover their results in the seemingly natural logical order. There is a temptation to let logic be one's guide and conjecture an origin for mathematical ideas that is largely or entirely wrong. For example, Brouwer's proof of his fixed-point theorem was not constructive. From the point of view of his intuitionism, what he had proved is that *either* every continuous mapping of a closed ball into itself has a fixed point *or* the axioms of analysis are inconsistent. (There are now constructive proofs of this theorem.) I have heard rumors that it was this nonconstructive nature of the theorem that set Brouwer on the path to intuitionism. Although it seems psychologically natural that he should have developed it in this way, there is good documentary evidence pointing to a different conclusion. Brouwer was writing about the foundations of mathematics already in his 1907 doctoral dissertation, whereas his topological results were obtained between 1909 and 1913. Thus it was not doubts about topology that led him to intuitionism. However, his intuitionism did cause him to worry about the validity of his topological results. As van der Waerden said [8]:

> Even though his most important research contributions were in topology, Brouwer never gave courses on topology, but always on—and only on—the foundations of intuitionism. It seemed that he was no longer convinced of his results in topology because they were not correct from the point of view of intuitionism, and he judged everything he had done before, his greatest output, false according to his philosophy.

In most cases involving the modern era, there are enough documents to produce a clear picture of mathematical developments, and conjectures for which there is no eyewitness or documentary evidence are not needed. Even so, legends do arise. (Who has not heard the "explanation" of the absence of a Nobel Prize in mathematics?) The situation is different regarding ancient mathematics, however, especially in the period before Plato's students began to study geometry. Much of the prehistory involves allegations about the mysterious Pythagoreans, and sorting out what is reliable from what is not is a tricky task.

In this article, I will begin with some modern anecdotes that have become either legend or folklore, then work backward in time to take a more detailed look at Greek mathematics, especially the Pythagoreans, Plato, and Euclid. I hope at the very least that the reader finds my examples amusing, that being one of my goals. If readers also take away some new insight or mathematical aphorisms, expressing a sense of the worthiness of our calling, that would be even better. Still better would it be if readers become wary of inferring "the way it must have been" by looking at the mathematical achievements of the past through the lens of the present and learn to look for documentary or eyewitness confirmation before repeating a legend. Best of all, I think, would be a reader who is inspired to undertake a systematic investigation of the many mathematical legends that are "out there", waiting to be studied. There are many examples of such anecdotes ([18], [9]), and a few examples of systematic investigation of them ([12], [10]). A definitive book on the subject remains to be written.

By way of preview, I note that both Plutarch (quoted in the section "The Pythagorean Theorem", below) and Vitruvius (again in the introduction to Book IX of *De architectura*) say that Pythagoras discovered the 3-4-5 right triangle. Vitruvius says he made a sacrifice of oxen after the discovery, but Plutarch says that sacrifice was occasioned by his discovery of the transformation of areas. This example shows how the same story can be attached to different discoveries—or perhaps that Pythagoras routinely sacrificed oxen.

Some Modern Legends

Even in the full light of day provided by modern journalism, legends arise quite easily, creating a large number of hits at websites where they can be reliably checked, such as `snopes.com`. One of those legends, carefully checked out by Snopes and uncharacteristically confirmed in most of its aspects, is a story about George Bernard Dantzig (1914–2005). According to legend, Dantzig arrived late for class one day in 1939, too late to hear that his professor Jerzy Neyman (1894–1981) had posted two unsolved problems on the board. Thinking they were homework, he went home and solved them, although it took a little longer than usual because they seemed to be rather difficult. All that is confirmed by Dantzig himself [1].

Such stories are the stuff of which legends are made, and this much of the legend is well attested. But the story does not end there. Dantzig told the story to Robert Schuller, the Lutheran minister best known for his broadcasts from the Crystal Cathedral. Schuller got Dantzig's permission to use the story in a book on what he called "possibility thinking". From there, it found its way into sermons all over the country, one of which was heard by Donald Knuth while visiting Indiana. In the sermons—fortunately or unfortunately, depending on one's view of legends—the story was embroidered with a few details that should have aroused suspicion in a careful listener or reader. It was said that the two problems were part of an examination, that Einstein had worked on them without success, and that Dantzig had immediately been offered a position at Stanford on the basis of this work. It appears that what Schuller thought he heard is not quite what Dantzig said.

The story continued to expand, reaching out from Dantzig to embrace at least one other eminent mathematician. A version essentially the same down to minor details was told to me by my undergraduate roommate in 1962, only in this version the student was said to be John Milnor. In this case, we can see how colorful details attach themselves to a core of facts, like barnacles on a ship. The mathematical result in this case was the Fáry-Milnor theorem, which Milnor proved as an undergraduate. Milnor did indeed hear about this problem in the classroom, from Al Tucker. But there is no indication in his own account [22] that he arrived late, or that he mistook the statement of the theorem for a homework problem. The colorful version of the story was widely believed among graduate students at Princeton at the time, and Dennis Sullivan once took the time to explain to me the technique that Milnor had used for solving the problem.

Unpublished Theorems

In the modern world, where so much mathematics gets into print, legends tend to involve the personal rather than the technical side of mathematics. There are many legends about the sayings and doings of famous modern mathematicians, almost none involving theorems or proofs passed along by an oral tradition. The closest approximation to an oral tradition comes from results tossed off as remarks because they are not regarded as serious or profound enough to merit formal statement as theorems. These may get passed around and repeated without citation, so that their origin may become obscure unless someone writes it up in a historical piece. An example is the following proof of the infinitude of the primes, reported in the reminiscences of Luzin's Moscow school of mathematics by L. A. Lyusternik ([21], p. 176).

According to Lyusternik, exotic proofs of the infinitude of primes were a routine challenge among Luzin's students, and many such proofs were found. But apparently no one thought of publishing them. The one that follows remained unpublished until Lyusternik wrote his reminiscences. The proof, which Lyusternik ascribed to Khinchin, is based on Euler's formula

$$\prod_{p \text{ prime}} \left(1 - \frac{1}{p^2}\right)^{-1} = \sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6}.$$

If the set of primes were finite, the left-hand side of this formula would be a rational number, and hence π^2 would be rational.

Such proofs attract interest because they make unexpected connections. They often seem slightly whimsical, especially if (as in the case of Khinchin's proof) the principle invoked to prove the result is more complicated than the result itself. A good example is the remark of Loomis that the maximal ideal space of the Banach algebra of bounded continuous complex-valued functions on a completely regular topological space X is the Stone-Čech compactification of X ([20], pp. 55–56).

Khinchin's proof does not make it into the class of legends, since it eventually got written down and published with the correct (I presume) attribution. The other proofs alluded to by Lyusternik no doubt lived on in the memory of those who heard them, but I do not know of any written exposition of them. They can be classified as legendary but well authenticated. If anyone has heard them and remembers what they are, writing them down would be a small service to people interested in the minutiae of mathematics.

A referee has pointed out that Khinchin's proof wasn't a new result. Dickson ([7], pp. 413–415) gives two pages of citations of standard and exotic proofs of the infinitude of primes. In particular, he notes a pamphlet by J. Braun (dates and first name unknown) [2], in which Khinchin's argument was ascribed to Jacob Hacks (1863–??). Moreover, the principle used in the proof has a long history. Euler had used the formula

$$\prod_{p\,\text{prime}} \left(1 - \frac{1}{p^s}\right)^{-1} = \sum_{n=1}^{\infty} \frac{1}{n^s},$$

taking $s = 1$, to argue that if the number of primes were finite, the right-hand side would be infinite and the left-hand side finite. Of course, the formula asserts only that one infinite quantity equals another when $s = 1$. But it *would be* a true equality between finite real numbers if the number of primes were finite, and so Euler was right: The fact that the right-hand side is infinite does prove that the number of primes is infinite. Kronecker pointed out that Euler's proof can be rescued in another way by simply letting s decrease to 1 on both sides ([7], p. 413).

Aphorisms

One type of legend in the history of mathematics is the species known as the Famous Quotation. Every mathematician has a stock of these: Pythagoras's "Number is all," Archimedes' "Give me a place to stand and I will move the earth," Galileo's "Nevertheless, it *does* move," Laplace's "I have no need for that hypothesis," and the like. These quotations seldom, if ever, arise from eyewitness testimony. Aphorisms are sometimes attributed to more than one person, and who can say whether they might not have been spoken by more than one person? They float around in the mathematical community like ions in a solution, opportunistically fastening on any attractive object. The following is a modern example, which again relies on my own far-from-infallible memory.

I took William Feller's 1963 course in probability, in which he mentioned that obviously every collection of sets generates a minimal σ-field, obtained as the intersection of all σ-fields containing the collection. He then said, as nearly as I can remember, "I hope you understand this type of argument. When it was first given, Kronecker said, 'That is not mathematics, that is theology!'" Given the reputation Kronecker has acquired among mathematicians as a champion of traditional mathematics and an opponent of abstraction—a reputation not entirely deserved, by the way, as he clearly saw the advantages of abstract group theory as early as 1870—this does seem typical of the kind of thing he *would* say, like his aphorism, "The good Lord made the integers; everything else is a human creation." [1]

Later, when I read Gerhard Kowalewski's mathematical autobiography *Bestand und Wandel* (*Permanence and Change*), I encountered the quotation again, this time ascribed to Paul Gordan. According to Kowalewski, it had nothing to do with σ-fields or ethereal set-theoretic arguments. Gordan supposedly said it when he first looked at Hilbert's proof of the Hilbert basis theorem in 1888. Here is what Kowalewski wrote ([17], pp. 24–25):

> Hilbert then came along and proved that the theorem holds in general, not only for forms in one variable, but for systems of forms in n variables…That was a mathematical achievement of the very first rank. Gordan said at the time, "That is *no longer* mathematics [Das ist nicht mehr Mathematik], that is theology." Whenever such a mighty discovery is made, one has the sensation that a ray of light from a higher realm has penetrated our mundane darkness. That is probably what Gordan meant by his exclamation.

The importance of statements like Gordan's lies in what they tell us about the motives and attitudes of mathematicians. Kowalewski's view was that, since theology brings heavenly knowledge down to earth, it becomes the standard by which knowledge is judged, and rarely does a human discovery such as the Hilbert basis theorem merit comparison with it. Kowalewski was a deeply religious man, and his view of theology probably led him to this interpretation.

Unfortunately, what Kowalewski reported is not quite what Gordan said, as set down in Max Noether's obituary notice ([24], p. 18), and his interpretation is certainly not what Gordan meant. Gordan supposedly said "That is *not* mathematics" ("Das ist keine Mathematik"). He thought Hilbert's

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[1] *This quotation first appeared in print in Heinrich Weber's obituary of Kronecker in the 1893* Jahresbericht der deutschen Mathematiker-Vereinigung, *where it was said that Kronecker had made the statement in 1886. The German is "Die ganzen Zahlen hat der liebe Gott gemacht. Alles andere ist Menschenwerk." I have somewhat inaccurately translated "Der liebe Gott" as "The good Lord" since the German exclamation "Lieber Gott!" has approximately the force of the English "Good Lord!".*

arguments were not sufficiently robust to establish what Hilbert was claiming, and he strongly advised Felix Klein not to publish Hilbert's result in the *Mathematische Annalen*. Fortunately for all concerned, Klein did not heed that advice, and even Gordan later became reconciled to Hilbert's methods.

While I have written citations asserting that Gordan made this statement, I have only my memory of what Feller said as evidence that Kronecker said it in connection with set-theoretic arguments. (He could not have said it in reference to σ-fields, which were not invented until after his death.) That by no means proves that Feller got the story wrong. If Gordan's statement was well known in the years following 1888, one might imagine that Kronecker repeated it in disparaging the kind of reasoning one finds in set theory. But I don't think he did. Kronecker had a high opinion of theology and a low opinion of set theory; that would seem inconsistent with his using the former to disparage the latter. Although I am confident that Feller related this anecdote in connection with measure theory, the person quoted may not, after all, have been Kronecker.

Some Ancient Examples

Here is a more famous example of the free migration or association of an aphorism. It forms part of that stock of quotations we all carry around with us. The first version of the quotation comes from the commentaries on Euclid's *Elements* by Proclus, written in the fifth century:

> The latter [Euclid] lived in the time of the first King Ptolemy. For Archimedes, who came after the first Ptolemy, mentions Euclid, while on the other hand it is also said that Ptolemy once asked Euclid if there was some way to geometry shorter than the *Elements*, and he replied that there was no king's highway to geometry.

The second version comes from an anthology of literary excerpts compiled by Stobaeus (Book 2, Ch. 31, § 115) at the same time that Proclus was writing, or a little later:

> Alexander demanded that the geometer Menaechmus give him a short course in geometry. But he said, "O king, in the physical world there are private roads and royal roads, but in geometry there is only one road for everybody."

Before I comment on these quotations, let me provide a bit of exegesis to clarify the highway metaphor. The word I have translated as *highway* in the first quotation (ἀτραπός) means literally *without turning*. The royal highways in the Hellenistic world were the equivalent of the U.S. interstate highway system, with straight roads that connected cities remote from one another, in contrast to the private roads (ἰδιωτικαὶ ὁδοί), which were more like county roads meandering around and connecting nearby villages with one another. If Menaechmus and Euclid had known about railroads, they might have said, "There is no express train to geometry." Both quotations warn that one cannot simply proceed directly to the major results in geometry. It is necessary to make many stops, learning the definitions and lemmas before the theorems.[2]

Which, if either, of these statements was really spoken by the person alleged to have done so? Did Menaechmus make this reply to Alexander, and Euclid copy him in his reply to Ptolemy? Or was the story told about one of them, after which it became inaccurately attached to the other? Or were both quotations simply invented by imaginative biographers? What really matters is that, after many centuries of repetition, what they assert has become folklore, expressing a sentiment shared by mathematicians.

The image of a road in geometry may have been common in the ancient intellectual world. In his commentary on Plato's *Phaedo* (Ch. 11, § 13), the sixth-century philosopher Olympiodorus inverts this metaphor in disparaging the use of diagrams in geometry, saying, "For among the geometers there is a distinction [between a true line and one drawn with instruments], since there is only one road, a narrow one, and it is the highway [ἀτραπός] and not the public road [λεωφόρος, the "people-bearer"] that masterfully holds it together." Earlier (Ch. 5, § 4), Olympiodorus had reported that it was a Pythagorean precept to use the highway and eschew the local road. He explained that to take the highway meant to seek with purity (with the intellect and not the senses) and that the "public road" was the way chosen by the multitude, meaning apparently that they rely on objects of sense such as diagrams.

For mathematicians who are not seriously interested in history, there is no need to address the problem that legends pose for the historian, which is to reconstruct what most likely happened in the past based on what is told in the surviving documents. It is in this area, mostly ancient history, that resorting to logic and imagination can lead to

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2 *Another, less plausible, interpretation comes from the phrase I translated as* in the physical world, *which is* κατὰ μὲν τὴν χώραν, *literally* now, according to space. *The phrase* κατὰ τὴν χώραν εἶναι *means* to be in one's proper place. *I would like to think that Menaechmus said, "O king, there are private and royal roads to keep people in their proper places, but in geometry there is only one road for everybody." That would credit geometry with creating a democracy of the mind working in opposition to the class divisions in society. However, I doubt if this interpretation is correct. On the other hand, most ordinary people were too poor to undertake long journeys and therefore were unlikely to be on the highways.*

interesting but usually unprovable reconstructions. No harm is really done unless the imaginative version gets repeated many times and hardens into a "fact".

Reconstructed Legends: The Pythagoreans

The richest vein of legend in all of mathematics is associated with the name of Pythagoras. The theorem to which we now attach his name has appeared in many times and places, and nationalistic priority disputes for the credit of having discovered it continue. Both the prehistory of the theorem and Pythagoras's connection with it have given rise to legends. Besides the main legend that Pythagoras discovered and proved this theorem, sacrificing an ox in thanksgiving for the discovery, there are also conjectures that have become "facts" about the role this theorem played in ancient Egypt and in the discovery of irrational numbers.

Much of the standard view of Pythagoras and the Pythagoreans was upset nearly fifty years ago with a lengthy study by Walter Burkert ([3],[4]), in which the efflorescence of the Pythagorean legend over the centuries was thoroughly documented. Given that the best testimony for early Greek mathematics is the summary by Aristotle's pupil Eudemus, used as a source by Proclus, Burkert ([4], pp. 449–451) inferred that the Pythagorean portion of Euclid's *Elements* is limited to some isolated results (including, however, all of Book IV, which gives the constructions for inscribing regular polygons of 3, 4, 5, 6, and 15 sides in a circle and converse constructions).

As a result of Burkert's work, Cuomo ([6], p. 30) is rightly cautious when broaching the subject of the Pythagoreans:

> Indeed, everything we know about their *mathematical* discoveries and interests comes from later, often much later, centuries and is generally thought to be unreliable—which is why the reader will not find much about Pythagoras and the Pythagoreans in this chapter.

Burkert's analysis seems to be the current consensus on the Pythagoreans (see [14], pp. 68–69). It is a commonplace, however, that any historical consensus is liable to be overturned. For example, Burkert ([4], p. 454), in discussing the supposedly Pythagorean theory of application of areas in Book VI of the *Elements*, says:

> Scholars now agree that the point of these exercises is primarily algebraic; they provide an equivalent for quadratic equations. In Babylonian mathematics they had been solved algebraically, and the individual examples of the application of areas correspond exactly to the methods developed there. Thus the "geometrical algebra" of the Greeks is revealed as the transposition of Babylonian techniques of calculation into a geometrical form.

That passage was correct when it was written. At the time *some* scholars had embraced the "geometrical algebra" interpretation of Books II and VI. For example, van der Waerden ([29], p. 63) considered a problem from the cuneiform tablet AO 8862, in which the following cut-and-paste geometric problem is solved: *The area plus the excess of length over width is* 183*; the sum of length and width is* 27*. What are the length, width, and area?* Van der Waerden decided it would be permissible to ignore the geometric meaning of these terms, since they are indeclinable, and he concluded that "We can therefore safely put the problem in the form of 2 algebraic equations" (namely $xy + x - y = 183$ and $x + y = 27$). Because there are such beautiful correspondences between the algebraic operations performed on the cuneiform tablets and the propositions in Book VI of Euclid, van der Waerden ([29], p. 119) enthusiastically endorsed the name *geometric algebra* proposed by a number of historians, saying that "this geometric algebra is the continuation of Babylonian algebra." Thus, even though there are no Greek records indicating any familiarity with these cuneiform tablets, imagination and logic provided a very attractive hypothesis of transmission from Babylon to Alexandria.

However, in 1975, this hypothesis was savaged by Unguru [28], and it has been on the defensive since that time. Where earlier scholars were eager to find evidence of "transmission" from ancient Iraq to the Greek world, scholars today (see [26], p. 281) tend to minimize the use of explanation by transmission, emphasizing the distinctness of Babylonian and Greek mathematics.

In particular, Pythagoras's connection with the theorem that bears his name is highly doubtful. Burkert says ([4], p. 429), "There is no testimony that he gave a strict proof of the theorem, and this cannot be made to seem probable." And, in a footnote:

> The classic "windmill proof" comes from Euclid, but more primitive proofs are possible…It is pure guesswork to suggest that Pythagoreans tried anything of the sort.

Yes indeed. And pure guesswork blossoms into legend very easily. Van der Waerden, who made a point of debunking one of these legends, was cited by Unguru as one of the principal offenders in the propagation of the "geometric algebra" legend. (While I have no opinion that matters on the subject of transmission from Mesopotamia to Greece, I must confess that I find the geometric algebra hypothesis an attractive one and relinquish it very reluctantly.)

The Pre-Pythagorean History of the Theorem

A cuneiform tablet (BM 85 196) dating back more than a millennium before Pythagoras describes a problem involving a beam leaning against a wall, whose solution is found by implicitly invoking what we know as the Pythagorean theorem. The geometric formulation of this problem is crucial, since the mere occurrence of what we call *Pythagorean triples*, that is, integers x, y, and z such that $x^2 + y^2 = z^2$, proves nothing about any knowledge of right triangles. Such number sets might have arisen in solving certain problems in pure number theory having no connection at all with geometry. The cuneiform tablet VAT 8402, for example ([23], p. 76), contains a table of values of $n^2 + n^3$. What it was used for is not known, but one does not immediately suspect a geometric application. On the other hand, what is perhaps the most famous cuneiform tablet containing Pythagorean triples, Plimpton 322 ([26], pp. 110–115), provides several indications that its application is cut-and-paste geometry. The claim one sometimes hears that it contains a *proof* of the Pythagorean theorem, however, strikes me as very implausible. The cuneiform tablets simply don't contain proofs in that sense. We know the writers of cuneiform tablets knew the theorem because they applied it. We don't know what convinced them that it was a reliable principle.

It is a reasonable inference that the geometric fact expressed by the Pythagorean theorem was known, perhaps empirically or perhaps through some simple abstract geometric considerations, at least a thousand years before Pythagoras. This theorem was also discovered in other places. An analysis of a rectangle occurs in the Chinese classic *Zhou Bi Suan Jing*, which dates back at least as far as the time of Euclid, and shows that the diagonal c of a rectangle of sides a and b satisfies the relation that we would write as $c^2 = (a + b)^2 - 2ab$. It is also said ([25], p. 18) that the *Sulva Sutras*, which predate Pythagoras, contain the statement that "the diagonal of a rectangle produces both areas which the legs produce separately," exactly the form of the Pythagorean theorem we now recognize. In these cases, we can be sure we are dealing with the geometric theorem.

Egyptian "Use" of the Pythagorean Theorem

No legend that is utterly without foundation has so well stood the test of time as the story that the ancient Egyptians not only knew the Pythagorean theorem but actually used it in constructing right angles. This legend has legs! You can find it all over the Internet and even in literature published by mathematical societies. Valiant attempts by historians of mathematics (most recently [15], pp. 791–793) to give this story the plausibility it deserves (not very high) have been powerless to stop the juggernaut of long-repeated rumor.

It is not beyond the realm of possibility that the ancient Egyptians knew about the 3-4-5 right triangle. For one thing, Plutarch says they did in his essay *Isis and Osiris* (373f–374b). In addition, some Egyptian papyri contain Pythagorean triples. What is legendary here is not Egyptian *knowledge* of the theorem but its *use* in construction. Plutarch mentions this triangle only in connection with the mystical properties of numbers, Osiris being the upright side of length 3, Isis the base of length 4, and Horus the hypotenuse of length 5, and he goes on to relate all this to the properties of male and female numbers, in other words, exactly the kind of mystical numerology we have come to associate with Pythagoreanism and with Platonism, for example, in the arranging of marriages in the *Republic* (546c). But Plutarch does not mention any connection with engineering or construction.

What seems to have triggered the connection with construction is a statement in the *Stromata* (*Miscellanies*) by Clement of Alexandria in the second century (Book 1, Ch. 5, § 69.5), in which he quotes a reference by Democritus to the "rope-fasteners" of Egypt. Ropes and chains were among the standard tools of surveyors for millennia, and there are wall paintings in Egypt showing ropes being used to measure fields. But there are no such paintings of Egyptian engineers stretching ropes into the shape of a triangle.

The two ingredients of the legend seem to have lain dormant and separate from each other for centuries until they were combined in a history of mathematics published by Moritz Cantor in 1880. Here is what Cantor wrote ([5], Vol. 1, p. 56). I urge careful attention to the first sentence, in which I have added the emphasis:

> Let us suppose, *without any actual evidence, however*, that the Egyptians knew that when three sides of lengths 3, 4, and 5 are joined in a triangle, they form a right angle between the two shorter sides. Further let us suppose that the pegs [marking the corners of one side of a building] are 4 units apart along a meridian. Finally, let us suppose that the rope is 12 units long and divided into lengths 3, 4, and 5 by knots. It is then clear…that when the rope is pulled taut at one knot while the other two are laid down at the pegs, it will necessarily form a right angle with the meridian.

Cantor had preceded that quotation with an essay on the supreme importance of constructing accurate right angles for such important buildings as temples and concluded that some precise geometric construction must have been necessary. But why this particular construction? One could also stretch a rope taut to form a straight line and (with one end fixed) a circle. By doing that, one could draw right angles as we were all taught to do in school.

If we wish to dream up a way in which Egyptian surveyors and contractors might have laid out a rectangular building, ancient tradition provides plenty of material for conjecture. Thales, for example, is said to have learned geometry in Egypt and is also said to have known that an angle inscribed in a semicircle is a right angle. Putting these two attributes together, we could assume that he learned the geometric fact from the Egyptians. Perhaps he saw them laying out the foundation of a large rectangular building by drawing a circle whose diameter was a diagonal of the building, then simply drawing a chord along one of the sides of the projected building. The connection with "rope-fasteners" would also hold for such a construction.

This legend was summarized by B. L. van der Waerden (in the preface to [29]):

> Is this not incredible? Not that Cantor at one time formulated this hypothesis, but that repeated copying made it a "universally known fact".

What most likely happened is that the interesting conjecture began to be repeated out of context, and Cantor's warning that there was no direct evidence for the conjecture simply got left out. I first saw it in its full developed form in my high-school algebra text over fifty years ago. Van der Waerden gives some speculation of his own on the line of reasoning that led Cantor to this hypothesis. I shall quote it here, calling it a *pseudo-syllogism of type* 1:

(1) These right angles must have been constructed by the rope-stretchers.
(2) I (Cantor) cannot think of any other way of constructing a right angle by means of stretched ropes than by using three ropes of lengths 3, 4, and 5, forming a right triangle.
(3) *Therefore* the Egyptians must have known this triangle.

The source of the legend. Now that this legend has grown to its present extent, it begins to take on an interest of its own, independent of its accuracy as history. Until recently, it never occurred to me that it might have originated anywhere except in Cantor's history. However, in a book [19] giving 367 proofs of the Pythagorean theorem, Elisha Scott Loomis (1852–1940) quoted in English translation a passage from a German book [30] by one Jury Wipper that gave 46 proofs of the same ([19], p. 11):

> Fifteen hundred years before the time of Pythagoras…the Egyptians constructed right angles by so placing three pegs that a rope measured off into 3, 4, and 5 units would just reach around them, and for this purpose professional "rope fasteners" were employed.

I have not been able to find a copy of the German book by Wipper cited by Loomis. However, I find it very intriguing that it was published in the same city and year as Cantor's book and reports Cantor's conjecture as fact. It may be that Cantor had published this conjecture earlier. Jury Wipper was the Russian scholar Yurii Vipper (1824–1891), a generalist rather than a specialist, who wrote books on a variety of scientific and religious topics. The 1880 German book is a translation of the Russian original, published in Moscow in 1876 under the title *Forty-five Proofs of the Pythagorean Theorem* (evidently, one proof was added in translation). At my request, S. S. Demidov checked the Russian original out of the Russian State Library in Moscow and reported to me what Vipper had to say about the history of this theorem (p. 2):

> Pythagoras, who lived in Egypt for 21 years and in Babylon for 12, could have learned the properties of the [3-4-5] right triangle in either country. As for the geometric proof, it most likely is due to Pythagoras himself.

It appears, then, that the passage quoted by Loomis was added to the book in the process of translating it into German. Interestingly, Vipper does mention Cantor (*Mathematische Beiträge zur Kulturgeschichte der Völker*), but only in connection with the origins of the Pythagorean theorem in China.

The Pythagorean Theorem

What was the connection of Pythagoras with this theorem, and how did it come to bear his name? We rely on the commentators for what we know of Pythagoras, since there is no mention of him in the writings that have come down to us from people who knew him personally, with the possible exception of Heraclitus, who sneered at him. If there is a documentary chain from us back to him, some of the early links disappeared, presumably after being partly incorporated in the writings of the commentators. Among these commentators were Aristotle, Plutarch, the third-century writers Porphyry Malchus and Diogenes Laertius, and the early fourth-century writer Iamblichus. Most of these writers do not mention the Pythagorean theorem. However, some of them do, and here is what two of them say.

Plutarch, in *Nine Books of Symposium Topics* (usually called by the Latin name *Questiones Conviviales*), Book 8, Problem 2, "Why does Plato say that God eternally geometrizes?":[3]

[3]*Here again, we encounter a legendary quotation. Plato does not make any such statement explicitly in the extant dialogues.*

> Among the most geometric theorems, or rather problems, is the following: *Given two figures, to construct a third equal [in area] to the one and similar to the other.* It is said that Pythagoras offered a sacrifice on the discovery of this theorem. It is insufficiently appreciated that this theorem is more refined and elegant than the theorem proving that the square on the hypotenuse is equal to those on the two sides enclosing the right angle.

Proclus, in his commentary on the first book of Euclid:

> Proposition XLVII, Theorem XXXIII. *In a right triangle, the square on the side opposite the right angle equals the squares on the two sides enclosing the right angle.* To hear those who like to research [*historein*] the origins of things tell of it, this theorem is to be attributed to Pythagoras, and they say that he sacrificed an ox upon the discovery of it. But while I admire those who first understood the truth of this theorem, I am much more impressed by the author of the *Elements*…

From Proclus's words, it seems there was by his day a tradition of connecting this theorem with Pythagoras. What the contribution of Pythagoras to it was, however, is not known. Proclus goes on to say that the theorem is much less impressive than the generalizations of it that Euclid produces in Book VI. That also is the place where the problem of transformation of areas, mentioned by Plutarch, can be found.

The Discovery of Incommensurables

In his book *On the Pythagorean Life* (Ch. 34, § 247), Iamblichus says that "The first who disclosed the nature of commensurability and incommensurability, making it possible for the uninitiated to take part in the discussion, was so hated that not only was he expelled from the society and its way of life, but his funeral was conducted, as if he had already departed from the life of the men whose comrade he had once been." Iamblichus does not say who this wretch was. If the sources Iamblichus used are reliable and he was not mistakenly ascribing a later result to the Pythagoreans (always a possibility), then the Pythagoreans were somehow able to discover that certain pairs of lines in geometry have no common measure. The likeliest candidates for such pairs are the simplest: the side and diagonal of a square or the side and diagonal of a pentagon.

The way in which incommensurables were discovered is not known with certainty, and as usual, certain hypotheses have been repeated so many times that they are frequently told as established fact. The reasoning seems to incorporate the principles of a pseudo-syllogism of type 1. It goes as follows:

(1) One commentator says the Pythagoreans knew about incommensurables.
(2) I personally am aware of one prominent achievement attributed to the Pythagoreans, namely the Pythagorean theorem.
(3) *Therefore*, the Pythagorean theorem must have been the route by which incommensurables were discovered.

Such reasoning would not be cogent unless there were some mathematical connection between the Pythagorean theorem and incommensurable pairs of lines, and of course there is: The theorem shows that the diagonal of a square is $\sqrt{2}$ times the side and that the diagonal of a pentagon is $\frac{1+\sqrt{5}}{2}$ times the side, and both of these constants are irrational numbers.

From these ingredients, one can prepare a rather common version of the history, found in many places, among them Chapter 3 of Bertrand Russell's *History of Western Philosophy* [27]. Apparently, the reasoning is that there was no need to deal with the number $\sqrt{2}$ until geometry, via the Pythagorean theorem, forced the confrontation.

To that, one can only say "Perhaps." The number-theoretic Books VII–IX of the *Elements* have some results on square and cube integers. If these are Pythagorean in origin, it does not seem far-fetched that the Pythagoreans would have sought fractional but rational square roots of integers for purely arithmetic reasons.

The version of the discovery as described by Russell contains what I call a *pseudo-syllogism of type* 2, which has the following form:

(1) Mathematician N proved Proposition A.
(2) Proposition A implies Proposition B.
(3) *Therefore*, Mathematician N proved Proposition B.

The fallacy in this pseudo-syllogism was neatly formulated long ago by Abbé Charles Batteux (1713–1780): One should not assume that ancient authors perceived either the consequences of their principles or the principles from which their results could be derived (cited by Burkert, [4], p. 405).

One might argue that as a mathematical demonstration, this syllogism is not "pseudo", since proving A when A implies B does establish that B is true. However, that statement presumes we *know* that A implies B. Historically, that is precisely the issue. If the mathematician who proved A didn't know that A implies B, then he/she had not proved B. In the present case, one would know the Pythagorean theorem implies that $\sqrt{2}$ is irrational only if one knew that the side and diagonal of a square were incommensurable. One could prove the latter geometrically by showing that the Euclidean algorithm applied to these lengths cycles with period 2 and hence does not terminate. Otherwise, one might as well start from scratch to prove that 2 has no rational square root; the proof doesn't at all require the Pythagorean theorem, only the properties of even and odd numbers. I'm inclined to think that that is what the Greeks did.

It was mentioned above that an unnamed Pythagorean was said to have been "made dead" to the Pythagoreans for not keeping the existence of incommensurables a secret within the Pythagorean brotherhood. Legends tend to grow and become more elaborate. This unnamed unfortunate frequently acquires the name Hippasus and is said to be the discoverer of incommensurables and also the leader of a schismatic group of Pythagoreans. It is also sometimes said that he was thrown overboard by angry Pythagoreans. There apparently was a man of this name among the Pythagoreans. According to Iamblichus (*On the Pythagorean Life*, Ch. 18, § 88), Hippasus perished at sea, but his crime was not revealing the fact that there are incommensurable pairs of lines. It was that he revealed "the sphere of the twelve pentagons" to noninitiates of the Pythagorean mysteries. Moreover, it was not merely the revelation that doomed the hapless Hippasus. His offense was taking credit for this discovery, when the Pythagoreans were supposed to attribute all their results to The Man, that is, Pythagoras himself. Iamblichus says nothing about Hippasus having been thrown overboard by outraged Pythagoreans. ("The Man" is exactly the name by which the Pythagoreans called their legendary leader. Its resemblance to modern American argot is coincidental.)

What then becomes of the alleged connection between the Pythagorean theorem and irrational numbers? It is a possibility, but it is not established beyond a reasonable doubt. There are other possible scenarios by which incommensurables could have been discovered.

The arithmetic fact that there are no integers m and n such that $m^2 = 2n^2$ is always demonstrated by very simple even-and-odd reasoning having no connection with geometry at all. There is a similar argument by which one can show that there are no integers m and n such that $m^2 = kn^2$ for any integer k not equal to a square and not congruent to 1 mod 8, since the square of any odd integer *is* congruent to 1 mod 8. Knorr ([16], Chs. III and VI) made a very good case that the original reasoning by which *some* square roots of integers were proved irrational was exactly of this type. Knorr analyzed Plato's dialogue *Theaetetus*, in which it is reported that Theodorus proved the irrationality of the square roots of all nonsquare integers less than 17, but "there he somehow got stuck." Knorr conjectured—plausibly, I believe—that Theodorus got stuck at that point because his argument broke down, 17 being the first nonsquare integer that is congruent to 1 mod 8.

It thus appears that in Plato's time a general proof that the square root of a nonsquare integer is irrational had not been found. However, the Greeks did eventually find a proof. Proposition 22 of Book VII of the *Elements* asserts that if three integers are in proportion and the first is a square, then the third is, also. In our language, if a, b, and c are integers, $a/b = b/c$, and a is the square of an integer, then c is the square of an integer. (By writing this paragraph, I have deliberately produced a pseudo-syllogism of type 2. Euclid would not have recognized the proposition in the first sentence, since the phrase *irrational number* would have been an oxymoron to him.)

A Modest Proposal

I would like to invite some ambitious mathematician with time on his/her hands to write a monograph on the role played by legends in the mathematical community. Or perhaps someone would be willing to set up the mathematical equivalent of the `snopes.com` website, where mathematical "urban legends" can be checked out.

The kind of investigation I have in mind is typified by the following two examples. First, Jeremy Gray's investigation [12] of a rumor I heard as a graduate student that Poincaré called set theory "a cancer on mathematics". By 1908 Poincaré probably thought set theory *had* a disease from which it would recover (namely its paradoxes), but he didn't think it *was* a disease. The incorrect quotation was spread by E. T. Bell and Morris Kline, and Gray shows how they both came to get the story slightly wrong.

Second, there is a famous story that as a boy, Gauss impressed his stodgy teacher Büttner by performing an amazing feat of mental calculation. This story occurs in the memorial volume *Gauss zum Gedächtnis* published by Wolfgang Sartorius, Baron von Waltershausen, in 1856, the year after Gauss's death. Like other rumors, it has grown with the telling, as we now know, thanks to the diligent research of Brian Hayes [13]. It seems to have been Ludwig Bieberbach who added the detail that Gauss summed the first 100 integers, although, as with so much that mathematicians believe, this version was amplified and popularized by E. T. Bell. According to Bell's version in *Men of Mathematics*, the problem had been assigned to keep the boys busy, and Gauss's solution of it so impressed Büttner that from then on he made an exception for Gauss when applying his usual harsh teaching methods.

I imagine that, as happens at the already-existing `snopes.com`, most of the legends will be refuted. However, even when a legend is refuted, there is some interest in seeing how it arose, as I think there is in the case of the rope-stretching legend. Here are some examples of such exploded myths, which still tantalize. One would like to know how they came into general circulation.

(1) Some twenty years ago, a colleague of mine (actually in the philosophy department) asked me who it was that Euler had confounded with his mathematical "proof" of the existence of God. Being well-versed in legends (but not in the truth behind them), I was able immediately to supply the name of Diderot. The story itself is surely false, however. Just about every aspect of the story arouses suspicion in the careful reader. A referee has provided me with a reference that thoroughly debunks it [11]. The legend arose in Volume 3 of Dieudonné Thiébault's 1804 book *Mes souvenirs de vingt ans de séjour à Berlin*, then was reported in a distorted form by Augustus De Morgan in his 1872 book *A Budget of Paradoxes* and further spread through the efforts of Florian Cajori, Eric Temple Bell, and Lancelot Hogben. Given the obvious fact that the story is false, only historical interest attaches to it, and the primary issue is, "How did something so blatantly implausible ever come to be believed?"

(2) We all "know" that Plato had the motto "Let no one ignorant of geometry enter" at the entrance to his Academy. This legend has been investigated ([10], Ch. 6), and it turns out that the earliest verifiable citation with anything resembling that language occurs some 1500 years after Plato and more than 500 years after the Emperor Justinian closed the Academy. How then did this motto come to be so confidently reported, one of those "universally known truths", referred to by van der Waerden?

(3) Why is the formula $e^{i\pi}+1=0$ called Euler's formula? (A referee suggested this legend as an example of a pseudo-syllogism of type 2.)

(4) Under what circumstances did Newton really solve the brachistochrone problem?

The book/website I am imagining would assemble as many rumors and legends as possible, classify them, investigate their validity, and discuss their significance for the history of mathematics. Even if these "universally known truths" are not true in the straightforward sense, they often contain ideas that are worth contemplating. Rumors and legends are continually arising. In an ideal world, the proper approach is not to try to eradicate them, only to recognize and appreciate them for what they are.

Conclusion

I hope the preceding examples have at the very least amused the reader. Mathematics should have some amusing aspects. On a more serious level, we all feel that mathematics is a dignified and worthy profession; and some of the legends we tell hold up an ideal of nobility for us. Along with this sense of the dignity of the profession, we can, with caution, use legends as hypothesis generators when we try to imagine the parts of the history of our subject that have not left enough mathematical texts to tell us what happened. These three purposes motivated the examples I have presented, and I hope the examples will motivate some ambitious reader to undertake the systematic investigation I have proposed.

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Seized Opportunities

Victor H. Moll

To Donald J. Newman, who knew that integrals were fun.

Every undergraduate student encounters the evaluation of integrals at an early stage of his/her education. In my case this happened in a class at the Universidad Santa Maria, Valparaiso, Chile. There, we aspiring engineers were required to use the CRC Table [27]. This note tells the story of a series of fortunate encounters that have introduced the author to the wonderful world of *the evaluation of integrals*. The reader will see that there are very interesting questions left even in apparently elementary parts of mathematics. Many of the results contained here are on the author's website `http://www.math.tulane.edu/~vhm`.

The main character of this paper is a sequence of rational numbers

$$(1) \quad d_{l,m} = 2^{-2m} \sum_{k=l}^{m} 2^k \binom{2m-2k}{m-k} \binom{m+k}{m} \binom{k}{l}, \quad m \in \mathbb{N} \text{ and } 0 \le l \le m,$$

that appeared in the evaluation of the quartic integral

$$(2) \qquad N_{0,4}(a;m) = \int_0^\infty \frac{dx}{(x^4+2ax^2+1)^{m+1}}.$$

This is a remarkable sequence, connected to many interesting questions. The recent advances in communications and the possibility of fast search on literature have accelerated collaborations in mathematics. The study of the properties of $\{d_{l,m}\}$ has led the author to many rewarding and unexpected collaborations.[1]

Victor H. Moll is professor of mathematics at Tulane University. His email address is `vhm@math.tulane.edu`.

The Evaluation of Integrals

Elementary mathematics leaves the impression that there is a marked difference between the two branches of calculus. *Differentiation* is a systematic subject: every evaluation is a consequence of a number of established rules and basic examples. However, *integration* is a mixture of art and science. The successful evaluation of an integral depends on the right approach, the right change of variables or a patient search in a table of integrals. In fact, the theory of *indefinite* integrals of elementary functions is complete [11]. Risch's algorithm determines whether a given function has an antiderivative within a given class of functions. For example, this theory shows that if f and g are rational functions with $g(x)$ nonconstant, then $f(x)e^{g(x)}$ has an elementary primitive precisely when $f(x) = R'(x) + R(x)g'(x)$ for some rational function R. In particular e^{-x^2} has no elementary primitive—a well-known fact.

However, the theory of *definite* integrals is far from complete, and there is no general theory available. The nature of the constant in the evaluation of a definite integral is hard to predict, as seen in the example

$$(3) \quad \int_0^\infty e^{-x}\,dx = 1, \int_0^\infty e^{-x^2}\,dx = \frac{\sqrt{\pi}}{2}, \quad \text{and } \int_0^\infty e^{-x^3}\,dx = \Gamma\left(\frac{4}{3}\right).$$

[1] *The author wishes to thank Dante V. Manna for remarks on an earlier version of the paper and the partial support of NSF-DMS* 0070567.

The first integrand has an elementary primitive, the second integral is the classical Gaussian, and the evaluation of the third requires Euler's *gamma function* defined by

$$\Gamma(a) = \int_0^\infty x^{a-1} e^{-x}\, dx. \tag{4}$$

Interesting numbers emerge from elementary manipulations of integrals. To wit, differentiating (4) at $a = 1$ yields the numerical constant

$$\int_0^\infty e^{-x} \log x\, dx = -\gamma \tag{5}$$

known as *Euler's constant*, defined by $\gamma = \lim_{n\to\infty}\left(\sum_{k=1}^{n} \frac{1}{k} - \log n\right)$. Havil's book [16] is devoted to the story of this intriguing constant.

Another illustration of the deceptiveness of definite integrals is the fact that

$$\int_{-\infty}^{\infty} \frac{dx}{(e^x - x - 1)^2 + \pi^2} = \frac{1}{2} \tag{6}$$

is obtained by elementary methods, but the similar-looking integral

$$\int_{-\infty}^{\infty} \frac{dx}{(e^x - x)^2 + \pi^2} \tag{7}$$

is given by $(1 - W(1))^{-1}$, where $W(z)$ is the *Lambert W-function*, defined as the solution to the transcendental equation $xe^x = z$. It is unknown whether this integral has a simpler analytic representation, but experts believe it is unlikely that it does.

In this note, the reader will find some of the mathematics behind the evaluation of definite integrals. Most of the results are quite elementary, but be mindful if somebody asks you to compute an integral: if $\zeta(s)$ denotes the classical Riemann zeta function, V. V. Volchkov [26] has shown that establishing the exact value

$$\int_0^\infty \frac{(1 - 12t^2)}{(1 + 4t^2)^3} \int_{1/2}^\infty \log|\zeta(\sigma + it)|\, d\sigma\, dt = \frac{\pi(3 - \gamma)}{32} \tag{8}$$

is equivalent to the Riemann hypothesis. *Evaluating* (8) *might be hard.*

It remains to explain *why we evaluate integrals.* This paper gives some anecdotal answers. The general response is that these questions lead to challenging problems that do not require an extensive background, which have provided inspiration for interesting student research projects [5, 6]. In addition, the computation of integrals has been shown to be connected to many parts of mathematics.

Once in a while, a nice evaluation produces a beautiful proof. For example,

$$\int_0^1 \frac{x^4(1 - x)^4}{1 + x^2}\, dx = \frac{22}{7} - \pi \tag{9}$$

proves that $\pi \neq \frac{22}{7}$. This evaluation, which has a long history, is used by H. Medina [21] to produce reasonable approximations to $\tan^{-1} x$ and has been revisited by S. K. Lucas in [19]. The latter contains, among many interesting results, the identity

$$\int_0^1 \frac{x^5(1 - x)^6(197 + 462x^2)}{530(1 + x^2)}\, dx = \pi - \frac{333}{106} \tag{10}$$

that exhibits the relation of π to its second continued fraction approximation.

To explain our motivation, we adapt a quote from George Mallory, when asked about climbing Everest. *We evaluate integrals because they are there.*

The mathematical point of view described here is the author's perspective of experimental mathematics. Supplementary accounts are given by D. H. Bailey and J. M. Borwein in [2] and also by D. Zeilberger in his interview [14].

A Graduate Student

A version of this story has already been told in [22]. George Boros (1947-2003) came to my office one day, stating that he could evaluate the integral

$$N_{0,4}(a; m) = \int_0^\infty \frac{dx}{(x^4 + 2ax^2 + 1)^{m+1}}. \tag{11}$$

His result says: for $a > -1$ and $m \in \mathbb{N}$, we have

$$N_{0,4}(a; m) = \frac{\pi}{2^{m+3/2}\,(a + 1)^{m+1/2}} P_m(a), \tag{12}$$

where P_m is a polynomial of degree m, written as

$$P_m(a) = \sum_{l=0}^{m} d_l(m) a^l, \tag{13}$$

and

$$d_{l,m} = \sum_{j=0}^{l} \sum_{s=0}^{m-l} \sum_{k=s+l}^{m} \frac{(-1)^{k-l-s}}{2^{3k}} \binom{2k}{k} \binom{2m+1}{2(s+j)} \binom{m-s-j}{m-k} \binom{s+j}{j} \binom{k-s-j}{l-j},$$

from which it follows that $d_l(m)$ is a rational number.

The proof is elementary and is based on the change of variables $x = \tan\theta$, and then George had the clever idea of *doubling the angle*; that is, introducing a new variable $u = 2\theta$. This yields a new form for the integral (11) and the expression for $d_l(m)$. The double angle substitution is the basic idea behind the new theory of *rational Landen transformations.* The reader will find in [20] a recent survey on this topic.

Having no experience in special functions, my reaction to this result was that (i) a symbolic language like Mathematica or Maple must be able to do it, (ii) there must be a simpler formula for the coefficients $d_{l,m}$, and (iii) it must be known.

It was surprising to find out that the Mathematica version available at that time was unable to compute (11) when a and m are entered as parameters. The symbolic status of $N_{0,4}(a;m)$ has not changed much since it was reported in [22]. Mathematica 7.0 is still unable to solve this problem.

On the other hand, the corresponding indefinite integral is evaluated in terms of the Appell-F1 function, defined by

$$(14)\quad F_1(a;b_1,b_2;c;x,y) := \sum_{m=0}^{\infty}\sum_{n=0}^{\infty} \frac{(a)_{m+n}(b_1)_m(b_2)_n}{m!n!(c)_{m+n}} x^m y^n,$$

as

$$\int \frac{dx}{(x^4+2ax^2+1)^{m+1}} = x F_1\left[\frac{1}{2}, 1+m, 1+m, \frac{3}{2}, -\frac{x^2}{a_+}, -\frac{x^2}{a_-}\right],$$

where $a_{\pm} := a \pm \sqrt{-1+a^2}$. Here $(a)_k = a(a+1)\cdots(a+k-1)$ is the ascending factorial. This clarifies my reaction (i) and also makes the point that the evaluation of integrals, with the help of a symbolic language, is a natural guide into the field of special functions.

The search for a simpler formula started with the experimental observation that, in spite of the alternating signs in the formula for $d_{l,m}$, these coefficients are all positive. It took us some time to find

$$(15)\quad d_{l,m} = 2^{-2m}\sum_{k=l}^{m} 2^k \binom{2m-2k}{m-k}\binom{m+k}{m}\binom{k}{l}.$$

The first proof is based on the mysterious appearance of the integral $N_{0,4}(a,m)$ in the expansion

$$(16)\quad \sqrt{a+\sqrt{1+c}} = \sqrt{a+1} + \frac{1}{\pi\sqrt{2}}\sum_{k=1}^{\infty}\frac{(-1)^{k-1}}{k} N_{0,4}(a;k-1)c^k.$$

George figured out how to use Ramanujan's Master Theorem [3] to produce (15). The author asked him many times to explain his train of thought leading to this connection. There was never a completely logical path: *He simply knew how to integrate.*

The expression

$$(17)\quad P_m(a) = 2^{-2m}\sum_{k=0}^{m} 2^k \binom{2m-2k}{m-k}\binom{m+k}{m}(a+1)^k$$

shows that the polynomial $P_m(a)$ is an example of the classical Jacobi family

$$(18)\quad P_m^{(\alpha,\beta)}(a) := \sum_{k=0}^{m}(-1)^{m-k}\binom{m+\beta}{m-k}\binom{m+k+\alpha+\beta}{k}\left(\frac{a+1}{2}\right)^k$$

with parameters $\alpha = m+\frac{1}{2}$ and $\beta = -(m+\frac{1}{2})$. The parameters α and β, usually constants, are now dependent upon m. We were surprised not to find an explicit evaluation for $N_{0,4}(a;m)$ in [15]. It turns out that this integral appears in an equivalent form as entry 3.252.11. This is the answer to (iii).

A Conference at Penn State or How I Got Erdős Number 2

It was then important to present our results in public. We decided to volunteer a talk at a conference. A special one celebrating Basil Gordon's sixty-fifth birthday was being organized at Penn State.[2] Trying to find a way to close my talk with a question in number theory, it occured to me to describe a new formula for $d_{l,m}$. The idea behind it is simple: write (12) as

$$(19)\quad P_m(a) = \frac{2}{\pi}[2(a+1)]^{m+\frac{1}{2}} N_{0,4}(a;m)$$

and compute $d_{l,m}$ from the Taylor expansion at $a=0$ of the right-hand side. This yields

$$(20)\quad d_{l,m} = \frac{1}{l!m!2^{m+l}}\left[\alpha_l(m)\prod_{k=1}^{m}(4k-1) - \beta_l(m)\prod_{k=1}^{m}(4k+1)\right],$$

where α_l and β_l are polynomials in m of degrees l and $l-1$, respectively. The last transparency from my talk contained the formula

$$(21)\quad d_{1,m} = \frac{1}{m!\,2^{m+1}}\left[(2m+1)\prod_{k=1}^{m}(4k-1) - \prod_{k=1}^{m}(4k-1)\right]$$

and the observation that the numerator is an even number, so it might be of interest to find out the exact power of 2 that divides it, that is, its 2-adic valuation $\nu_2(d_l(m))$. (For a prime p, write $m = p^a r$ where p does not divide r. Then the integer a is the *p-adic valuation* of m, denoted by $\nu_p(m)$.)

A short time later, I received a fax from Jeffrey Shallit stating that he had established the result

$$(22)\quad \nu_2(d_1(m)) = 1-2m+\nu_2\left(\binom{m+1}{2}\right)+S_2(m),$$

where $S_2(m)$ is the sum of the binary digits of m. *Revista Scientia* is a journal produced by the Department of Mathematics at Universidad Santa Maria, Valparaiso, Chile, my undergraduate institution. This was perfect timing: there was going to be a special issue dedicated to the memory of Miguel Blazquez, one of my undergraduate teachers. The results of the valuation of $d_{1,m}$ appeared in [7].

[2] *The author wishes to use this occasion to thank the organizers for the chance to speak there.*

The polynomials α_l and β_l do not have simple analytic expressions. One uninspired day, we decided to compute their roots numerically. We were pleasantly surprised to discover the following:

Theorem 4.1. *For all $l \geq 1$, all roots of $\alpha_l(m) = 0$ lie on the line $\operatorname{Re} m = -\frac{1}{2}$. Similarly, the roots of $\beta_l(m) = 0$ for $l \geq 2$ lie on the same vertical line.*

The first step in the proof of this theorem took place at lunch during the 2000 Summer Institute for Mathematics for Undergraduates at the University of Puerto Rico at Humacao. John Little was a guest speaker, and he is enthusiastic about problems involving polynomials. The result of that conversation is a series of email exchanges in which the details of the proof of Theorem 4.1 were explained to me. The location of the zeros of $\alpha_l(m)$ now suggest studying the behavior of this family as $l \to \infty$. In the best of all worlds, one will obtain an analytic function of m with all the zeros on a vertical line. Perhaps some number theory will enter and…*there is no telling what will happen.*

The Gradshteyn and Ryzhik Project

The problem of analytic evaluations of definite integrals has been of interest to scientists since integral calculus was developed. The central question is, loosely stated:

Given a class of functions $\mathfrak{F}$ and an interval $[a,b] \subset \mathbb{R}$, express the integral of $f \in \mathfrak{F}$

$$I = \int_a^b f(x)\, dx$$

in terms of the special values of functions from an enlarged class $\mathfrak{G}$.

The theory in the case of indefinite integrals is well developed. For instance, by elementary arguments it is possible to show that if $\mathfrak{F}$ is the class of rational functions, then the enlarged class $\mathfrak{G}$ is obtained by including logarithms and inverse trigonometric functions. In the 1980s G. Cherry discussed extensions of this classical paradigm. The following example illustrates the relevant issues in describing $\mathfrak{G}$: we can evaluate

$$\int \frac{x^3\, dx}{\log(x^2-1)} = \frac{1}{2}\mathrm{li}(x^4 - 2x^2 + 1) + \frac{1}{2}\mathrm{li}(x^2-1), \tag{23}$$

but

$$\int \frac{x^2\, dx}{\log(x^2-1)} \tag{24}$$

cannot be written in terms of elementary functions and the logarithmic integral

$$\mathrm{li}(x) := \int \frac{dx}{\log x} \tag{25}$$

that appears in (23). The reader will find in [11] the complete theory behind integration in terms of elementary functions.

On the other hand, the theory of definite integrals is less developed. Examples are evaluated by a series of ad hoc procedures and have been collected in tables. The earliest volume available to the author is *Tables d'integrales definies* [4], compiled by Bierens de Haan, who also presented in 1862 a survey of the methods employed in the verification of the entries. These tables form the main source for the popular volume by I. S. Gradshteyn and I. M. Ryzhik [15]. There are many other interesting tables of integrals, from the one by A. Apelblat, small and beautiful, to the five-volume compendium by A. P. Prudnikov et al., encyclopedic and very expensive. The choice of [15] is a popular compromise.

Once the author realized that there was interesting mathematics encoded in formula 3.252.11 of [15] that gave (11), we began to wonder what else was in that table. Perhaps it would be a good idea to *verify every formula in it by hand*, since most entries cannot be evaluated symbolically. This has proven to be a larger task than originally thought. The author has begun a systematic verification of the entries in [15], and the proofs have appeared in *Revista Scientia*.

Given the large number of entries in [15], we have not yet developed an order in which to check them. Once in a while an entry catches our eye. This was the case with entry 3.248.5 in the sixth edition of the table by Gradshteyn and Ryzhik. The presence of the double square root in the appealing integral

$$\int_0^\infty \frac{dx}{(1+x^2)^{3/2}\left[\varphi(x) + \sqrt{\varphi(x)}\right]^{1/2}} = \frac{\pi}{2\sqrt{6}}, \tag{26}$$

with

$$\varphi(x) = 1 + \frac{4x^2}{3(1+x^2)^2}, \tag{27}$$

reminded us of (16). *Unfortunately* (26) *is incorrect.* The numerical value of the left-hand side is approximately 0.666377, and the right-hand side is about 0.641275. The table [15] is continually being revised. After we informed the editors of the error in 3.248.5, it was taken out. There is no entry 3.248.5 in [15]. At the present time, we are still reconciling this formula.

The revision of integral tables is nothing new. C. F. Lindman compiled in 1891 a long list of errors from the table by Bierens de Haan [4]. The editors of [15] maintain the webpage `http://www.mathtable.com/gr/`, where the corrections to the table by I. S. Gradshteyn and I. M. Ryzhik are stored.

Integral tables are organized like a phone book: entries that *look* similar are placed together. However, the fact that two integrals are close in the table is not a reflection of the techniques involved in their evaluation. For example, 4.229.4 gives

$$\int_0^1 \log\left(\log\frac{1}{x}\right)\left(\log\frac{1}{x}\right)^{\mu-1} dx = \psi(\mu)\Gamma(\mu), \tag{28}$$

for $\operatorname{Re}\mu > 0$, and 4.229.7 states that

$$\int_{\pi/4}^{\pi/2} \log\log\tan x\, dx = \frac{\pi}{4}\left(4\log\Gamma\left(\frac{3}{4}\right) - \log\pi\right). \tag{29}$$

Indeed, the formula (28) is established by the change of variables $v = -\log x$ followed by differentiating the gamma function (4) with respect to the parameter μ. The function $\psi(\mu)$ in (28) is simply the logarithmic derivative of $\Gamma(\mu)$, and the formula has been checked. The situation is quite different for (29). This formula is the subject of the elegant paper [25], in which the author uses analytic number theory to check its validity. The ingredients of the proof are quite formidable: I. Vardi shows that

$$\int_{\pi/4}^{\pi/2} \log\log\tan x\, dx = \frac{d}{ds}\Gamma(s)L(s)\Big|_{s=1}, \tag{30}$$

where $L(s) = 1 - \frac{1}{3^s} + \frac{1}{5^s} - \frac{1}{7^s} + \cdots$ is the Dirichlet L-function. The computation of (30) is done in terms of the *Hurwitz zeta function*

$$\zeta(q,s) = \sum_{n=0}^{\infty} \frac{1}{(n+q)^s}, \tag{31}$$

defined for $0 < q < 1$ and $\operatorname{Re} s > 1$.

Vardi's technique has been extended in Luis Medina's Ph.D. thesis at Tulane. Examples of integrals evaluated there include

$$\int_0^{\infty} \log x\, \log\tanh x\, dx = \frac{\gamma\pi^2}{8} - \frac{3}{4}\zeta'(2) + \frac{\pi^2\log 2}{12}, \tag{32}$$

and

$$\int_0^1 \log(1+x+x^2)\,\log\log 1/x\,\frac{dx}{x} = -\frac{\gamma\pi^2}{9} + \frac{1}{18}\pi^2\log 3 + \frac{2}{3}\zeta'(2). \tag{33}$$

A Productive Trip to Chile

During the summer of 1999 I was invited to lecture on integrals at Universidad Santa Maria. During the presentation of Vardi's method using the Hurwitz zeta function to evaluate (28), Olivier Espinosa mentioned that this function plays a role in the problem of a gas of noninteracting electrons in the background of a uniform magnetic field. For instance, it is shown that the *density of states* $g(E)$, in terms of which all thermodynamic functions are to be computed, is written as

$$g(E) = V\frac{4\pi}{h^3}(2e\hbar B)^{1/2}E\,\mathcal{H}_{1/2}\left(\frac{E^2-m^2}{2e\hbar B}\right), \tag{34}$$

where V stands for volume and B for magnetic field, m is the electron mass, $\hbar$ is Planck's constant, e is the electron charge, and

$$\mathcal{H}_z(q) := \zeta(z,\{q\}) - \zeta(z,q+1) - \frac{1}{2}q^{-z}, \tag{35}$$

with $\{q\}$ the fractional part of q. The Hurwitz zeta function also appears in the evaluation of functional determinants and many other parts of mathematical physics [13].

The function $\log\Gamma(x)$ makes its appearance through Lerch's formula

$$\frac{d}{dz}\zeta(z,q)\Big|_{z=0} = \log\Gamma(q) - \log\sqrt{2\pi}. \tag{36}$$

The first few formulas are evaluated symbolically:

$$\int_0^1 q\log\Gamma(q)dq = \frac{\zeta'(2)}{2\pi^2} + \frac{1}{3}\log\sqrt{2\pi} - \frac{\gamma}{12},$$

$$\int_0^1 q^2\log\Gamma(q)dq = \frac{\zeta'(2)}{2\pi^2} + \frac{\zeta(3)}{4\pi^2} + \frac{1}{6}\log\sqrt{2\pi} - \frac{\gamma}{12},$$

$$\int_0^1 q^3\log\Gamma(q)dq = \frac{\zeta'(2)}{2\pi^2} + \frac{3\zeta(3)}{8\pi^2} - \frac{3\zeta'(4)}{4\pi^4} + \frac{1}{10}\log\sqrt{2\pi} - \frac{3\gamma}{40}.$$

My favorite unevaluated integral is, without a doubt, one that is related to Euler's result

$$\int_0^1 \log\Gamma(q)dq = \log\sqrt{2\pi}. \tag{37}$$

Using Lerch's formula and an expression for the product of two Hurwitz zeta functions, we obtained

$$\int_0^1 \log^2\Gamma(q)dq = \frac{\gamma^2}{12} + \frac{\pi^2}{48} + \frac{1}{3}\gamma\log\sqrt{2\pi} + \frac{4}{3}\log^2\sqrt{2\pi} - (\gamma + 2\log\sqrt{2\pi})\frac{\zeta'(2)}{\pi^2} + \frac{\zeta''(2)}{2\pi^2}. \tag{38}$$

The obvious next step would be to evaluate

$$L_3 := \int_0^1 \log^3\Gamma(q)\,dq. \tag{39}$$

We have been unable to do this, but this question has interesting connections with *multiple zeta values* of the form

$$T(a,b,c) = \sum_{n=1}^{\infty}\sum_{m=1}^{\infty} \frac{1}{n^a m^b (n+m)^c}. \tag{40}$$

The book [8] has a nice introduction to these sums.

This encounter in Chile began a fruitful collaboration. Olivier, who studies particle physics for a living, now spends his free time thinking about integrals. *Evaluating integrals will take you to unexpected places.*

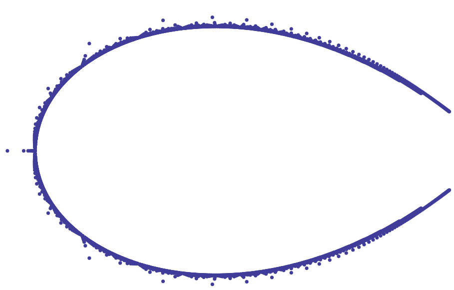

Figure 1. The zeros of $P_m(a)$.

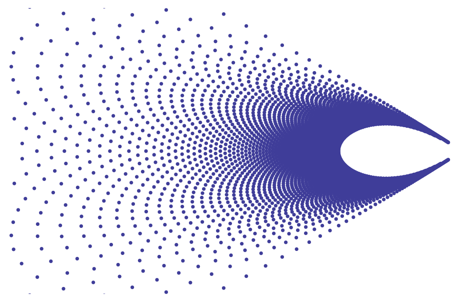

Figure 2. The scaled zeros of $P_m(a)$.

Combinatorial Aspects of the Coefficients $d_{l,m}$

Now we return to the coefficients $d_{l,m}$ in (15). Fixing m and plotting the list $\{d_{l,m} : 0 \leq l \leq m\}$ reveals their unimodality. Recall that a finite sequence of real numbers $\{x_0, x_1, \dots, x_m\}$ is said to be *unimodal* if there exists an index m^* such that x_j increases up to $j = m^*$ and decreases from then on, that is, $x_0 \leq x_1 \leq \cdots \leq x_{m^*}$ and $x_{m^*} \geq x_{m^*+1} \geq \cdots \geq x_m$. A polynomial is said to be unimodal if its sequence of coefficients is unimodal. Unimodal polynomials arise often in combinatorics, geometry, and algebra.

The unimodality of the coefficients $d_{l,m}$ follows directly from the representation (17) and the next theorem.

Theorem 7.1. *If $P(x)$ is a polynomial with positive nondecreasing coefficients, then $P(x+1)$ is unimodal.*

A condition stronger than unimodality is *logconcavity*. A sequence of positive real numbers $\{x_0, x_1, \cdots, x_m\}$ is said to be *logarithmically concave* (or *logconcave* for short) if $x_{j+1}x_{j-1} \geq x_j^2$ for $1 \leq j \leq m-1$. It is easy to see that if a sequence is logconcave then it is unimodal. Extensive computations showed that the sequence $\{d_{l,m} : 0 \leq l \leq m\}$ was logconcave. This question leads us to the study of the zeros of the polynomial $P_m(a)$. It turns out that if all the zeros of a polynomial are real and negative, then it is logconcave and therefore unimodal. Unfortunately P_m has the minimal possible number of real zeros: 0 if m is even and 1 if odd. Figure 1 plots these zeros for $1 \leq m \leq 100$ and Figure 2 plots the zeros of P_m divided by the corresponding degree.

A remarkable result of Dimitrov [12] shows that the zeros of $P_m(a)$ divided by the degree m converge to the left half of the lemniscate of Bernoulli given by the polar equation $r^2 = 2\cos 2\theta$, for $\theta \in (3\pi/4, 5\pi/4)$. This is reminiscent of the phenomena observed by Pólya for the zeros of the partial sums of the exponential function.

The unimodality of $d_{l,m}$ was relatively easy to show. The fact that $d_{l,m}$ was logconcave turned out to be considerably more difficult, and its proof came from an unexpected source [17]. Starting with the triple sum

$$d_{l,m} = \sum_{j,s,k} \frac{(-1)^{k+j-l}}{2^{3(k+s)}} \binom{2m+1}{2s} \cdot \binom{m-s}{k}\binom{2(k+s)}{k+s}\binom{s}{j}\binom{k}{l-j}, \tag{41}$$

the authors used the RISC package MultiSum to produce the recurrence

$$2(m+1)d_{l,m+1} = 2(l+m)d_{l-1,m} + (2l+4m+3)d_{l,m} \tag{42}$$

that implies the positivity of $d_{l,m}$. The next recurrence derived in automatic fashion is

$$(m+2-l)(m+l-1)d_{l-2,m} - (l-1) \cdot (2m+1)d_{l-1,m} + (l-1)l d_{l,m} = 0. \tag{43}$$

This enabled them to identify $P_m(a)$ as a Jacobi polynomial. Finally, using the method of cylindrical algebraic decomposition, the authors produced the inequality

$$d_{l,m+1} \geq \frac{4m^2+7m+l+3}{2(m+1-l)(m+1)} d_{l,m} \tag{44}$$

that implies the logconcavity of $d_{l,m}$.

Define the operator $\mathcal{L}(a_j) := a_j^2 - a_{j-1}a_{j+1}$ so that a logconcave sequence $\mathbf{a}$ is one such that $\mathbf{a} := \{a_n : n \in \mathbb{N}\}$ and $\mathcal{L}(\mathbf{a})$ are positive. A sequence is called *infinitely logconcave* if it remains positive after applying $\mathcal{L}$ any number of times. We have conjectured that $\{d_{l,m} : 0 \leq l \leq m\}$ is infinitely logconcave. A remarkable result that implies infinite logconcavity for a sequence $\{a_n\}$ is the subject of a preprint by Petter Brändén [9]: it is shown that if the polynomial $a_nz^n + a_{n-1}z^{n-1} + \cdots + a_0$ has only real and negative zeros, then the same holds for the polynomial produced by replacing a_k by $a_k^2 - a_{k-1}a_{k+1}$. This does not apply directly to the coefficients $d_{l,m}$ considered here, but it proves that the binomial coefficients $\{\binom{m}{l} : 0 \leq l \leq m\}$ are infinitely logconcave.

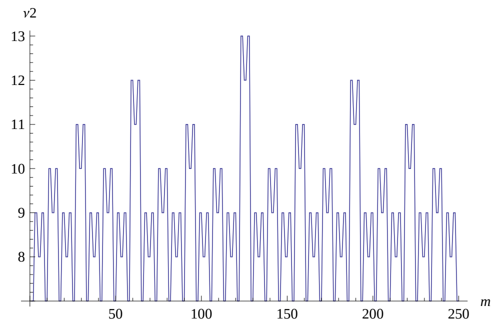

Figure 3. The valuation of $A_{3,m}$.

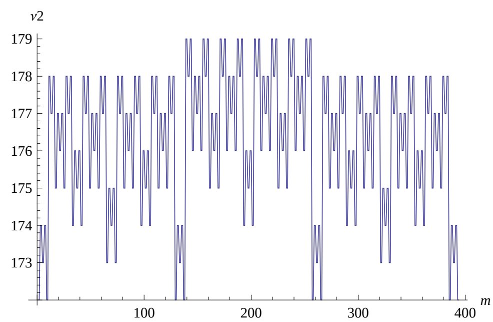

Figure 4. The valuation of $A_{59,m}$.

The *p*-adic Point of View

In this last section we go back to divisibility questions for the sequence $d_{l,m}$. The generalization of (22) was obtained in joint work with T. Amdeberhan and D. Manna during the post-Katrina semester[3] when we were all on sabbatical out of necessity.

It is convenient to introduce some rescaling of $d_{l,m}$ given by

$$A_{l,m} := l!m!2^{m+l}d_{l,m}$$

$$= \frac{l!m!}{2^{m-l}} \sum_{k=l}^{m} 2^k \binom{2m-2k}{m-k}\binom{m+k}{m}\binom{k}{l}. \tag{45}$$

The pictures of the 2-adic valuations of $A_{l,m}$ become increasingly complicated as l increases. Figure 3 shows $l = 3$ and Figure 4 shows $l = 59$. It was surprising to find out that the valuation of $A_{l,m}$ is intimately linked to the Pochhammer symbol $(a)_k = a(a+1)\cdots(a+k-1)$ in a very simple manner.

Theorem 8.1. *The 2-adic valuation of $A_{l,m}$ satisfies*

$$\nu_2(A_{l,m}) = \nu_2((m+1-l)_{2l}) + l. \tag{46}$$

This result is now obtained in completely automatic fashion. Define the numbers

$$B_{l,m} := \frac{A_{l,m}}{2^l(m+1-l)_{2l}}. \tag{47}$$

[3]*The author wishes to thank the Courant Institute for its hospitality during that period.*

It is required to prove that $B_{l,m}$ is odd. The WZ-method [23] provides the recurrence

$$B_{l-1,m} = (2m+1)B_{l,m} - (m-l)$$
$$(m+l+1)B_{l+1,m}, 1 \le l \le m-1. \tag{48}$$

Since the initial values $B_{m,m} = 1$ and $B_{m-1,m} = 2m+1$ are odd, it follows that $B_{l,m}$ is an odd integer. There is also a genuine computer-free proof of this result. The point of view of the author is that we use all the tools available to us. *Experimenting with the computer is here to stay.*

In view of the complexities seen in Figures 3 and 4 it was a remarkable surprise when Xinyu Sun told me that he had an *exact* formula for the 2-adic valuation of $A_{l,m}$. To describe it, we associate to each index l a labeled binary tree $T(l)$ that encodes the 2-adic information of $A_{l,m}$. This is the *decision tree* for l (Figure 5). It is sufficient to consider l odd. Vertices of degree 1 will be called *terminal*. The description of $T(l)$ is remarkably simple. The first generation of $T(l)$ that contains terminal vertices is given by $k^*(l) = \lfloor \log_2 l \rfloor$, and there are precisely $2^{k^*+1} - l$ terminal vertices there. The tree $T(l)$ has one more generation consisting of $2(l - 2^{k^*})$ terminal vertices. There is also a well-defined mechanism to label the terminal vertices (involving valuations of factorials).

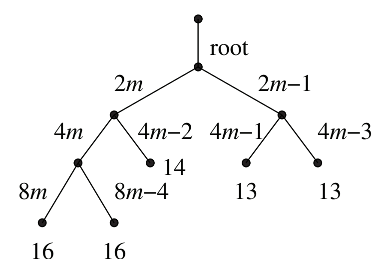

Figure 5. The decision tree for $l = 5$.

The explicit formula for $\nu_2(A_{5,j})$ is given by

$$\nu_2(A_{5,2j}) = \begin{cases} 14 + \nu_2\left(\frac{j+2}{4}\right) & \text{if } j \equiv 2 \bmod 4, \\ 13 + \nu_2\left(\frac{j+1}{4}\right) & \text{if } j \equiv 3 \bmod 4, \\ 13 + \nu_2\left(\frac{j+3}{4}\right) & \text{if } j \equiv 1 \bmod 4, \\ 16 + \nu_2\left(\frac{j}{8}\right) & \text{if } j \equiv 0 \bmod 8, \\ 16 + \nu_2\left(\frac{j+4}{8}\right) & \text{if } j \equiv 4 \bmod 8, \end{cases} \tag{49}$$

for even indices. The odd index case is obtained from the relation $\nu_2(A_{5,2j+1}) = \nu_2(A_{5,2j})$.

The analysis for the prime 2 seems rather complete, but what about odd primes? A symbolic calculation shows that $\nu_p(A_{l,m})$ grows linearly with m. Moreover, the slope is conjectured to be $1/(p-1)$. The error term for $p = 5$ is shown in Figures 6 and 7 for $A_{l,m}$ with $l = 3$ and $l = 4$, respectively. An analytic description might produce some more insight into this sequence.

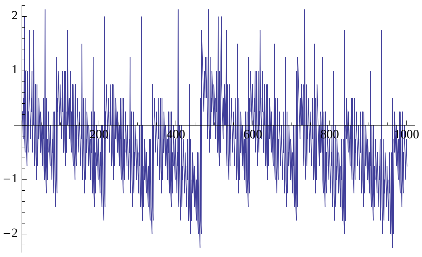

Figure 6. The error term $\nu_5(A_{3,m}) - m/4$.

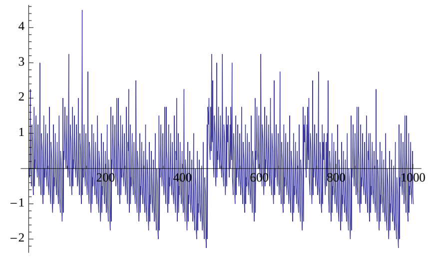

Figure 7. The error term $\nu_5(A_{4,m}) - m/4$.

The question of evaluation of definite integrals has taken us into a journey full of mathematical surprises. Many of them would not have been possible without the help of symbol manipulation software. We conclude with figures illustrating two instances of experimental mathematics:
(1) The presence of the function $S_2(n)$ in formula (22) led us to work of T. Lengyel [18] on the 2-adic valuation of Stirling numbers of the second kind $S(n,k)$. These numbers have been around for a long time, so we expected everything to be known about them. The next four figures show a small sample of the graph of $\nu_2(S(n,k))$ with k fixed. The case $k = 5$ has been analyzed [1], but the problem for $k \geq 6$ is completely open.

(2) The special case $p = 3$ of the sequence

$$T_p(n) := \prod_{j=0}^{n-1} \frac{(pj+1)!}{(n+j)!}, \tag{50}$$

appears as the number of n by n *alternating sign matrices*. The wonderful book [10] tells the story of this sequence. A seminar at Tulane devoted to this question led to the exploration of p-adic properties of these numbers. Figure 12 shows the graph of the 2-adic valuation of $T_3(n)$ and Figure 13 the corresponding 3-adic valuation. The structure observed in these graphs is now beginning to be explored, and only Figure 12 is well understood [24]. There are many interesting questions regarding $T_p(n)$. We leave the reader with the most natural one: *what do these numbers count?*

During the social parts at mathematical gatherings, the most common beginning of conversations is: *What do you do?* The author frequently encounters surprised faces when he states: *I compute integrals.* Perhaps this note has provided the reader a clearer response.

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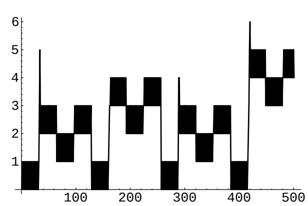

Figure 8. 2-adic valuation of $S(n, 195)$.

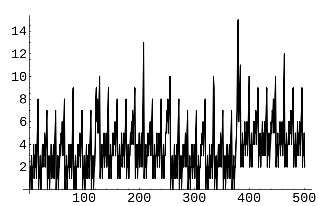

Figure 9. 2-adic valuation of $S(n, 279)$.

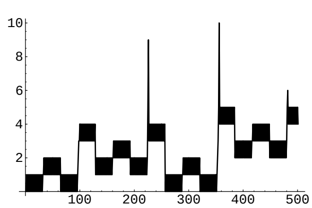

Figure 10. 2-adic valuation of $S(n, 324)$.

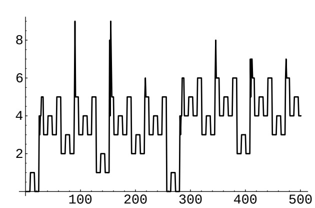

Figure 11. 2-adic valuation of $S(n, 465)$.

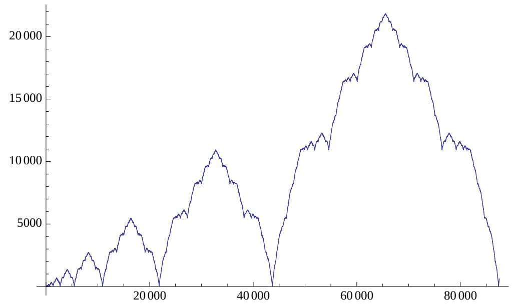

Figure 12. 2-adic valuation of $T_3(n)$

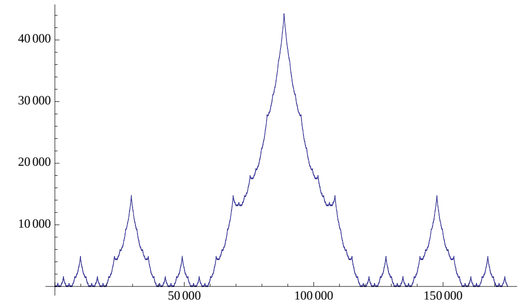

Figure 13. 3-adic valuation of $T_3(n)$

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Awareness of Ethical Pitfalls: A Requirement for Professional Protection

Catherine A. Roberts

The AMS Committee on Professional Ethics (COPE) serves an important role in our profession. It deals with cases of ethical impropriety that are reported to it and takes actions as warranted. In this article I report on my experience as a member of COPE.

The cases that I describe are ones that I had direct involvement with as chair of COPE. Established in 1983, COPE is designed to help deal with delicate ethical dilemmas. Some of the stories I'll share here might not strike you as particularly grievous or alarming. Still, each contains an apt lesson about how we, as mathematicians, can behave in a professional and ethical fashion. Although the actual clout of COPE is limited, it carries considerable moral weight in the profession. A censure from COPE is a very serious matter. COPE's resolution of certain cases during my tenure included a request that an article such as this be published in the *Notices* for the purpose of educating the mathematical community. COPE believes broadcasting these accounts may help prevent similar situations from arising in the future.

You may have heard whispers about distasteful situations that have arisen within our community. There was the case of the stolen thesis result, in which one student's quickly published doctoral thesis contained proofs that were pilfered from original results that another graduate student had recently presented at a conference. There was a situation in which tenure was denied to a mathematician—a decision that was determined to be based in departmental nepotism aimed to open the position for a relative of the department chair. Then there was a professor who stole his graduate student's result and published it under his own name. The details of these older cases are contained in confidential reports that are not available to me, and I hesitate to try to describe them in any detail. In January 2009, as I finished my term, COPE directed me to write to the wider mathematical community, asking me to focus specifically on new cases that we had seen. Our recent work provides many examples of lapses in ethical judgment; these will inform readers in the remainder of this article.

The cases that I highlight are likely to be of particular interest to graduate students, postdoctorates, and new faculty members; however, due to the confidential nature of these reports, I cannot describe them in much detail.

Before I go further, I find it worth mentioning that the mathematical community is, for the most part, well behaved. We treat each other with respect, and we strive to do the right thing. Nonetheless, COPE's recent work provides copious examples of lapses in ethical judgment.

As you can imagine, COPE has addressed multiple cases of plagiarism. Indeed, there are several AMS committees that discuss the issue of plagiarism from various angles. Sadly, one could make a compelling argument that plagiarism is ubiquitous and stands as one of the biggest challenges to our profession. For example, someone I know was reviewing a paper for a reputable journal, only to discover that the manuscript contained paragraphs lifted from one of her own, previously published, manuscripts. As editor of the journal *Natural Resource Modeling*, I had a situation arise in which an identical manuscript had been submitted simultaneously to us and to another journal. Serendipitously, the same reviewer had been contacted for both submissions and was able to alert the journals to the breach in protocol. Both journals banned future submissions from this author. When we encounter behavior that is

Catherine A. Roberts is associate professor and chair of the Department of Mathematics and Computer Science at the College of the Holy Cross in Worcester, MA, and editor-in-chief of the journal Natural Resource Modeling. *Her email address is* `croberts@holycross.edu`.

unethical, sometimes resolution is relatively easy. There are times, however, when COPE ought to be invited to the table.

The Case of the Plagiarized Teaching Statement

One component of many academic job applications is the Teaching Statement, which is written by the applicant to describe his or her teaching experience, style, and philosophy. When graduate students begin to assemble their application materials, there is a desire to figure out the best style and format for selling oneself as a job candidate. It is natural to examine the curriculum vitae, cover letters, teaching statements, etc., from successful mathematicians. Indeed, good ideas are shared this way, and I would encourage graduate students to ask to see the application materials of their friends who have recently been on the job market. It is also straightforward to find such materials on the Internet by visiting the websites of newly hired assistant professors at other institutions. Oftentimes there are Career Centers or special workshops at one's university intended to help people prepare for job searches. We learn best from each other, and this kind of effort to prepare one's own application package is essential and recommended.

COPE cautions anyone on the job market, however, to be careful not to be unduly influenced by the application materials of others. Even if you find a sentence or idea that captures your thoughts precisely, do not copy from someone else's materials. First of all, when too much sharing goes on, then over time the universe of applicant dossiers averages out. Your ability to stand out is diluted. Moreover, there's a risk that you might wander into the danger zone of plagiarism.

This particular advice is being delivered to the readers of *Notices* because COPE had a case in which a faculty member reading applications for an open position at his school recognized that the teaching statement from one of the job applicants was extremely similar to the teaching statement that he, himself, had written years ago. It was unclear how this particular job applicant would have accessed this faculty member's statement, except that for a short time it had been posted on the faculty's website. As COPE pursued this investigation, we suspected that the original teaching statement had been widely circulated. It was impossible to tell if the guilty job applicant even knew the identity of the initial author, as he may have seen the original, a secondary, or even a tertiary copy of the material. Even with the uncertainty regarding how this applicant would have seen the faculty member's teaching statement, it was clear that the statement was plagiarized. There was no way that these two people could have separately come up with such identical language and phrasing.

The resolution of this case is confidential. As you might expect, it involved the graduate student's institution and their internal process for penalizing the ethical violation of the graduate student.

It is crucial to remember that the application materials you send out must be a unique expression of your own individual personality. These materials report on your credentials and tell your story. The content of your teaching statement must reflect your own ideas and experiences. I realize that it is hard to construct a teaching statement, especially if you've had little teaching experience. Nonetheless, if you lift phrases from someone else's statement—even if those phrases articulate your own beliefs perfectly—you are plagiarizing. Teaching statements are widely circulated and over time have been getting more and more similar to each other; this needs to stop. The best way to stand out is to write your own, honest statement that explores your thoughts about becoming a college-level teacher. If you encounter another teaching statement that reflects your own ideas, then spend some time reflecting on why those words resonate with you. Next, write a statement in your own words, one that articulates your thoughts in a fashion that is unique to you.

The fact remains that graduate students tend to be unpracticed in writing teaching statements, and they are wise to seek out examples to emulate. If you are concerned, seek professional writing assistance from the resources that are available to you. The challenge is for each job applicant to minimize how much he or she is influenced by reading other statements and for each person to strive to write with integrity. Sure, there will be similarities—but none of your phrasing should match that of anyone else. I also advise everyone to protect their intellectual property! Reconsider posting your statements on your website. You might want to have a tighter control over who gets to view your writing.

The Case of the Withdrawn Offer

In this case, a department ended its search for a new tenure-track faculty member when their administration's verbal offer to their top candidate was accepted. Before a contract was signed, however, the economic situation at the institution changed, and all hiring was halted. In the meantime, the successful candidate had removed herself from the job market. She had turned down interviews at other campuses and didn't know what she was going to do, now that the hiring season was effectively over. She was without a job. This situation was particularly difficult since the hiring cycle for academic positions is focused on just a few months of the year. This highly desirable candidate found herself with a whole year ahead of her before she would be able to seek another tenure-track position.

This is, sadly, not a new scenario. In fact, a March 12, 2008, article from the *Chronicle of Higher Education* titled "The Disappearing Job Offer"[1] discusses a situation in which a university had withdrawn several offers. With the heightening economic problems facing academia, it is sure to happen again.

COPE cautions all applicants to finalize any offer they accept before withdrawing from the job market. It has even been suggested that job candidates be advised to have their contract read over by a lawyer, who will have more experience in identifying weaknesses in the document. A senior colleague, especially one who has been involved in administration, can also help in this regard. You may not have much success modifying the language of a contract, but at least you will have a deeper awareness of what you are signing.

As an aside, during this economic crisis faculty are being asked to make all sorts of concessions to support their institutions: pay cuts (or "furloughs"), increases in teaching loads, increases in class sizes, reductions in benefits such as travel money, etc. Are these changes in expectations and employment benefits violations of ethical codes of conduct? I imagine that this would be a matter of some dispute. If you have a case that you think falls within the purview of COPE, a simple inquiry to the committee is encouraged. The next case gets at some of these very issues.

The Case of the Reworked Contract

Fortunately, this case resolved itself before COPE had to get actively involved. Still, the story presents a cautionary tale for all of us. The chair of a department of mathematics contacted COPE when the administration at his school made a move to modify the expectations for multi-year postdoctorate positions. This was due to the growing financial difficulties of the institution. Essentially, the duration of the postdoctorate appointment was to be abbreviated and the teaching load increased.

Both of these changes were in sharp contrast to the initial deal that helped this institution attract promising young researchers in the first place. According to the institution's lawyers, the contractual language allowed for modifications to the offer letter that the postdocs had signed. Naturally, the chair was concerned, not only for the affected individuals but also for the possible damage to the professional reputation of his department. Initial discussion among the members of COPE was spirited and outraged. We felt that this situation warranted action. Before we moved forward, though, the chair was able to work with his administration to preserve the initial contracts with his postdocs. Essentially, this particular issue went away, but I mention it here to point out that contracts typically contain language that grants the employer a way out of the deal should the financial situation of the institution change. In today's economic climate, we need to brace ourselves for more such scenarios.

The Case of the Two-Body Problem

In this circumstance, a professor contacted COPE to complain about a failed job search at his institution. He speculated that the job search had failed in part because its top candidate was married to someone who was also on the job market. The candidate had disclosed this fact rather late in the hiring process, and although the school was able to make some kind of offer to the spouse, it was not good enough to attract the couple. The person who contacted COPE suggested that his institution might have had more success if it had known about the two-body problem earlier—he said the whole experience was rushed, inadequate, and frustrating. It is well understood that it is illegal for prospective employers to ask certain questions, including questions about a candidate's marital status.

Much has been written and spoken about the two-body problem. A literature search can yield a full range of advice for a couple seeking academic positions together.[2] The Association for Women in Mathematics, as well as other groups, has hosted panel discussions on this topic at Joint Mathematical Meetings a number of times.

There is no consensus on how a couple should approach their two-body job search. It is a delicate issue. On the one hand, a department with good intentions might be able to be more proactive, and ultimately more successful, if it is informed of the two-body challenge early on. On the other hand, there are ample stories in which early disclosure proved to be a liability. If the couple seeks to be hired by the same institution but in two different departments, the administration may need to be involved in the interdepartmental coordination. The cultures of different disciplines could react quite differently to the situation. Moreover, a simple instance of the hiring calendars in the two disciplines being out of sync could scuttle the best of intentions.

On a personal note, my husband is a chemist, and we have been on the job market together twice. The first time, we did not disclose our two-body constraint until we had accepted an on-campus interview. We were successful at a school that was initially only interested in hiring my husband. He told the dean that he would accept the position if something suitable was offered to me. The second time we were on the market, several years later, we

[1] `http://chronicle.com/jobs/blogs/onhiring/503/the-disappearing-job-offer`.

[2] *Try a Google search with keywords* "*two-body problem*" *and/or* "*AWM*".

did a targeted search and explained in our initial cover letters that we were seeking jobs together. In each search, there were pros and cons to our approach. I have no doubt that some places chose not to pursue us as a couple for fear that it would be too complicated. On the other hand, the administrators who worked with us successfully shared their appreciation for the advanced lead time. In conclusion, even after going through this twice myself, I still do not know what to suggest.

The members of COPE had a vigorous discussion on the topic of the two-body problem and concluded that there really is no clear advice to give to couples on the job market. As one committee member said, "it is a very fine balancing decision that a candidate has to make."

The Case of the Uninformed Author or "I Didn't Write That!"

This next case was long and complex, but there's a valuable take-home message for journals and authors. I will only mention one facet of this case. A person writing up a research manuscript for publication listed a coauthor without informing or securing the permission of this person. The situation took a long time to sort itself out and get corrected. Current practices generally have a journal only requiring that the lead author of a manuscript sign a Copyright Transfer Agreement on behalf of all the coauthors. In this particular case, there was some delay before the unaware coauthor learned that he was listed on the paper.

COPE now advises all journals to require a signed copyright agreement from every author listed on a manuscript. This way, each author is acknowledging that he or she was a contributor to the research and is in agreement that it ought to be published. Some journals are also acknowledging the initial submission to all authors, in the hopes of identifying any troubling issues with authorship prior to the review process getting underway.

Clearly, one should not list any coauthor without receiving permission from that individual in the first place. Sometimes new researchers might wish, as a sign of respect, to include as coauthors professors who inspired the research or who participated in some small way with the analysis. Sometimes a weak author will list a well-known coauthor to add to the prestige of the paper. Suffice it to say that all researchers must be satisfied with the content of the manuscript before being included as coauthors. The lead author must take responsibility to ensure that all coauthors are on board.

History of COPE

According to the COPE Procedures Manual,[3] the Committee on Professional Ethics "was established by action of the Council of the AMS in 1983". It is customary for professional societies to have established ethical guidelines and codes of conduct. As stated in the June/July 2006 article in the *Notices*,[4] setting forth such guidelines "helps in the preservation of that atmosphere of mutual trust and ethical behavior required for science to prosper." The guiding principles for the committee can be found in the previously mentioned *Notices* article and online.[5] These official documents address four areas: mathematical research and its presentation; social responsibility of mathematicians; education and granting of degrees; and publications.

There are times when inquiries directed to COPE do not fall cleanly into one of the four areas listed above. Generally, the chair of COPE initiates a discussion among the members of the committee—first to determine if the inquiry is suitable for consideration by COPE. Oftentimes some research is done or some confidential verifications of the story are made. COPE then makes a determination on how best to proceed, works with the parties involved, and comes to some resolution.

There is no set procedure for raising a complaint with COPE—a simple email inquiry to any member of the committee or to someone on staff at the AMS is sufficient to begin a dialogue about your situation. It is common for an initial email to be along the lines of "I've encountered something that doesn't sit right with me, and I'm wondering if this is the sort of thing you might be able to help me with." Together, COPE and the person raising the complaint come up with a strategy for the particular issue.

The president of the Society appoints members of COPE to three-year terms. The list of committee members is available on the governance page of the AMS website. Dr. William Trotter, who can be reached at `trotter@math.gatech.edu`, currently chairs the committee.

Conclusion

The important question to ask ourselves is, "What can we take away from these stories?" We are often faced with making decisions about how we will behave in different situations, and we must keep in mind that there are consequences to our actions. When in doubt, ask for advice from others and choose the path that sits best in your gut and that will reflect upon your profession and yourself in the most positive light. Be careful. In summary, COPE has advice for graduate students and new researchers: Write your own teaching statements and do not take yourself off the job market until you have completely settled your negotiations with a hiring institution and have a written contract,

[3] `http://www.ams.org/secretary/copemanual.pdf`.

[4] `http://www.ams.org/notices/200606/from-ethical.pdf`.

[5] `http://www.ams.org/secretary/ethics/html`.

which you may want to have reviewed by a professional prior to signing.

Serving on COPE was an eye-opener for me. I'm a fairly "goodie two shoes" type of person, so when I was made aware of behaviors that had an unethical component, I was both surprised and genuinely disturbed. As a problem solver, I wanted to march in and fix each situation. I soon realized, however, that solutions are not always clearly defined and that sometimes the resolution cannot be completely satisfactory. I think that my time on COPE made me much more aware of my own behavior—I reflect more about how something I say or do might be misinterpreted, and I work hard to be very explicit. I keep much better records now, so that I will be better able to reconstruct my side of a story if things ever go sour. When faced with an ethical decision, even a small one (should I tell the sales clerk that my toddler niece ate some grapes before we made it over to the register?), I am choosing to be honest even more often than before. It is a more challenging way to live, but it is rewarding to live an honest life.

If You Have a Concern

If you have a matter that you feel might be appropriate for COPE to consider, the best place to start is to contact the chair of the committee (see above). All inquiries are confidential. Some are handled simply and do not involve initiating an official case; others might stretch over several months as COPE tries to understand the full nature of the situation and settle on an appropriate action plan. Even if you are already pursuing a situation on your own, if it involves ethical conduct pertaining to you as a mathematician, COPE would appreciate being informed—even if COPE remains on the sidelines. Involving COPE can help to build and maintain the integrity of our profession that we all value.

Acknowledgments

Thank you to the current and former members of COPE and the AMS Council, some of whom read early drafts of this article and provided helpful advice, as well as some nonconfidential information about past COPE cases. I am grateful for the helpful comments of the reviewers. I would also like to thank Dan Pacek for providing title suggestions for this article.

Baseball and Markov Chains: Power Hitting and Power Series

John P. D'Angelo

As children, my friends and I often played a game called All-Star Baseball. Each of us would manage a team of major league players. The *players* were circular cards. Each card was divided into labeled sectors of various sizes, corresponding to possible outcomes such as strikeout, walk, single, home run, and so on. The sizes varied considerably from player to player. To have a player bat, we placed the card on a spinner, filliped the spinner, and read the result. We all had a clear intuitive understanding of how the situation reflected baseball and how it didn't.

We kept intricate stats. We experimented with ways to make pitching matter. We introduced random fielding errors using a buzzer. Later I invented a version using dice instead of a spinner. Throwing four dice at a time was required to accurately model the statistical profiles of actual players. I created new players. One (call him Kingman) had only two possible outcomes, a strikeout and a home run. Another (call him Bowa) had only two outcomes, a single and a strikeout. I made the single on Bowa four times as likely as the home run on Kingman. I would play full games in which one team had nine players like Bowa and the other had nine players like Kingman.

Years later I realized that we had been regarding the game of baseball as a Markov chain. Before discussing Markov chains and how to use them to model baseball, I pose three exercises for the reader. I put the first two of them in the book [DW] (page 335), and I have assigned them on several occasions, in order to give an amusing application of summing power series. The following simple lemma on power series, and its generalization to more variables, can be used to evaluate explicitly many of the expected value formulas arising in a more involved treatment of these ideas. The reader who wishes to focus on baseball may skip the lemma, but she should at least attempt to estimate the answer to part 3 of Exercise 1.2. The answer appears in the conclusions.

John D'Angelo is professor of mathematics at the University of Illinois. His email address is `jpda@math.uiuc.edu`.

Lemma 1.1. *Let f be a polynomial of degree d in one variable, and consider the power series*

$$s(x) = \sum_{k=0}^{\infty} f(k)x^k. \tag{1}$$

The series in (1) converges for $|x| < 1$, and there is a polynomial $b(x)$ of degree at most d such that

$$s(x) = \frac{b(x)}{(1-x)^{d+1}}. \tag{2}$$

In particular, s is a rational function.

Lemma 1.1 can be proved by differentiating the geometric series d times or by using the method of generating functions. We include it because it provides an elegant method for solving the key parts of Exercise 1.2, namely the formulas for $K(q)$ and $B(p)$. The calculation of $K(q)$ amounts to finding the expectation of a random variable with the *negative binomial distribution.* See page 95 of [HPS] for a derivation using probability generating functions.

Exercise 1.1. Prove Lemma 1.1. Find $s(x)$ explicitly when $f(k) = k\binom{k+2}{2}$ and when $f(k) = k^3$.

Exercise 1.2. Consider a player (B) who hits a single with probability p and otherwise strikes out. Make the assumption that three singles score a run. Assume that all at-bats are independent. Let

$B(p)$ denote the expected number of runs scored per half inning (until three outs occur), assuming only (B) bats. Consider a second player (K) who hits a home run with probability q and otherwise strikes out. Let $K(q)$ be the expected number of runs scored per half inning.

- Prove that $K(q) = \frac{3q}{1-q}$ and that $B(p) = \frac{p^3(3p^2-10p+10)}{1-p}$.
- Sketch their graphs for $0 \leq p \leq 1$.
- Set $q = \frac{p}{4}$. For what values of p is $B(p) \geq K(\frac{p}{4})$?
- Set $q = \frac{2}{5}p$. For what values of p is $B(p) = K(\frac{2p}{5})$?
- How does $B(p)$ change if four singles are required to score a run?

Exercise 1.3. Consider a player who hits a single with probability p, a home run with probability q, and otherwise strikes out. Assume at-bats are independent and three singles score a run. For each nonnegative integer k, find the probability that this batter scores exactly k runs in a half inning. (Be careful of runners left on base.)

This article is a short introduction to the ideas connecting baseball and Markov chains. Many baseball fans have invented fantasy baseball games based on the Markov idea, and what I discuss in this article is by now a well-established notion. I do not intend to discuss the vast literature, but I do mention a few entries to it.

Lindsey [L] viewed baseball in this fashion as early as the 1950s. Cover and Keilers [CK] provided a Markov version for evaluating batters. Pankin ([P] and also `http://www.pankin.com/markov/theory.htm`) has written several precise articles about baseball and Markov chains. See also [N] and its references for serious discussion about the evaluation of baseball players using these methods. Katz [K] applies Markov chain analysis to the pitch count.

One of my favorite references on the subject of mathematical baseball is [TP], to which I refer for references published up to the early 1980s. Thorn and Palmer also edited *Total Baseball* [TB], more than two thousand pages of discussion and statistics. I am truly thankful for my research in several complex variables; without it I would have spent thousands rather than merely hundreds of hours with this volume. The many books by Bill James (item [J] in our reference list gives two early versions) helped introduce a generation of baseball fans to related ideas, especially the notion of *runs created*. Many additional aspects of baseball appeal to mathematicians. See, for example, the recent book [R].

The main idea in this article is the notion of *Markov runs*. We imagine, as described more precisely below, that a player is the only batter on his team. He bats randomly based on his statistics. How many runs will his team score? We also imagine a pitcher who pitches randomly based on his statistics. How many runs will his team allow? Jeff Sagarin, once upon a time a math major at MIT, publishes Markov-runs-per-game baseball statistics (and much more) online and updates them daily during the season. See `http://www.usatoday.com/sports/sagarin/nlb09.htm`.

Most mathematically inclined baseball fans have played with their own formulations of these ideas, and some baseball managers and executives have embraced them. On the other hand, many people in the baseball world sneer at "computer baseball", perhaps because they tremble with trepidation at anything scientific. I will never forget my disgust when a former Cubs manager, who was broadcasting a game on the radio, dismissed a physicist's study of how a baseball travels in varying weather conditions with "He don't know baseball."

This article is intended to be a short introduction whose primary purpose is to illustrate some of the connections between mathematics and baseball. Let us pause and briefly mention some interesting topics I omit.

One of the most interesting such topics concerns the notion of a *clutch hitter*. Such a player allegedly hits better when the situation matters more, but numerical studies seem to indicate that the concept is an illusion. On the other hand, the discussion in this article presumes that each plate appearance is an independent event. This assumption cannot be completely true. How accurate is it? A related question is whether players *get hot*. See, for example, [A].

What about fielding? Errors are rather unusual occurrences in professional baseball, and fielding percentages convey little important information. More important is how many plays a defensive player (fielder) makes. Would player (A) have made the same play as player (B) did? Except for completely routine plays, there is no way to know. Recent studies of fielding have attempted to measure how much ground a fielder covers. Many subtleties arise, and I do not know of any literature providing a good Markov chain model. Hence this article will ignore fielding.

Another omission from our discussion concerns the impact of pitching. In principle one can account for pitching via the Markov chain model, but, typically, a player will have faced a specific pitcher too few times for the statistical profile to be meaningful. Instead one could use a weighted average of the statistics of the pitcher (versus all batters) and the batter (versus all pitchers). Careful studies would then answer empirically the eternal conundrum: pitching is what percentage of baseball? When asked this question, the catcher Yogi Berra answered by saying "Ninety percent of this game is half mental."

I acknowledge the following people (all with Ph.D.s) for their insightful observations about baseball statistics over the years: Phil Baldwin (physics), John Marden (statistics), Bob Northington (statistics), Bruce Reznick (mathematics), and Kirk Sanders (classics). I also acknowledge NSF Grant DMS 07-53978 for research support. Finally I wish to thank several referees for useful comments on the exposition and for asking me to expand the reference list.

Markov Chains

Let us now recall the concept of a Markov chain. Let $X_1, X_2, \ldots,$ be a sequence of random variables taking values in a finite set. We think of this situation as a random system that can be in a finite number of possible states, labeled $e_1, \ldots, e_n$. The sequence of random variables is called a *Markov chain* if the following holds:

For each pair of indices i, j there is a fixed probability M_{ij} such that each time the system is in state e_i it will be in state e_j the next time with probability M_{ij}.

In other words, the conditional probability that $X_{k+1} = e_j$ given $X_k = e_i$ is, for each k, independent of the values of X_m for $m < k$.

We will regard the states e_i as basis vectors for n-dimensional real Euclidean space. Consider a convex combination $a(\lambda) = \sum_{j=1}^{n} \lambda_j e_j$ of these states. (The coefficients λ_k are nonnegative, and they sum to 1.) The n-tuple $a(\lambda)$ is called a *probability vector*. The coefficient λ_k represents the probability that the system is in state e_k at some fixed unit of time.

The system evolves in discrete intervals, often but not necessarily regarded as units of time. In baseball the unit will be a *plate appearance*. A plate appearance is similar to an at-bat, but includes certain situations (walks, hit batters, sacrifices) that baseball does not regard as an official at-bat.

The Markov matrix M, whose entries are M_{ij}, governs the evolution of the system. If x denotes the state at one moment (the value of the random variable X_k), then Mx denotes the state one moment later (the value of the random variable X_{k+1}). The matrix is time independent; in other words, the chance of going from state x to state Mx does not depend on any of the previous states. The number M_{ij} is called the *transition probability* from state e_i to state e_j. Each M_{ij} is nonnegative and, because the state must go somewhere, we have $\sum_{j=1}^{n} M_{ij} = 1$.

The reader should consult a book such as [KSK] for a more precise treatment of Markov chains and references to their many applications. Many elementary linear algebra books also discuss Markov chains and their applications.

Baseball

How do we regard baseball as a Markov chain? The number of outs and the location of the baserunners will determine twenty-five states. We will keep track of runs scored, but runs will not be part of the setup. What are the states?

We regard all situations with three outs as the same, and this situation is one of the states. Once we reach this state, we cannot leave it. For clarity we mention that in the simplified model we discuss, it makes no difference how many men are on base or where they are located after the third out is made. Runs scored will be the only thing that matters.

Otherwise the number of outs can be 0, 1, or 2, and there are eight possibilities for the runners. The bases can be empty; there can be one runner on first, second, or third base; there can be two runners on (in three different ways); or the bases can be *loaded*. These twenty-four situations define the other states.

Player H comes to the plate. Ignoring such situations as stolen bases or pick-offs that could occur during the plate appearance, we ask what happens after it. We imagine that the player bats randomly, according to his statistical profile. His plate appearances are independent. In other words, his chance of getting a specific kind of hit or making a specific kind of out is independent of how many runners are on and of how many outs there are. Based on this profile, we compute the transition probabilities for each pair of states, obtaining a Markov chain.

We could use stats from the previous year, the current year, or the career. But we must use the same profile each time. For convenience here, we will write the player's profile as follows, deviating slightly from the standard listing. Here AB denotes at-bats, S denotes singles, D denotes doubles, T denotes triples, HR denotes home runs, BB denotes walks plus hit batters, AVE denotes batting average, SA denotes slugging average, OB denotes on-base average, and $OPS = OB + SA$. We will discuss this rather new statistic later. We note for us that the number of plate appearances is $AB + BB$.

In the simplified scenario suggested above, we regard all outs as equivalent. Sluggers who often strike out are fond of reminding their managers that there is no practical difference between a strikeout and a pop-out. We will ignore double plays, sacrifice bunts, and sacrifice flies, also for simplicity. As a result our values of OB and OPS differ slightly from those in the official records.

Here is the profile; note that the last four elements can be computed from the first six, and hence they are not truly needed.

$$AB \;\; S \;\; D \;\; T \;\; HR \;\; BB \;\; AVE \;\; SA \;\; OB \;\; OPS$$

For example, we give a fictional line for a star player X. We also include actual profiles for Albert Pujols and Chase Utley in 2009.

(X)	500	100	25	5	30	100	.320	.570	.433	1.003
(AP)	568	93	45	1	47	124	.327	.658	.443	1.101
(CU)	571	98	28	4	31	112	.282	.508	.398	.905

Player X has 500 at-bats but 600 plate appearances. In a given plate appearance player X has a $\frac{1}{6}$ chance to hit a single, a $\frac{1}{6}$ chance to reach first base by either a walk or hit batter, a $\frac{1}{120}$ chance to hit a triple, and so on.

We mention a small point here. In certain situations different actions by the batter produce the same effect. For example, if no one is on base, then a single and a walk have the same effect. On the other hand, assuming that a single advances a runner two bases, a single with a runner on second is far better than is a walk.

The sequence of random variables will be the list of situations arising in a half inning. It is easier to understand the baseball situation by focusing on the transition matrix. Given the batter H, we determine from his statistical profile a (twenty-five by twenty-five) matrix M_H. Under the assumptions discussed below, we claim that M_H defines a Markov chain.

We know the complete statistical profile of H. In other words, we know the probabilities that H makes each kind of hit or out, draws a walk, gets hit by a pitch, and so on. We assume a fixed result given each type of hit; for example, a single always

advances runners two bases. We could, but we do not do so here, refine the model by allowing several different kinds of singles! Assuming that each plate appearance is independent (and in particular that what the batter does does not depend on the pitcher), we can assign probabilities that we pass from each state x to the state $M_H(x)$.

In this manner we encode the statistical profile of the player as a Markov matrix. For the player Kingman who either hits a home run with probability q or strikes out, we can easily determine the matrix M_K. We will not write out this 25 by 25 matrix. We simply note that, with probability $1 - q$, the number of outs increases by one and the base runners remain the same. With probability q, the number of outs remains the same, and the bases are cleared. Of course, the batter and the base runners all score a run in this case.

Now that we are regarding baseball as a Markov chain, there is little point in keeping the usual statistics. We know, for example, that a player who hits a home run every ten at-bats will on average hit one every ten at-bats in the Markov model. The key new statistic is how many runs will a team score if it uses this player for every plate appearance. We naturally call this statistic *Markov runs*. As we mentioned earlier, Sagarin publishes this stat, normalized using nine innings, for all players each day of the season.

It is possible, but inappropriate for this short article, to combine probability theory and linear algebra to compute the expected number of Markov runs by using the Markov matrix. Such results generalize the idealized situations discussed in Exercise 1.2. Rather than heading in this direction, we imagine finding expected Markov runs via computer simulation. We will then consider the relationship between Markov runs and other baseball statistics.

Given the statistical profile, the player bats randomly, using a computer simulation, according to the Markov chain model, until he makes three outs. The test is run thousands of times, and from it we determine the average number of runs scored per each nine innings. Below we will see that a team consisting of (nine clones of) Albert Pujols would score 9.38 runs per game; no other National League player would come within one run of him in 2009.

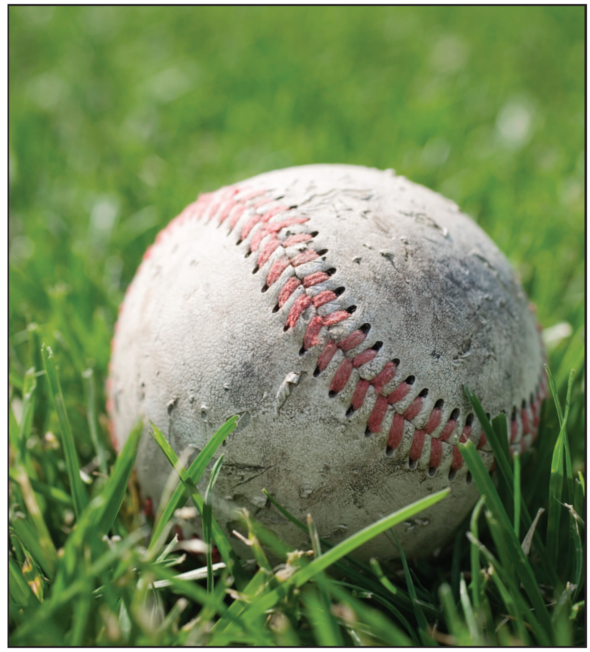
Some nice simplifications and approximations to these computations are known. Bill James [J] has found many formulas for runs created. In 1978 Pete Palmer [TP] ran a computer simulation of all games played since 1901. From this mammoth amount of data, he assigned *linear weights* to each batting event. Palmer performed these calculations separately for the years 1901–1920, 1921–1940, 1941–1960, and 1961–1978. The positive values of hits and the negative values of outs are not identical over the four periods, but they are all close to the following values:

A home run is worth 1.40 runs, a triple is worth 1.02, a double is worth .80, a single is worth .46 runs, and a walk is worth .33 runs. An out is worth −.25 runs. Given a profile, one can estimate Markov runs using these weights.

A second simplification now appears in official baseball statistics. One simply adds the player's slugging average to his on-base average, obtaining what is called OPS. It was discovered empirically that this number correlates fairly well with the expected number of runs scored using the Markov chain model. The list below of the top ten NL batters in 2009, ordered by Markov runs, suggests a correlation. It is likely that the correlation between Markov runs and OPS has been investigated carefully, but I do not know any references other than [J] and [TP], which are intended for baseball fans rather than for statisticians.

We make an important remark. For the actual values arising in baseball, OPS and Markov runs provide similar information. On the other hand, two players can have identical OPS but very different Markov runs. We give an example.

Example 3.1. We consider player one to have the profile of our contrived Bowa. His slugging average and his on-base average both equal p, and hence his OPS is $2p$. Now consider a player with the profile of Kingman, who hits a home run with probability q and otherwise strikes out. His slugging average is $4q$, and his on-base average is q. Hence his OPS is $5q$. Hence, if $q = \frac{2}{5}p$, then the two



players have the same OPS. By Exercise 1.2, one sees that the Markov runs are not the same in general even when this equality holds. One can derive this conclusion more easily by noting what happens when p approaches 1. (Can analysis be worthwhile?) Obviously the Markov runs for Bowa approach infinity, whereas the Markov runs for Kingman are finite when $q = \frac{2}{5}$.

From a mathematician's perspective OPS is a bit strange. Let TB denote total bases, that is,

$$TB = S + 2D + 3T + 4HR. \tag{TB}$$

Roughly speaking, because we are ignoring sacrifices, as noted before, we compute OPS as follows:

$$OPS = \frac{TB}{AB} + \frac{S + D + T + HR + BB}{AB + BB}$$
$$= \frac{S + 2D + 3T + 4HR}{AB} + \frac{S + D + T + HR + BB}{AB + BB}. \tag{OPS}$$

Formula (OPS) shows that we are adding two quantities with different denominators, at-bats and plate appearances. Perhaps a better number would be something such as

$$\frac{BB + 2S + 3D + 4T + 5HR}{AB + BB}. \tag{3}$$

Notice that (3) is essentially a linear weights formula.

Next we list, based on the Sagarin ratings for 2009, the top ten players in the National League, based on expected number of runs scored per nine innings computed via Markov chains. In this list, the first number after the player's name and team is this expected number of runs. The other number is the player's OPS, the sum of on-base average and slugging average.

1.	Pujols, Albert	St. Louis	9.38	1.101
2.	Votto, Joey	Cincinnati	8.26	.981
3.	Fielder, Prince	Milwaukee	8.24	1.014
4.	Lee, Derrek	Chicago	7.96	.972
5.	Ramirez, Hanley	Florida	7.81	.954
6.	Gonzalez, Adrian	San Diego	7.68	.958
7.	Helton, Todd	Colorado	7.61	.904
8.	Utley, Chase	Philadelphia	7.58	.905
9.	Braun, Ryan	Milwaukee	7.53	.937
10.	Dunn, Adam	Washington	7.24	.928

The method of *linear weights* warrants an entire fascinating chapter in [TP]. This method is essentially equivalent to the Markov chain method. In the Markov method, the batter himself bats every time. In the linear weights method, the value of each sort of hit is determined by empirical data involving all players. Both methods are based upon the assumptions of independence we have discussed.

Conclusions

One way to evaluate a batter is to determine his Markov runs. This very natural idea has been known intuitively for decades, and it lies at the basis of various strategy games. For the situations actually arising in baseball, the simpler statistic of OPS provides similar information. On the other hand, the formula for OPS is rather dissatisfying for a mathematician. Mathematicians who desire a simple statistic can use linear weights.

It is possible to include pitching in this discussion, where the key stat becomes Markov runs allowed. Space considerations prevent us from doing so here. Fielding is more difficult.

Readers who solved Exercise 1.2 can conclude that a player who bats .070 but hits only home runs is essentially equivalent (via Markov runs) to a player who bats .280 but hits only singles. Fix the ratio at $\frac{1}{4}$. For averages (for the singles hitter) lower than .27945 the home run hitter generates more runs, and for higher averages the singles hitter does so. I wonder how accurately baseball managers could guess this cut-off value.

Here is a novel idea for the true fan. Look up the Sagarin ratings. For each pitcher, find the Markov runs allowed, and then find a batter whose Markov runs equal this number. In this way you can determine tidbits such as whether there is any pitcher for whom the generic hitter he faces has the stats of Albert Pujols.

The world of baseball provides a striking application of Markov chains. Conversely, the use of Markov chains introduces fascinating new baseball statistics, such as *Markov runs* for batters and *Markov runs allowed* for pitchers. These statistics and simplified versions of them have evolved into standard methods for the evaluation of baseball players. As ever, mathematics provides artistic and insightful perspectives on another topic.

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Photographs by E. David Luria, Diane Boumenot (AMS), and Annette Emerson (AMS).

See photo key on page 559

The Science of a Drive

Douglas N. Arnold

This article is a sample of material produced for Mathematics Awareness Week, intentionally pegged at an elementary level with an eye to distribution to a broad audience. The piece will also appear in *Mathematics and Sports*, edited by Joseph A. Gallian, Mathematical Association of America Dolciani Series, to be published in the summer of 2010. It is reproduced here with permission.

—Steven G. Krantz

"Math and science are everywhere." With those words, championship golfer Phil Mickelson began a public service television advertisement produced by ExxonMobil and premiered during the 2007 broadcast of the Masters Golf Tournament. I had the privilege to serve as the mathematical consultant for the ad and for the accompanying website, *The Science of a Drive*, from which the title of this article is taken, and which can still be viewed at `www.exxonmobil.com/Corporate/Imports/scienceofadrive/`. Figure 1 displays a still frame taken from the advertisement and another taken from the website.

The golf drive does indeed provide numerous examples of the ways mathematics elucidates common physical phenomena. Many aspects of it can be illuminated or improved through mathematical modeling and analysis of the mechanical processes entering into the game. Here I present a few simple examples collected during my consulting work. Specifically I briefly discuss three applications of mathematical modeling to fundamental mechanical processes in the golf drive: the double-pendulum model of a golf swing, transfer of energy and momentum in the club head/ball impact, and drag and lift in the flight of the golf ball.

These examples just scratch the surface of the subject. Indeed, there is a large literature on the subject of mathematics and mechanics of golf. See, for example, the survey [5], which discusses several aspects:

- models of the golf swing,
- the physics of the golf club and ball,
- the impact of the club head and the golf ball,
- golf ball aerodynamics,
- the run of the golf ball on turf.

Douglas Arnold is McKnight Presidential Professor of Mathematics at the School of Mathematics, University of Minnesota and president, Society for Industrial and Applied Mathematics (SIAM). His email address is `arnold@umn.edu`.

The Double-Pendulum Approximation of the Swing

When a golfer swings for a long drive, the goal is to accelerate the club head so that it impacts the ball at just the right point, going in just the right direction, and moving as quickly as possible. To do so, the golfer exerts force with his or her arms on the shaft of the club, which in turn exerts force on the club head. This situation may be approximated as a double pendulum, as depicted in Figure 2. The arms, pivoting at the shoulders, roughly behave as a pendulum, and the hands, grip, and shaft, pivoting at the wrists, behave as a second pendulum attached at the end of the first. For a well-timed drive, at the moment of impact the upper pendulum—the arms—is swinging very rapidly about its pivot point, and, at the same moment, the club is swinging very rapidly around its pivot point. These movements combine to accelerate the club head to speeds as high as 120 miles per hour.

Of course the double-pendulum model is a crude approximation of the complex mechanism formed by the body and the club during a swing. The model can be refined in many ways, for example by taking into account the movement of the shoulders (and so of the pivot point of the upper pendulum) [7], the flexing of the club shaft [3], and the three-dimensional aspects of the motion [4].

Figure 1. Frames from the television advertisement and the website.

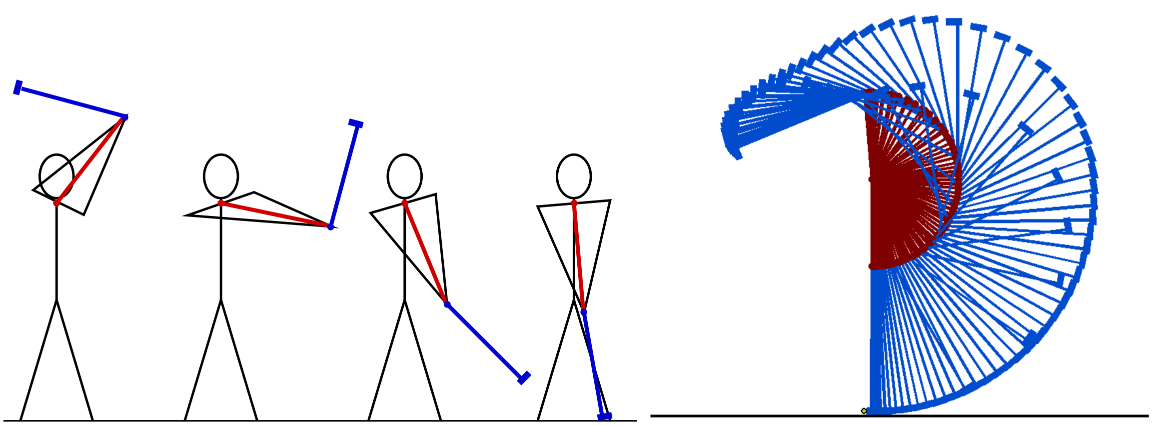

Figure 2. The double-pendulum model of a golf swing.

The Impact of the Club Head and the Ball

The velocity of the club head, together with its mass, determine its kinetic energy and momentum. As the swing progresses, the golfer applies more and more force to the club head, causing it to accelerate and so increase its speed. Therefore its momentum and energy increase. Upon impact, some of this energy and momentum is transferred to the ball. To determine the speed of the ball as it leaves the tee, we use conservation of both energy and momentum. Let m_{club} and m_{ball} denote the mass of the club and the ball, respectively. Let V_{club} and v_{ball} denote their speeds right after impact, and let v_{club} denote the speed of the club head just before impact. (Of course the speed of the ball just before impact is zero.) Since $E = mv^2/2$, conservation of energy tells us that

$$\frac{1}{2}m_{\text{club}}v_{\text{club}}^2 = \frac{1}{2}m_{\text{club}}V_{\text{club}}^2 + \frac{1}{2}m_{\text{ball}}v_{\text{ball}}^2,$$

while conservation of momentum tells us that

$$m_{\text{club}}v_{\text{club}} = m_{\text{club}}V_{\text{club}} + m_{\text{ball}}v_{\text{ball}}.$$

The solution to these equations is easily found:

$$V_{\text{club}} = v_{\text{club}}\frac{m_{\text{club}} - m_{\text{ball}}}{m_{\text{club}} + m_{\text{ball}}},$$

$$v_{\text{ball}} = v_{\text{club}}\frac{2m_{\text{club}}}{m_{\text{club}} + m_{\text{ball}}} = v_{\text{club}}\frac{2}{1 + m_{\text{ball}}/m_{\text{club}}}.$$

Thus the ratio of the ball speed to the speed of the club head before impact is $2/(1+r)$, where r is the ratio of the mass of the ball to the mass of the club head. Notice that, no matter how small the ratio of masses, the ball speed will always be less than twice the club head speed. For instance, if $v_{\text{club}} = 54.0$ meters per second (about 120 miles per hour), $m_{\text{club}} = 0.195$ kilograms, and $m_{\text{ball}} = 0.0459$ kilograms, then v_{ball} is about 87.4 meters per second, or just about 195 miles per hour.

In reality, not all of the kinetic energy lost by the club head during impact is converted into kinetic energy of the ball. That is, the impact is not perfectly elastic. Some energy is lost to heat and damage to the ball. In this case, the ball launch speed is given by

$$v_{\text{ball}} = \frac{(1 + c_R)v_{\text{club}}}{1 + m_{\text{ball}}/m_{\text{club}}}, \tag{1}$$

where c_R is called the *coefficient of restitution*. For an elastic collision, $c_R = 1$, but in reality it is somewhat smaller. Using a typical value of $c_R = 0.78$, we obtain a launch velocity $v_{\text{ball}} = 77.8$ meters per second, or about 175 miles per hour. Even to the nonspecialist, formula (1) conveys a sense that math impinges on golf, and it was prominently displayed in the television advertisement (see Figure 1).

The period of contact of the club head with the ball is about one two-thousandth of a second. During this time the center of mass of the ball has barely moved, but the ball is bent way out of shape. A significant portion of the kinetic energy has been converted into potential energy stored in the deformed ball. Essentially, the ball is like a compressed spring. See Figure 3. When the ball takes off from the tee, it returns to a spherical shape, releasing the spring, and most of this potential energy is converted back into kinetic energy. Detailed analyses of the club head/ball interaction can be made through a full 3-dimensional finite element analysis [2] or via simplified 1- or 2-dimensional models [1].

Figure 3. Golf ball under compression from impact of club on left.

The Ball's Flight

Once the ball is in flight, its trajectory is completely determined by its launch velocity and launch angle and the forces acting on it. The most important of these forces is, of course, the force of gravity, which is accelerating the ball back down toward the ground at 9.8 meters per second^2. But the forces exerted on the ball by the air it is passing through are important as well. To clarify this, we choose a coordinate system with one axis aligned with the direction of flight of the ball and the others perpendicular to it. Then the forces exerted by the atmosphere on the ball are decomposed into the *drag*, which is a force impeding the ball in its forward motion, and the *lift*, which helps the ball fight gravity and stay aloft longer (Figure 4). Drag is the same force you feel pushing on your arm if you stick it out of the window of a moving car. Lift is a consequence of the back spin of the ball, which speeds the air passing over the top of the ball and slows the air passing under it. By Bernoulli's principle the result is lower pressure above and therefore an upward force on the ball.

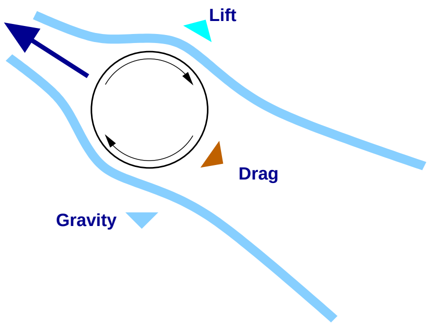

Figure 4. Forces acting on a golf ball during its flight.

Drag and lift are very much affected by how the air interacts with the surface of the ball. The dimples on a golf ball are there primarily to decrease drag and increase lift. Proper dimpling of a golf ball induces turbulence in the boundary layer, delaying the point at which the flow past the ball separates from the surface, and resulting in a ball which can carry nearly twice as far as a smooth ball would with the same swing. Based on aerodynamic and manufacturing considerations, a great many dimple designs have been manufactured, leading to an elaborate crystallography of golf balls [6].

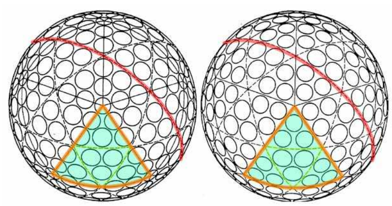

Figure 5. Two golf ball dimple patterns with icosahedral symmetry.

Mathematics Awareness Month 2010, with the theme Mathematics and Sports, provides us mathematicians with another opportunity to get out the vitally important message that mathematics can be found everywhere in the physical world and human activity. In this note, I have discussed briefly a few of the ways in which mathematics relates to golf. All of these could be, and in fact have been, the subject of extended studies, because they enable us not only to better understand, but also to optimize, the performance of a golfer and golf equipment.

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Book Review

Can Baseball Be Used to Teach Statistics?

Reviewed by Mason A. Porter

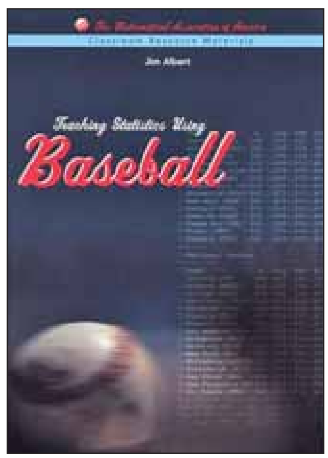
Teaching Statistics Using Baseball
Jim Albert
Mathematical Association of America, 2003
US$56.95, 304 pages
ISBN-13:978-0883857274

"Statistics are the lifeblood of baseball. In no other sport are so many available and studied so assiduously by participants and fans. Much of the game's appeal, as a conversation piece, lies in the opportunity the fan gets to back up opinions and arguments with convincing figures, and it is entirely possible that more American boys have mastered long division by dealing with batting averages than in any other way."

—Leonard Koppett, *A Thinking Man's Guide to Baseball,* 1967 [7]

Starting Lineups

Much of my initial inclination towards mathematics arose from my passionate interest in baseball. As the above quote by Hall of Fame sportswriter Leonard Koppett indicates, I am hardly the only person who has discovered mathematics and statistics through such means.[1] It probably ran a bit deeper in my case than in most—as a child, I actually used to search for errors on the backs of baseball cards just so I could send letters to the companies that produced them to ask them about their errors. (On one occasion, one of them actually wrote back to inform me that the error was in one of the counts rather than in the computation.) It should thus come as no surprise that I am fascinated by the idea of using baseball to help teach subjects like statistics and probability.



Teaching Statistics Using Baseball by Jim Albert [1] is certainly founded on a solid idea: Given the long marriage between statistics and baseball, the wealth of baseball fans in the U.S., and the desperate need to develop clever ways to ensure that students learn statistics, why not use baseball to help teach the subject?

Albert's intended audience is students with little mathematics background—e.g., his book does not assume any knowledge of calculus—and he has used it as a textbook for a course that gives a gentle introduction to statistics for students with an established interest in baseball. I am skeptical about using Albert's book as the main text for a course, as I think that it would work only for a very specific niche audience. This is indicated explicitly in the book's preface, though I believe that this niche is significantly smaller than the author seems to think. Albert's book offers much better value as a source for exercises and project ideas for statistics and modeling courses with a broader scope.[2] (It might also be nice for self-study.)

Mason A. Porter is a University Lecturer in the Oxford Centre for Industrial and Applied Mathematics at the University of Oxford and a Tutorial Fellow of Somerville College. His email address is `porterm@maths.ox.ac.uk`.

[1] *More recent editions of Koppett's book [7] have more gender-neutral titles, but I wanted to cite the original version to give some indication of how long baseball and statistics have been married.*

[2] *Indeed, it offers enough value that my review shouldn't make anybody reminisce too much about the time that Tommy Lasorda gave his opinion of Dave Kingman's performance.*

Albert's book is intentionally introductory, but I think that it is too gentle—to the point of coming across as condescending. (For example, do the students who are going to use this book really need to be informed that the square $\mathbf{A}^2$ of a matrix $\mathbf{A}$ is equal to $\mathbf{A}\times\mathbf{A}$ and then immediately be shown the same level of detail for the cube of a matrix? I think that college students ought to be given more credit than this!) My own introductory formal experience in statistics was as a teacher's assistant in a rigorous, calculus-based course taught by Gary Lorden at Caltech using portions of the book by Ross [10]. (I had also previously taken courses in probability.) Although Albert's book is intended for an audience with considerably less preparation, I nevertheless think the book's hand-holding approach goes too far and actually damages the facility of weaker students to learn the material. Several important concepts, such as correlation, are used without *ever* being defined with mathematical formulas. Others, such as standard deviation, are mentioned in the exercises without any definition or description until one or more chapters later. Albert also seems to eschew the idea of developing concepts further with the exercises, which essentially ask the same questions over and over again. A smattering of more advanced exercises, discussions, and appendices would have been nice, and I don't think that the introductory nature of the book would have been ruined one bit by including such components. There are also flaws with the baseball discussion, including an incomplete definition of a balk that includes only one of the ways that a balk can occur [4]. Frustratingly, Albert often includes raw speculation in his baseball-related conclusions in a book that specifically introduces tools that are meant to be used to tackle such questions more seriously. The book would also have benefited from including pointers to a wider variety of supplementary reading material.

Albert's book does cover a good selection of topics—including data batches, standardization, relationships between measurement variables, probability distributions, statistical inference, Markov chain modeling, etc. It also has a nice accompanying website that includes helpful tidbits such as solutions to odd-numbered exercises and *vital* information such as the data sets that are necessary for the end-of-chapter exercises. The introductory chapter presents a good roadmap for the organization of the remainder of the book and the format of the subsequent chapters. This chapter also presents some basic baseball statistics to get students warmed up and indicates some online resources (especially `retrosheet.org` and `baseball-reference.com`) that are indispensable sources for baseball statistics and research. Each of the subsequent chapters begins with a summary of the ensuing contents and then proceeds through several case studies, numerous exercises, and (in my opinion, unsatisfactorily minimal) suggestions of other reading materials. The first exercise (or two) in each chapter is a "leadoff exercise" about Rickey Henderson, though I was unable to find substantive differences between these exercises and the regular ones. I think that the book's case-study approach has the potential to be extremely valuable. Unfortunately, the variable quality of the case studies curtails their utility. A few of them are legitimately fantastic, as they cover salient topics—such as whether hitters can have inherent differences in their ability to be streaky—that remain active areas of modern baseball research that students can already investigate in an introductory course.[3] Other case studies don't have any meat, and several of them contain material that would be better placed as intermediate discussions between case studies.

Unfortunately, Albert's book has some notable and unfortunate gaps. Despite the book's premise, it inexplicably has almost no discussion of sabermetrics, the quantitative study of baseball [4]. I find it astounding, for example, that the book develops interesting considerations similar to concepts from sabermetrics such as Runs to End of Inning (RUE)—which attempts to give a value to each outcome of a plate appearance based on the number of runs expected to score before the inning ends—without even a mention of any of the modern sabermetric statistics (or "Jamesian" statistics, as I like to call them) [5, 11–13]. Instead, Albert seems to be satisfied with mentioning OPS (on-base plus slugging percentage), which was already commonplace by the time his book was published. Defensive statistics, which have now become much more sophisticated than they were for decades precisely because of statistical research, were *never* examined even once in the book. Also omitted were important statistical topics such as Monte Carlo simulations, which are now used in the Diamond Mind simulations of baseball seasons [14]. A brief discussion with pointers to appropriate references that build on germane concepts discussed in the book would have been welcome, and such topics could have at least been introduced in the exercises at the end of each chapter. I think that Albert missed a wonderful teaching opportunity by not doing this.

Play by Play

In this section, I'll give some more details about the topics covered in the book. These topics are introduced in a reasonable order, although I am more familiar with expositions in which concepts

[3] *Some of the case studies—including one that poses the question of whether or not Roger Clemens deserved his Cy Young Award in 2001—are particularly meaningful to me, as they remind me of specific, passionate arguments in which I have participated.*

from basic probability are introduced earlier in the game.

Chapter 2 is concerned with exploring single batches of baseball data. Stem plots, distributions, and five-number summaries (smallest value, lower quartile, median, upper quartile, and largest value) are introduced in a case study about teams' offensive statistics. Time series, fitting, histograms, dot plots, and comparisons of distributions are then introduced in subsequent case studies. One of my favorite moments in reading the book was going through Case Study 2.3 about Roger Clemens because after illustrating his miraculously increased strikeout rate at an advanced stage of his career, it contains the following lovely statement: *It is not clear if this pattern in the plot corresponds to any change in Roger's physical condition or his style of pitching, but it may deserve further investigation.* Given the strong evidence—revealed years after the release of Albert's book—that Clemens used steroids during this period of his career, Albert's comment seems to be a rather prescient statement indeed. (For similar reasons, I was also amused by Case Study 3.1, which compares the hitting statistics of Ken Griffey Jr. and Barry Bonds.) This also underscores the importance of statistical analysis in finding apparent anomalies that might suggest something interesting that awaits discovery and is a point that can be made to students who are learning introductory statistics from this book.

Chapter 3 discusses standardization and the comparison of data batches. In addition to the application of topics from Chapter 2, the author introduces new topics such as box plots, mean, standard deviation, the normal distribution, and standardized (z) score. I especially liked Case Study 3.5, in which Albert examines the relative greatnesses of high batting averages in different seasons. I have a quibble, however, that first shows up in this chapter and is then repeated elsewhere—namely, that the author claims that certain skewed distributions (such as slugging percentages in 1999 in Case Study 3.4) are normal when perhaps that is not a good enough model. I think that the idea of skewness should have been discussed at appropriate points in the book.

Chapter 4 discusses the relationships between measurement variables. The new topics introduced include scatter plots, correlation, linear and nonlinear regression, root mean square error, least-squares fitting, and residuals. I especially like Case Study 4.4, which concerns the creation of a new measure of offensive performance using multiple regression, and Case Study 4.6, which examines regression to the mean in player performance (which sabermetricians and sabermetrics-friendly baseball writers such as Rob Neyer stress repeatedly in their analyses and outcome predictions).

Chapter 5 gives an introduction to probability using tabletop games such as *Strat-O-Matic Baseball*. The new topics introduced in this chapter include the relative frequency interpretation of probability, the law of large numbers, sample spaces, finding probabilities of events, randomization devices, multinomial experiments, and conditional probability. Although tabletop games provide a reasonable way to introduce fundamental concepts from probability, in 2003 (when the book was published) this comes across as rather anachronistic. I suspect that almost none of the students who might use Albert's book have ever played any of these games, and I wonder if that might prove problematic when teaching from this chapter. Additionally, some aspects of the chapter aren't well thought out; for example, it is silly to have exercises that ask students to actually construct spinners to represent events of different probability. I think that college students—even ones who are learning basic statistics as part of their general education—should be given more credit than that.

Chapter 6 discusses probability distributions and baseball. The topics that it covers include binomial and multinomial distributions, independence, expected counts, simulation, and Pearson residuals. Case Study 6.3's discussion of modeling runs scored made me think of the RUE measure employed by sabermetricians (see my earlier discussion).

Chapter 7 provides an introduction to statistical inference. The topics it covers include the distinction between ability and performance, modeling of ability and simulating the data produced by such a model, Bayes' rule, finding the most likely ability for a given performance, interval estimates, and subjective interpretation of probability. I really like Case Studies 7.2 and 7.3, which concern the simulation of a batter's performance if ability is known (7.2) and then attempting to learn a batter's ability based on performance (7.3). I also like Case Study 7.5, which compares the hitting performances of Wade Boggs and Tony Gwynn, because it entails the use of quantitative analysis to improve the level of sophistication of familiar water-cooler arguments.

Chapter 8 discusses topics in statistical inference. It builds on ideas introduced in previous chapters and also covers topics such as situational hitting data, goodness of fit, models with bias and/or ability effects, streakiness (and runs in the statistical sense), and moving averages. A couple of the case studies are concerned with ideas and baseball players that particularly interest me. For example, Case Study 8.1 discusses the situational hitting statistics of Todd Helton, who plays his home games in Coors Field, and offers a well-known (to baseball fans) situation in which there is a large disparity between home and road hitting statistics. (This disparity is a major issue when trying to discern Helton's ranking among the all-time greatest hitters [11].) Case Study 8.5

asks whether John Olerud (who is one of my favorite players) is streaky, and the subject of hitting streaks (and the existence or nonexistence of "hot streaks" more generally) is of course an active area of research [2, 8].

Chapter 9 discusses modeling baseball using Markov chains. The topics it covers include transition probabilities, absorbing states, matrices, matrix multiplication and inversion, computation of event probabilities using simulation, expected numbers of events, and values of batting events. As one might guess from my comments in the introduction, I like Case Studies 9.3 and 9.4, as the former includes a discussion of the expected numbers of runs in the remainder of an inning (though without the discussion of such quantities that have been studied by sabermetricians) and the latter discusses the values of different on-base events. Case Study 9.5 is also very interesting, as it discusses a frequently debated topic: the worth (or lack thereof) of sacrifice bunts.

Albert's book also includes two appendices: Appendix A provides an introduction to baseball, though I think that any reader who requires it likely won't be very interested in learning statistics using this book; and Appendix B discusses the data sets used in the book and more generally how to obtain baseball data online. Appendix B is crucial to teaching statistics using this book, because of course students need to possess data in a usable format to do numerical computations. The website `retrosheet.org` is mentioned prominently, and it remains an essential tool for everybody who does research using baseball statistics. One of my favorite sites, `baseball-reference.com` (the brainchild of former mathematics professor Sean Forman), is also mentioned prominently, and it is now much more expansive than it was in 2003 when Albert's book came out. (In particular, the site now has search features that can be used in conjunction with homework problems in a course that uses Albert's book.) Crucially, Albert's book has an accompanying website that has errata, solutions to the odd-numbered exercises, and (most importantly) data sets that go with the book's exercises. Appendix B also includes a welcome discussion of data format and formatting, although I am admittedly a bit perturbed by Albert's characterization of MATLAB as his "favorite graphing package". (Given that I am an applied mathematician with a healthy interest in computation, such a pithy description of this wonderful computational tool gives me the shakes.) Unfortunately, Albert's book fails to mention any of the numerous sabermetrics blogs and other websites, which were already prominent when the book came out and have continued to multiply during the past few years. Appendix B would have been a logical place to discuss the ones available in 2003. Some of the very nice ones currently available are Baseball Think Factory (`baseballthinkfactory.org/`), The Hardball Times (`hardballtimes.com`), and a blog associated with *The Book: Playing the Percentages in Baseball* (`insidethebook.com/ee/`).

The Final Score

In concluding this review, I should probably answer the question I posed in my title. Statistics is of course crucial to baseball, but that does not imply that one can make baseball the central point of an effective introduction to the subject. I think that Albert's book can provide a successful starting point for students who are not very mathematically inclined, but it seems to me that many students will become frustrated by the book's overabundance of hand-holding and lack of mathematical meat. (Where are the formulas and advanced exercises that introduce new concepts, and why can't at least some of the derivations be included in appendices?) Teaching an introductory statistics course using only baseball (via this book, for example) reduces the audience to a relatively small niche of people who are already interested in baseball and either want or (more likely) are forced to learn some statistics. The book does attempt to introduce baseball to people who aren't already baseball fans, but I just can't see how that's going to be effective. I think that most people who don't already like baseball are simply not going to appreciate learning statistics from this book, and I would also argue that being a baseball fan is a necessary but not sufficient condition to be a member of the book's target audience. On the other hand, this book has interesting exercises and case studies that can be used effectively to develop exercises and projects in statistics courses with a broader scope. In my opinion, this is by far the most valuable usage of Albert's book.

Mathematical and statistical research on baseball continues to flourish, and many interesting insights have been published since this book appeared. Tools such as Diamond Mind and CHONE are founded on ideas that rely on fundamentals that are discussed in Albert's book. (In fact, a discussion of Diamond Mind might be rather appropriate for Chapter 5, and a discussion of CHONE could be added when regression is introduced.) Obviously, there are also numerous interesting academic and sabermetric studies. For example, Samuel Arbesman and Steve Strogatz recently used Monte Carlo simulations to examine the likelihood of Joe DiMaggio's 56-game hitting streak (as well as which players were most likely to have such a streak, its length, and when it occurred) [2]. Trent McCotter built on this work and used permutation tests to conclude that hitting streaks are not mere byproducts of randomness [8]. Other researchers have borrowed tools from statistical physics and network analysis to study baseball problems [3, 9]. For instance, my collaborators and I recently examined the properties of the bipartite batter–pitcher matchup graphs from 1954–2008 for both individual seasons and the entire time period [11]. We looked at random walks on these graphs to develop rank orderings of hitters and pitchers using the head-to-head matchup as the fundamental quantity of interest, and we found interesting connections between the rankings and structural network properties (such as betweenness centrality) of baseball players. Naturally, the sabermetrics community also continues to produce numerous interesting insights. The possibilities for analysis have expanded even further with an abundance of new data, such as extractions from *Pitch f/x*, which can be used to determine the speed of a thrown baseball at its release time and the time history of the baseball's location (up to an accuracy of one inch) during its flight to the batter (see, e.g., [6] for one of myriad examples of research that uses Pitch f/x).

Despite my reservations about Albert's book, I need to give him a lot of credit: Reviewing his book has compelled me to think much more deeply about teaching statistics than I ever did before (whether or not one chooses to do so using baseball), and his book definitely merits a perusal by people in the mathematics teaching profession. I know that my students at Oxford would be turned off by Albert's overly gentle approach, but I do believe that a market exists for his book. However, I don't think that it's a good textbook and feel it would serve better as a source of interesting exercises and projects for broader-minded statistics courses.

Acknowledgements

I thank Joe Blitzstein, Sean Forman, Allyn Jackson, Trent McCotter, Tom Maccarone, Jesús Rodríguez, Serguei Saavedra, and Steve Strogatz for useful comments.

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WHAT IS...

a Wilf-Zeilberger Pair?

Akalu Tefera

One of the most exciting mathematical discoveries in the early 1990s was the Wilf-Zeilberger (WZ) algorithm that can be used for *proving*, *evaluating*, and *discovering* identities involving hypergeometric terms automatically by computer. A discrete function $F(n,k)$ is called *hypergeometric* if both

$$\frac{F(n+1,k)}{F(n,k)} \text{ and } \frac{F(n,k+1)}{F(n,k)}$$

are rational functions of n and k. The binomial coefficient $\binom{n}{k} = n!/(k!(n-k)!)$ is the simplest nontrivial example.

Suppose that you are faced with identities of the form $A = B$ where A is a sum of terms involving hypergeometric terms and B is a conjectured, simpler answer—for example, the *binomial theorem*

$$\sum_{k=0}^{n} \binom{n}{k} x^k y^{n-k} = (x+y)^n,$$

or *Dixon's identity*

$$\sum_{k=-n}^{n} (-1)^k \binom{2n}{n+k}^3 = \frac{3n!}{n!^3}.$$

You may ask yourself: "Is there a computerized method that would certify the validity of the identity without human intervention?" (for *all* n, not just for many special cases). Thanks to Herb Wilf and Doron Zeilberger, the answer is YES! Furthermore, unlike computerized proof techniques in other areas, the computerized proofs generated by their method may be directly verified by mere humans. The certification of the validity of a given identity is achieved by producing what is called a *WZ-pair*.

Akalu Tefera is associate professor of mathematics at Grand Valley State University. His email address is teferaa@gvsu.edu.

A WZ-Pair. A *WZ-pair*, or *Wilf-Zeilberger pair*, is a pair of discrete functions $(F(n,k), G(n,k))$ such that

$$F(n+1,k) - F(n,k) = G(n,k+1) - G(n,k).$$

Suppose that we want to prove an identity of the form

$$\sum_k f(n,k) = r(n), \quad n \geq n_0$$

(for some integer n_0, usually 0). If $r(n) \neq 0$, divide through by $r(n)$ to get

$$\sum_k F(n,k) = 1, \text{ where } F(n,k) = f(n,k)/r(n).$$

Let $S(n) = \sum_k F(n,k)$. To show $S(n) = 1$ for all $n \geq n_0$, it suffices to show that

(1) $\qquad S(n+1) - S(n) = 0$ for all $n \geq n_0$

and check that $S(n_0) = 1$ (usually a trivial check). A good way to certify (1) would be to display a "nice" function $G(n,k)$ such that

$$F(n+1,k) - F(n,k) = G(n,k+1) - G(n,k),$$

for then we simply sum over all integers k to find that (under suitable hypotheses) indeed

$$S(n+1) - S(n) = 0$$

(since the sum on the right side is telescoping).

Wilf and Zeilberger proved in general that if such a "nice" (i.e., hypergeometric) G exists, then it has the form

$$G(n,k) = R(n,k)\,F(n,k),$$

where $R(n,k)$ is a rational function of n and k. Surprisingly, $G(n,k)$ does exist in 99.99 percent of the cases where $r(n)$ is "nice", and whenever it does exist, it can be easily found by the Wilf-Zeilberger algorithm, which is based on an amazing algorithm of Bill Gosper for *indefinite hypergeometric summation*. $R(n,k)$ is called the *WZ proof certificate*.

If $r(n)$ is not "nice", then the more general algorithm of Zeilberger guarantees that it is *holonomic* (a solution of a linear recurrence equation with polynomial coefficients).

The WZ algorithm is implemented in Zeilberger's Maple package `EKHAD`, available from `http://www.math.rutgers.edu/~zeilberg/`, and the built-in `SumTools` package in Maple. A Mathematica package written by Peter Paule and Markus Schorn is also available.

Example. Suppose we want to prove:

$$\sum_{k=0}^{n} \binom{n}{k}^2 = \binom{2n}{n}.$$

Applying the WZ algorithm to the summand $\binom{n}{k}^2$ yields a WZ-pair (F, G), where

$$F(n,k) = \frac{\binom{n}{k}^2}{\binom{2n}{n}},\ G(n,k) = R(n,k)F(n,k) \text{ and}$$

$$R(n,k) = -\frac{k^2(3n+3-2k)}{2(n+1-k)^2(2n+1)}.$$

Doubling the fun! Besides getting a very short proof for any given summation identity, one can discover a new identity from a WZ-pair. Here is how. Suppose the identity

$$\sum_k F(n,k) = r(n),\ (n \geq n_0),$$

yields a WZ-pair (F, G). If the WZ-pair satisfies (i) for each k, $f_k := \lim_{n\to\infty} F(n,k) < \infty$ and (ii) $\lim_{L\to\infty} \sum_{n\geq n_0} G(n,L) = 0$, then we get a new identity

$$\sum_{n\geq n_0} G(n,k) = \sum_{j\leq k-1} (f_j - F(n_0, j)).$$

Example. The identity

$$\sum_k k\binom{n}{k} = n2^{n-1}, \quad n \geq 1,$$

has a WZ-pair (F, G), where

$$F = \frac{k}{2^{n-1}n}\binom{n}{k} \text{ and } G = -\frac{1}{2^n}\binom{n-1}{k-2}.$$

Furthermore, the WZ-pair satisfies the above conditions, and hence we have a new identity

$$\sum_{n=1}^{\infty} \frac{1}{2^n}\binom{n-1}{k-2} = \begin{cases} 1 & \text{if } k \geq 2 \\ 0 & \text{otherwise} \end{cases}.$$

Finding closed forms for sums. Does the WZ method apply to find directly the B part of $A = B$? The answer is yes whenever the summands in A are *proper-hypergeometric*. A discrete function $F(n,k)$ is proper-hypergeometric if it can be written in the form:

$$P(n,k)\frac{\prod_{i=1}^{I}(a_i n + b_i k + c_i)!}{\prod_{j=1}^{J}(u_j n + v_j k + w_j)!}x^n y^k,$$

where

- $P(n,k)$ is a polynomial in n and k,
- I and J are fixed integers,
- a_i, b_i, u_j, v_j are integers, and
- c_i, w_j, x, y may depend on parameters.

Finding closed forms for sums relies on the fundamental theorem of WZ theory, which states that if $F(n,k)$ is a proper-hypergeometric term, then there exists a (proper) hypergeometric term $G(n,k)$ such that

$$(2)\quad \sum_{j=0}^{J} a_j(n)F(n+j,k) = G(n,k+1) - G(n,k),$$

where $a_j(n)$ are polynomials in n. Suppose we want to find a closed-form expression for

$$S(n) = \sum_k F(n,k)$$

where F is proper-hypergeometric. Then by the fundamental theorem we get a recurrence equation of the form (2) for $F(n,k)$. Summing both sides of (2) with respect to k yields

$$\sum_{j=0}^{J} a_j(n)S(n) = 0$$

(assuming, as is usually the case, that $G(n, \pm\infty) = 0$). If the order of the recurrence, J, happens to be 1, then we can easily solve this recurrence and get the closed-form solution. If $J > 1$, then Petkovšek's algorithm can be used to find a closed-form solution, if one exists, or else rule out this possibility. Either way, describing a sequence $\{S(n)\}$ in terms of the linear recurrence equation with polynomial coefficients that it satisfies, together with the initial conditions $(S(0), S(1), \ldots, S(J-1))$, is an effective and canonical way to describe it and is almost as good as "closed-form". The recurrence can also be used to compute, in linear time and constant memory, as many terms as desired.

Proving identities of the form $A = B$ when B has no simple form. Suppose we want to prove identities of the form

$$\sum_k F(n,k) = \sum_k H(n,k),\ (n \geq n_0).$$

Let $L(n)$ and $R(n)$ be the left and right sides of the equation. Find recurrences for each side, see whether they coincide, and check the initial conditions.

Further Reading

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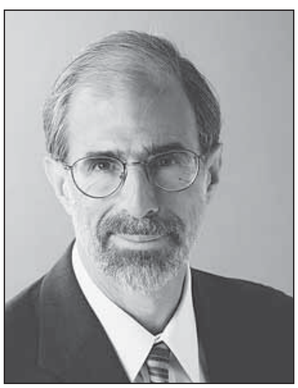
2010 Steele Prizes

The 2010 AMS Leroy P. Steele Prizes were presented at the 116th Annual Meeting of the AMS in San Francisco in January 2010. The Steele Prizes were awarded to DAVID EISENBUD for Mathematical Exposition, to ROBERT GRIESS for a Seminal Contribution to Research, and to WILLIAM FULTON for Lifetime Achievement.

Mathematical Exposition: David Eisenbud

Citation

The Leroy P. Steele Prize for Mathematical Exposition for 2010 is awarded to David Eisenbud in recognition of his book, *Commutative Algebra: With a View Toward Algebraic Geometry* (Graduate Texts in Mathematics, 150, Springer-Verlag, New York, 1995. xvi+785 pp.)



David Eisenbud

Commutative algebra has grown continuously over the last half-century. For many years, the classic book of Atiyah and MacDonald, *Introduction to Commutative Algebra,* which was first published in 1969, served as students' first glimpse of the field. But the subject has long since moved beyond the material in this book. Periods of strong growth, while enriching, sometimes contributed to distancing new researchers in the subject from one of its main reasons for being: algebraic geometry.

Published in 1995 by Springer, Eisenbud's book was designed with several purposes in mind. One was to provide an updated text on basic commutative algebra reflecting the intense activity in the field during the author's life. Another was to provide algebraic geometers, commutative algebraists, computational geometers, and other users of commutative algebra with a book where they could find results needed in their fields, especially those pertaining to algebraic geometry. But even more, Eisenbud felt that there was a great need for a book which did not present pure commutative algebra leaving the underlying geometry behind. In his introduction he writes, "It has seemed to me for a long time that commutative algebra is best practiced with knowledge of the geometric ideas that played a great role in its formation: in short, with a view toward algebraic geometry."

It is this view which permeates the book and makes it unique. Eisenbud distills from the pure beauty of the subject a "true meaning": he tries, and usually succeeds, in making clear to the reader what is going on behind the scenes—the "why", not only the "what", "who", and "how".

Commutative Algebra: With a View Toward Algebraic Geometry presents a wide range of topics, many not typically found in other texts. It gives serious attention to the all-important technique of Gröbner bases. Though there are other good books that use and explain this topic (such as the book by Cox, Little, and O'Shea), Eisenbud's book goes into depth concerning what is called "Gröbner deformation" and gives a full treatment of the critically important fact that generic initial ideals are Borel fixed. Computer and computational algebra is in full swing, a fact not lost in this book. Eisenbud has been on the forefront in relating geometry, syzygies, and regularity, and these topics are given much attention in the book. Likewise, his book has by far the most serious treatment of complexes arising from multilinear algebra. Numerous exercises are given, not just as individual problems but exhibiting the author's broad interests and experience, which further clarify underlying principles. Indeed, the book serves as far more than an introduction to the field; it is used by researchers around the world.

Throughout the text, Eisenbud sprinkles his own commentary, giving the book the strong sense of his own viewpoint. As the reviewer wrote in the *Mathematical Reviews*, "This text has 'personality'—those familiar with Eisenbud's own research will recognize its traces in his choice of topics and manner of approach. The book conveys infectious enthusiasm and the conviction that research in the field is active and yet accessible."

It is this personality, which conveys Eisenbud's broad vision of the field and insistence on conveying basic understanding, that makes *Commutative Algebra: With a View Toward Algebraic Geometry* so special and enduring.

Biographical Sketch

David Eisenbud was born on April 8, 1947, in New York City. He attended the University of Chicago for both his undergraduate and graduate education, receiving his Ph.D. in 1970 under Saunders Mac Lane and J. C. Robson. After his degree he joined the faculty at Brandeis University, where he remained until 1997, when he became director of the Mathematical Sciences Research Institute in Berkeley and joined the faculty at the University of California Berkeley. He stepped down as director in 2007 and assumed full-time responsibilities at UC Berkeley. In 2010 he will begin a part-time position as Vice President for Mathematics and the Physical Sciences at the Simons Foundation while continuing his activities at Berkeley.

In 2003–2004 Eisenbud served as president of the AMS. He has held numerous visiting positions at institutes and universities around the world. He has been a Sloan Foundation Fellow (1973–1975), was an invited speaker at the International Congress of Mathematicians in Vancouver in 1974, and was elected to the American Academy of Arts and Sciences in 2006. He has supervised twenty-six Ph.D. students and numerous postdocs. He has contributed to a wide variety of areas, including commutative algebra, algebraic geometry, and computational algebra, with fifty-six coauthors.

Response

While I was a graduate student at the University of Chicago (1967–1970), I listened at every chance I got to the beautiful lectures of Irving Kaplansky. He was then just finishing his book *Commutative Rings*, and lectured from it. I admired him and it a great deal, but—in the style of a rebellious adolescent—I was quite ready to proclaim that a lot was left out. In the fall of 1971, visiting at the University of Leeds in England, I had a chance to lecture on one of the things that I felt was missing: Noether normalization (in a version borrowed from Nagata's book, *Local Rings*).

This was the germ from which my own book grew…and grew and grew, by fits and starts, over more than twenty years. Kaplansky's book is a lapidary work, focused, polished, concentrated, like a fine short story. By contrast, mine seems a sprawling novel, trying somehow to include all of mathematics within its borders. I had a lot of fun writing it, though it seemed to take forever. I've been immensely gratified, in the nearly fifteen years since its publication, that people have found it useful and that at least some of them seem to have fun reading it (though that, too, might seem to take forever).

I feel truly privileged to have had such great teachers in commutative algebra and algebraic geometry: Kaplansky, David Buchsbaum, David Mumford, Antonius van de Ven, and Joe Harris in the ten years or so when I felt like a beginner; and, later on, a wonderful sequence of collaborators and students from whom I also learned a great deal. I wanted my book to make some of what I received from them accessible to the whole community. I'm honored to think that this prize recognizes some measure of success in that attempt.

Seminal Contribution to Research: Robert Griess

Citation

The Leroy P. Steele Prize for Seminal Contribution to Research for 2010 is awarded to Robert L. Griess Jr. for his construction of the "Monster" sporadic finite simple group, which he first announced in "A construction of F_1 as automorphisms of a 196,883-dimensional algebra" (*Proc. Nat. Acad. Sci. U.S.A.* **78** (1981), no. 2, part 1, 686–691) with details published in "The friendly giant" (*Invent. Math.* **69** (1982), no. 1, 1–102).

Griess and, independently, Bernd Fischer of the University of Bielefeld had earlier suggested the existence of this group, whose order (number of elements) is a 54-digit number. The construction was accomplished by Griess, not only for the first time but also entirely by hand without the aid of a computer. It was a tour de force. We now know, with the completion of the classification of all finite simple groups, that this is the largest "sporadic" finite simple group—that is, the largest finite simple group not fitting into the patterns established by the continuous Lie groups, broadly viewed.

Robert L. Griess

But beyond the sheer magnitude of the numbers involved, the discovery of this group has touched science and mathematics very deeply. Connections have emerged with areas as diverse as string theory in physics and, within mathematics itself, in very sophisticated number theory; see, for instance, the papers by Richard E. Borcherds, "Sporadic groups and string theory" (*First European Congress of Mathematics*, Vol. I (Paris, 1992), 411–421, *Progr. Math.* **119**, Birkhäuser, Basel, 1994) and "Monstrous moonshine and monstrous Lie superalgebras" (*Invent. Math.* **109** (1992), 405–444). (Here "Monstrous Moonshine" is a term coined by John Conway in reaction to the surprising relationships, first observed empirically by John McKay, of character degrees of the Monster and modular function theory. See the Wikipedia article http://en.wikipedia.org/wiki/Monstrous_moonshine. Also on the Web are lectures by Edward Witten suggesting a role for the Monster in 3-dimensional quantum gravity—e.g., http://www.nonequilibrium.net/81-edward-wittens-talk-3d-gravity/.) In addition, the group and its construction by Griess have stimulated the development of the important new subject of vertex operator algebras, cf. Igor Frenkel, James Lepowsky, Arne Meurman, "Vertex operator algebras and the Monster" (*Pure and Applied Mathematics* **134**, Academic Press, Boston, MA, 1988). There are even philosophical implications, in that these discoveries, though certainly related to topics investigated from the point of view of continuous Lie group theory, were not at all found from that perspective but were revealed when one pushed hard enough in the world of finite structures. The group is the "jewel in the crown" for those mathematicians who worked so hard to understand all the finite simple groups.

Biographical Sketch

Robert L. Griess Jr. was born in Savannah, Georgia, in 1945. Shortly afterward, his family returned to Pittsburgh, Pennsylvania, where he attended public schools. He received his undergraduate and graduate degrees at the University of Chicago, studying with adviser John Thompson, and wrote a thesis on central extensions of simple groups. In 1971 he became a Hildebrandt Instructor at the University of Michigan, where he is currently a professor.

His honors include a Guggenheim Fellowship, an invited address at the International Congress of Mathematicians in 1983, the Harold Johnson Diversity Award at the University of Michigan, and membership in the American Academy of Arts and Sciences. He has held visiting positions at Rutgers University, the Institute for Advanced Study, Yale University, Ecole Normale Supérieure in Paris, University of California Santa Cruz, National Cheng Kung University in Taiwan, and Zhejiang University in China. His current research interests are finite groups, finite aspects of Lie theory, vertex operator algebras, and rational lattices.

Response

My sincerest thanks go to the individuals who chose me for this great honor and those who helped me during my career. My construction of the Monster took place during my first sabbatical at the Institute for Advanced Study in 1979–1980. It was the result of intense mental and physical passion over several months.

Within the finite group theory community in the early 1970s, a feeling grew that classification of finite simple groups might be possible. The majority view remained skeptical for years. By 1973, when Bernd Fischer and I quite independently found evidence for the Monster, new sporadic groups had been appearing steadily for about eight years. There was no obvious reason why the flow should stop. Much larger groups than the Monster could have been out there, waiting to be discovered.

By the late 1970s the optimism about classifying finite simple groups had increased. A new school of thought, Moonshine, showed us that the Monster group was connected to some classical number theory on the upper half complex plane. Other amazing coincidences involving sporadic groups were proposed. Suddenly, there were new contexts in which to regard the finite simple groups. I felt inspired to try a construction. After some trial explorations came full involvement in late 1979. I built a nonassociative, commutative algebra of dimension 196883 and gave enough automorphisms to generate a finite simple group with the right properties. On 14 January 1980 I mailed an announcement about my existence proof to group theorists. What a wonderful coincidence that I would be awarded the Steele Prize on 14 January 2010, exactly thirty years later!

The construction of the Monster resolved an existence question in the classification of finite simple groups and, moreover, as corollaries, there followed new existence proofs of several smaller sporadic groups which had been constructed earlier by combinatorial methods or computer. This brought some unity to the world of sporadic groups. The Monster involves twenty of the twenty-six sporadic groups. Uniqueness of the Monster was proved in the late 1980s by Meierfrankenfeld, Segev, and me. (Like the construction, this uniqueness result was relatively hard and had been an open problem for years.)

As the years went by, we saw the sporadic groups play roles in emerging vertex algebra theory, in theoretical physics and algebraic topology. The nonassociative algebra which I defined is part of the Moonshine vertex operator algebra of Frenkel, Lepowsky, and Meurman, constructed in the mid-1980s. This vertex operator algebra has the Monster as its full group of automorphisms. Borcherd's proof of the Moonshine conjectures made use of vertex algebras and infinite-dimensional Lie theory. With coauthors, I have studied vertex operator algebras and their automorphism groups. About 2005, Chongying Dong, Ching Hung Lam, and I proved the first partial uniqueness theorem for that Moonshine vertex operator algebra. I expect that thirty years from today—when I hope to see all of you again!—finite simple groups will be more fully integrated into other parts of mathematics.

About the citation, I have two comments. First, while I was in graduate school, I met Bernd Fischer and corresponded with him for years. He taught me so much about his beautiful and original ideas. Secondly, the citation mentions that most finite simple groups are analogues of continuous groups over finite fields, while also remarking that the Monster led to mathematical insights not obtained from the continuous (Lie-theoretic) point of view. I add that sporadic group theory, in general, involves significant finite mathematics which I still do not see as contained in or suggested by Lie theory. There is no theory for sporadic groups like BN-pairs for groups of Lie type. While there are many theorems about sporadic groups, how they should be placed within mathematics remains an open question.

Lifetime Achievement: William Fulton

Citation

The 2010 Steele Prize for Lifetime Achievement is awarded to William Fulton. Through his research, his writing, and his intellectual leadership, Fulton has played a pivotal role in shaping the direction of algebraic geometry and in forging and strengthening ties between algebraic geometry and adjacent fields. His teaching and mentoring have nurtured several generations of younger mathematicians. In short, he is a giant of the mathematical profession.

Fulton has made important contributions to many topics in algebraic geometry, but he is probably best known for his transformational work in intersection theory. This theory has stood at the center of algebraic geometry since the beginnings of the field, but the foundational revolutions led by Weil, Zariski, Serre, and Grothendieck in the 1950s and 1960s largely passed it by. As late as the mid-1970s, intersection theory remained a collection of ad hoc tools without an overarching organizational principle, and it was not clear in what generality the tools applied. Working in part with MacPherson, in the late 1970s Fulton created a completely new approach that revolutionized the subject and greatly extended its applicability.

In the classical approach to intersection theory, one started by proving a moving lemma to reduce to the situation in which cycles met properly, i.e., in the expected dimension. The fundamental innovation of Fulton and MacPherson was to develop a theory that worked directly with possibly excess intersection and so avoided the necessity of perturbing the original data. This led to a vast strengthening and clarification of the machine, and the basic method they used—the so-called deformation to the normal cone—has had many important ramifications throughout algebaic geometry and beyond. For instance, it suggested the construction of virtual fundamental classes, which in turn opened the door to the explosive development of Gromov–Witten theory in the last fifteen years. Fulton's research in this area appears in his *Ergebnisse* volume *Intersection Theory*. Universally recognized as a classic, this beautifully written book has become an essential part of the library of every mathematician working anywhere near algebraic geometry. It was awarded the Steele Prize for Exposition in 1996.

In many respects, Fulton's writing and scientific leadership have been as important as his research. He has repeatedly shown an uncanny ability to recognize areas that are ripe for development and to create the framework making this development possible. The theory of toric varieties provides a good case in point. Although there had been important applications of the machine to combinatorics by Stanley, until the late 1980s the theory of toric varieties was a relatively quiet area. Fulton realized that this was in fact a very fertile subject having contact with many parts of mathematics, and in 1993 he published lectures giving a clean and concise working out of the theory. His book was in large part responsible for a dramatic growth of activity in the field, and nowadays toric varieties are a central feature of the algebro-geometric landscape. Something similar happened more recently when Fulton was one of the first to recognize the importance of a circle of questions linking Hermitian matrices, invariant theory, and Schubert calculus following work of Klyachko and others. Through lectures and an influential article in the *Bulletin of the AMS*, Fulton vigorously promoted what subsequently became one of the most exciting topics on the boundary between algebraic geometry and representation theory. One should also mention Fulton's behind-the-scenes influence at the beginning of quantum cohomology: his notes with Pandharipande in 1997 fulfilled a critical foundational need just as the area was starting to take off.

William Fulton

Fulton is also famous for his magic touch in mentoring postdocs and graduate students. He is extremely generous both with mathematical guidance and with the sort of practical advice that is so important at the start of a career. Many of the younger leaders of contemporary algebraic geometry were in Fulton's orbit as postdocs at Brown, Chicago, or Michigan, and he has been equally successful as a Ph.D. advisor. Under his leadership, all of the institutions where he was employed became international centers of the field. Finally, Fulton has a remarkable gift for recognizing and encouraging budding mathematical talent. For years, he has worked tirelessly to promote the careers of promising young mathematicians all over the world.

Biographical Sketch

William Fulton, born in 1939, grew up in Naugatuck, Connecticut, where he spent more time on music and sports than mathematics. As an undergraduate at Brown, the inspiration of John

Wermer and Herbert Federer led to a concentration on mathematics. He attended graduate school at Princeton, where John Milnor, John Moore, and Goro Shimura were particularly influential teachers; his thesis with Gerald Washnitzer was on tame fundamental groups.

During a postdoc at Brandeis, he taught a course on algebraic curves, which led to a text still in use (and available free on the Internet). He spent seventeen years at Brown, with Bob MacPherson and Paul Baum, joined later by Joe Harris, Dick Gross, and Jean-Luc Brylinski, where a remarkable center in algebraic geometry, topology, and number theory flourished. His book *Intersection Theory* appeared in 1984. This was followed by eleven years at the University of Chicago, where he became the Charles L Hutchinson Distinguished Service Professor. There he had the chance to teach splendid graduate students in advanced courses, leading to several texts. At Chicago he had the opportunity to interact with many stimulating postdocs, of whom Burt Totaro and Rahul Pandharipande were particularly influential.

In 1998 he moved to the University of Michigan, where he has held the Miner Keeler Chair in Mathematics and recently became the Oscar Zariski Distinguished University Professor. At Michigan he is enjoying the stimulating atmosphere provided by his colleagues, postdocs, and graduate students in algebraic geometry and surrounding areas. He has held visiting positions at the University of Genoa, Aarhus University, IHES, IAS, MSRI, Mittag-Leffler Institute as the Erlander Professor, and Columbia University as the Eilenberg Visiting Professor.

Fulton is a member of the National Academy of Sciences and the American Academy of Arts and Sciences, and he is a foreign member of the Royal Swedish Academy of Sciences. He was the managing editor of the *Journal of the AMS* from 1995 to 1998.

Response

Most pleasures in a mathematician's life, at least those related to mathematics, come from discovering something new or finding a proof of something one has worked on, alone or with others, for a long time. Other pleasures come from seeing colleagues or students solve problems one has thought about; indeed, the increase in these pleasures as one gets older compensates for fewer of the former. Being awarded a prize like this from one's peers is yet another fine pleasure for a mathematician, and I am most grateful to the committee and the AMS for this award.

I have indeed been fortunate in my career, with the inspiring teachers I had as an undergraduate and graduate student and the many splendid colleagues, postdocs, and students with whom it has been a joy to work. In particular, my career would be nothing like it has been without the collaboration with Bob MacPherson on intersection theory and the work with Rob Lazarsfeld on positivity. I am grateful to them and my many other collaborators for making this award possible.

About the Prize

The Steele Prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein. Osgood was president of the AMS during 1905–1906, and Birkhoff served in that capacity during 1925–1926. The prizes are endowed under the terms of a bequest from Leroy P. Steele. Up to three prizes are awarded each year in the following categories: (1) 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) Mathematical Exposition: for a book or substantial survey or expository-research paper; (3) 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. Each Steele Prize carries a cash award of US$5,000.

Beginning with the 1994 prize, there has been a five-year cycle of fields for the Seminal Contribution to Research Award. For the 2010 prize, the field was algebra. The Steele Prizes are awarded by the AMS Council acting on the recommendation of a selection committee. For the 2010 prizes, the members of the selection committee were: Enrico Bombieri, Russel Caflisch (chair), Peter S. Constantin, Lisa C. Jeffrey, Gregory F. Lawler, Richard M. Schoen, Joel A. Smoller, Richard P. Stanley, and Terence C. Tao.

The list of previous recipients of the Steele Prize may be found on the AMS website at `http://www.ams.org/prizes-awards`.

2010 Conant Prize

Bryna Kra received the 2010 AMS Levi L. Conant Prize at the 116th Annual Meeting of the AMS in San Francisco in January 2010.

Citation

The Levi L. Conant Prize for 2010 is awarded to Bryna Kra for her article, "The Green-Tao Theorem on arithmetic progressions in the primes: An ergodic point of view" (*Bull. Amer. Math. Soc. (N.S.)* **43** (2006), no. 1, 3–23).

The search for patterns in the prime numbers has fascinated both professional mathematicians and mathematical amateurs at least since the days of Euler, Goldbach, Lagrange, and Waring. Although the Prime Number Theorem provides asymptotic estimates on the distribution of primes, it does not yield information about regular patterns. The modern history of the subject began with a conjecture of Hardy and Littlewood in 1923 that, given k-tuples a_i and b_i of nonnegative integers, then, with obvious exceptions, there are infinitely many integers n such that the sets $a_{i_n}+b_i : 1 \leq i \leq k$ consist only of primes. In 1939 van der Corput proved that the primes contain infinitely many triples in arithmetic progression. Computational methods by Moran, Pritchard, and Thyssen found a progression of length 22 in 1995; a record that was finally broken in 2004, when Frind, Jobling, and Underwood found a progression of length 23 starting with the prime 56211383760397 and with common difference 44546738095860. That very same year Ben Green and Terence Tao achieved their striking breakthrough with a proof that the set of prime numbers contains arithmetic progressions of length k for every natural number k.

Kra's article is an engaging exposition of the many mathematical strands woven into the fabric of the proof—number theory, ergodic theory, harmonic analysis, discrete geometry, and combinatorics. The paper is written in a relaxed and readable style, while conveying a wealth of insight. Kra describes how a conjecture of Erdös and Turán sparked the imaginations of a succession of brilliant mathematicians—Szemerédi, Furstenberg, Gowers, Green, and Tao—all of whom contributed significant ideas from combinatorics, ergodic theory, and harmonic analysis. Although Szemerédi's Theorem itself is too weak to yield the Green-Tao Theorem directly, the contemplation of this theorem from many vantage points yielded enough insight to permit Green and Tao to prove their celebrated result.

Bryna Kra

Kra's narration captures the fascinating history of and conveys the key mathematical concepts behind the Green-Tao result. The article provides an instructive comparison of the proofs of Szemerédi's Theorem by Furstenberg, Gowers, and Tao, revealing the similarity lurking beneath the apparent differences in approach. It is an excellent and well-told lesson in the value of thinking and rethinking about important mathematical results.

Biographical Sketch

Bryna Kra earned her undergraduate degree from Harvard University in 1988 and her Ph.D. from Stanford University in 1995 under the direction of Yitzhak Katznelson. Before her appointment to Northwestern University in 2004, she held postdoctoral positions at the Hebrew University of Jerusalem, the University of Michigan, the Institut des Hautes Etudes Scientifiques, and Ohio State University, and was an assistant professor at Pennsylvania State University. Kra works in dynamical systems and ergodic theory with a focus on problems related to combinatorics and number theory, frequently in collaboration with Bernard Host. She was an invited speaker at the 2006 International Congress of Mathematicians and was awarded a Centennial Fellowship, also in 2006. Kra organizes a mentoring program for women in mathematics at Northwestern, runs a math enrichment program for children at a local elementary school, and is currently chair of the Northwestern math department.

Response

It is an honor and a pleasure to be awarded the Conant Prize. It is especially gratifying for me because this project is linked in my memory to the birth of my second son. The invitation to give a "Current Events" talk on Green and Tao's proof arrived while I was still in the hospital. As I sleepily rocked a newborn, their proof occupied my mind.

I would not be standing here without the support of many people. My parents have always been my strongest proponents, and I was pleased to finally write something that my mathematician father was happy to read! This article was only made coherent with the help of many colleagues who took the time to read and improve preliminary versions. And I especially thank my husband and children for their patience and support throughout.

About the Prize

The Conant Prize is awarded annually to recognize an outstanding expository paper published in either the *Notices of the AMS* or the *Bulletin of the AMS* in the preceding five years. Established in 2001, the prize honors the memory of Levi L. Conant (1857–1916), who was a mathematician at Worcester Polytechnic University. The prize carries a cash award of US$1,000.

The Conant Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2010 prize, the members of the selection committee were: Georgia Benkart, Stephen J. Greenfield, and Ronald M. Solomon.

Previous recipients of the Conant Prize are: Carl Pomerance (2001); Elliott Lieb and Jakob Yngvason (2002); Nicholas Katz and Peter Sarnak (2003); Noam D. Elkies (2004); Allen Knutson and Terence Tao (2005); Ronald M. Solomon (2006); Jeffrey Weeks (2007); J. Brian Conrey, Shlomo Hoory, Nathan Linial, Avi Wigderson (2008), and John W. Morgan (2009).

About the Cover

Preventing boundary layer separation

The cover for this issue was suggested by Doug Arnold's article, also in this issue.

The game of golf began over four centuries ago, and golf balls were, for a long time, if not the fastest projectiles launched by man, at least the fastest visible ones. Given this, it ought not to be too surprising that basic and perhaps paradoxical principles of aerodynamics were first observed in their behavior. Early ones were made by stuffing a nearly incredible quantity of feathers into a sewn leather pocket (this labor-intensive task making golf a game for only the wealthy), and they were somewhat rough on the outside. In the nineteenth century smoother balls were made of gutta-percha, but it was soon observed that, although superior in many ways, they didn't travel as far as the earlier ones. Thus began a long development of golf balls with artificially created rough surfaces, including "brambles" (covered with bumps and resembling blackberries), "meshes" (with square indentations marked out in a kind of grid), hammered curves, and a primitive kind of dimple. It was only with the invention of piloted aircraft that aerodynamics developed systematically, and one by-product was that the effect of rough surfaces on the trajectories of golf balls was experimentally documented and at least partially understood.

It is a very complex phenomenon. The basic idea is that the dimples cause turbulence in the boundary layer of air flow around the golf ball, and this in turn retards the separation of the boundary layer from the surface. The drag on the ball is therefore decreased. This can be easily demonstrated in wind tunnel experiments. But why does the turbulence prevent separation? Although many books on fluid mechanics discuss drag on bluff objects (for example, the classic text *Essentials of Fluid Dynamics* by Ludwig Prandtl), the clearest nontechnical discussion we have found is that in the book *Shape and Flow* by the late Ascher Shapiro (especially on pp. 161–166). In brief: in a nonviscous atmosphere there would be no drag—the pressure at the back of a sphere would equal that at the front, and there would be no other cause of drag. But viscosity dissipates energy in the boundary layer flow, and a laminar boundary layer escapes as it approaches the high-pressure region at the back. For a dimpled ball, flow in the boundary layer is turbulent. This brings about mixing in the boundary layer, which means in particular that flow in the boundary layer is sped up by contact with the exterior flow. This in turn gives the boundary layer enough energy to
(continued on page 525)

2010 Morgan Prize

Scott Duke Kominers received the 2010 AMS-MAA-SIAM Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student at the Joint Mathematics Meetings in San Francisco in January 2010. Receiving an honorable mention was Maria Monks.

Citation: Scott Duke Kominers

Scott Kominers is the winner of the 2010 Morgan Prize for Outstanding Research by an Undergraduate Student. The award is based on his outstanding and prolific record of undergraduate research spanning a broad range of topics, including number theory, computational geometry, and mathematical economics. Kominers already has several published papers in such journals as *Proceedings of the AMS, Journal de Théorie des Nombres de Bordeaux, International Journal of Number Theory*, and *Integers*. His work on extremal lattices sheds new light on some problems that have been extensively investigated in recent years, and his work (with collaborators) on "hinged dissections" resolves a problem going back to 1864.

In addition to his mathematical work, Kominers has published papers in musicology, as well as puzzles and haikus. He graduated in 2009 from Harvard and is engaged in doctoral studies in mathematical economics.

Biographical Sketch: Scott Duke Kominers

Scott Duke Kominers grew up in Bethesda, Maryland, attending Walt Whitman High School, where his teacher Susan Schwartz Wildstrom crystallized Scott's interest in mathematics. Scott's first research experience occurred at the 2004 Research Science Institute at MIT, at which he wrote a paper in quadratic form representation theory for which he won the AMS's Karl Menger Prize. Scott graduated from Harvard summa cum laude in mathematics in 2009, with a minor in ethnomusicology. He received Harvard's Thomas Temple Hoopes Prize for his senior thesis, "Weighted Generating Functions and Configuration Results for Type II Lattices and Codes".

In college, Scott had the good fortune and honor to work in a host of fields under many advisers: number theory under Noam D. Elkies; computational geometry under Erik D. Demaine; mathematical economics under Susan Athey, Edward L. Glaeser, Drew Fudenberg, John William Hatfield, William R. Kerr, Alvin E. Roth, Andrei Shleifer, and E. Glen Weyl; and musicology under Kay Kaufman Shelemay. Scott feels blessed with friends and family, especially Zachary Abel and Paul Kominers, with whom he collaborates on both research and the *Harvard College Mathematics Review*.

Scott Duke Kominers

Currently, Scott is pursuing mathematical economics studies as a graduate student in the Harvard Business Economics Ph.D. program, supported by a National Science Foundation Graduate Research Fellowship.

Response: Scott Duke Kominers

I am deeply honored to have received this award. I want to thank the AMS, MAA, and SIAM for this recognition, and Mrs. Frank Morgan for endowing the prize. I owe uncountably many thanks to my advisers—Susan Athey, Erik D. Demaine, Edward L. Glaeser, Drew Fudenberg, John William Hatfield, William R. Kerr, Alvin E. Roth, Kay Kaufman Shelemay, Andrei Shleifer, David Smith, E. Glen Weyl, and especially Noam D. Elkies—for their teaching, advice, and support. Additionally, I am grateful to my high school mathematics teacher, Susan Schwartz Wildstrom, for fostering and encouraging my love of mathematics. I want to thank both the Research Science Institute and the

Harvard College Program for Research in Science and Engineering for providing me with stimulating research environments. Finally, I thank my collaborators and classmates for energizing and enlightening me, and my family for its unceasing love and inspiration.

Citation for Honorable Mention: Maria Monks

The Morgan Prize Committee is pleased to award Honorable Mention for the 2010 Morgan Prize for Outstanding Research by an Undergraduate Student to Maria Monks.

The award recognizes her excellent work in combinatorics and number theory. She has an impressive portfolio of five papers, three of which have already appeared in *Proceedings of the AMS*; *Journal of Combinatorial Theory, Series A*; and *Electronic Journal of Combinatorics*. Maria is a 2009 Goldwater Scholar and a recipient of the 2009 Alice T. Schafer Prize for Women in Mathematics. She is currently a senior at MIT and, in addition to her achievements in mathematics, is an accomplished cross-country runner.

Biographical Sketch: Maria Monks

Maria Monks was raised in Hazleton, Pennsylvania, where her father fostered her interest in mathematical problem solving. She grew as a mathematician through competitions and programs such as the Lehigh Valley ARML Team and the Mathematics Olympiad Summer Program.

At the 2007 and 2008 Duluth REUs supervised by Joe Gallian, she solved an open problem on partition reconstruction from minors and discovered a new mock theta function which provides a new combinatorial proof of a partition congruence identity. As an undergraduate at MIT, Maria worked with Richard Stanley on a classification problem in matroid theory and also worked in a fluid dynamics laboratory modeling wave dynamics in trenches. In 2008 she was a coach of the USA team for the Girls Math Olympiad in China, and she is heavily involved with the Harvard–MIT Mathematics Tournament, a competition for high school students run by MIT and Harvard undergraduates. She was the primary author of the 2009 competition and enjoys writing problems in her spare time.

When she is not busy attacking a deep open problem in mathematics, Maria can often be found running. She has competed for the MIT varsity cross-country team for the past four years and intends to train for marathons upon completion of her cross-country career.

Response: Maria Monks

I am very honored to have been named an Honorable Mention for the Frank and Brennie Morgan Prize, and I thank the AMS, MAA, and SIAM for selecting me for this award.

There are more people that deserve to be thanked than can possibly fit into a reasonably sized response, but I would like to express my gratitude to the people who had the most impact on my mathematical career. I thank Joe Gallian for nominating me for this prize and for serving as a wonderful advisor at the Duluth REU. I also express my gratitude to Ken Ono and Richard Stanley for their help, advice, and mentorship in various research projects. Most importantly, I thank my father, Ken Monks, and the rest of my family for providing a wonderful environment in which to grow up and for opening my eyes to the beauty of mathematics.

About the Prize

The Morgan Prize is awarded annually for outstanding research in mathematics by an undergraduate student (or students who have submitted joint work). Students in Canada, Mexico, or the United States or its possessions are eligible for consideration for the prize. Established in 1995, the prize was endowed by Mrs. Frank (Brennie) Morgan of Allentown, Pennsylvania, and carries the name of her late husband. The prize is given jointly by the AMS, the Mathematical Association of America (MAA), and the Society for Industrial and Applied Mathematics (SIAM) and carries a cash award of US$1,200.

Recipients of the Morgan Prize are chosen by a joint AMS-MAA-SIAM selection committee. For the 2010 prize, the members of the selection committee were: Georgia Benkart, Anna L Mazzucato, Maeve L. McCarthy, Michael E. Orrison, Kannan Soundararajan, and Paul Zorn.

Previous recipients of the Morgan Prize are: Kannan Soundararajan (1995), Manjul Bhargava (1996), Jade Vinson (1997), Daniel Biss (1998), Sean McLaughlin (1999), Jacob Lurie (2000), Ciprian Manolescu (2001), Joshua Greene (2002), Melanie Wood (2003), Reid Barton (2005), Jacob Fox (2006), Daniel Kane (2007), Nathan Kaplan (2008), and Aaron Pixton (2009).

2010 Wiener Prize

David L. Donoho received the 2010 AMS-SIAM Norbert Wiener Prize in Applied Mathematics at the Joint Mathematics Meetings in San Francisco in January 2010.

Citation

The 2010 Norbert Wiener Prize is awarded to David L. Donoho for introducing novel fundamental and powerful mathematical tools in signal processing and image analysis. His many outstanding contributions include those to compressed sensing and the construction of multiscale analysis techniques that take advantage of the specific mathematical and physical properties of the problems under consideration. His methods are very deep mathematically and very efficient computationally. This explains their success with both theoreticians and practitioners, which causes him to be one of the most cited applied and computational mathematicians of our time.

Biographical Sketch

David Donoho received his A.B. in statistics (summa cum laude) from Princeton University, where his undergraduate thesis adviser was John W. Tukey. After working in seismic signal processing research at Western Geophysical under Ken Larner, he obtained the Ph.D. in statistics at Harvard, where his thesis adviser was Peter Huber. He held a postdoctoral fellowship at MSRI, then joined the faculty at the University of California, Berkeley, advancing to the rank of professor. He later moved to Stanford University, rising to the position of Anne T. and Robert M. Bass Professor in the Humanities and Sciences. He has also been a visiting professor at Université de Paris, University of Tel Aviv (Sackler Professor and Sackler Lecturer), National University of Singapore, Leiden University (Kloosterman Professor), and University of Cambridge (Rothschild Visiting Professor and Rothschild Lecturer). Donoho is proud of his more than twenty-five Ph.D. students and postdocs, many of whom have become very successful in academia and industry. Donoho is a member of the U.S. National Academy of Sciences and of the American Academy of Arts and Sciences, and he is a recipient of the honorary Doctor of Science degree from the University of Chicago. Donoho cofounded two companies while in Berkeley: D2 Software, makers of MacSpin for high-dimensional data visualization, and BigFix, makers of remote network management software. Donoho has served on the research staff of Renaissance Technologies, a prominent quantitative hedge fund.

David L. Donoho

Response

Norbert Wiener means a lot to me; I am a proud owner of his *Collected Works* [1] and have dived into them regularly for more than two decades. They allowed me to survey Wiener's career from close up: I became intimately familiar with many of Wiener's visionary achievements, including the generalized harmonic analysis, the work on Brownian motion and chaos, and the work on prediction and smoothing of signals, as well as his technical achievements, such as the algebra of absolutely convergent Fourier series and the space PW of bandlimited functions. From the nonmathematical fourth volume [2] of his *Collected Works*, I learned that Wiener had a "wild side" in his later career—a vision of the future; he aimed to be broader and to see farther than any other mathematician of comparable stature.

I am also the proud owner of a beaten-up old copy of a special issue of the *Bulletin of the AMS* dedicated to Norbert Wiener [3]. I have studied carefully what scholars of that time had to say about Wiener. Mathematicians were partially at a loss to assess Wiener's significance, for he was by then a public intellectual and, in some sense, a seer of our future; mathematics simply was too narrow a forum for discussing and evaluating some of his insights. Has any other issue of the *Bulletin* ever had an article with a title like "From philosophy to mathematics to biology"? It seems unlikely to me.

When Wiener did his great work on prediction and filtering in the early 1940s, he realized that the coming convergence of mathematics and computers was going to have great impacts on society and human life. Others had related insights at the time, notably von Neumann. But Wiener saw farther. He saw three things coming together: mathematical insights, computational power, and the capture of signals sensing the world around us and our position in and effects on the world. Wiener communicated the feeling that the convergence of these three elements was a great adventure for humankind, with great potential benefit but also some complexity and even moral peril.

I am fortunate to have lived part of Wiener's adventure: I have the good fortune to be inspired by mathematical analysis; to have rendered some inspiring mathematics operational through computers, and to actually use the resulting computer codes for processing some of the massive bodies of signals data our civilization is now capturing. I have been fortunate to be part of research teams imaging the earth seismically, probing molecular structure by NMR spectroscopy, using magnetic resonance imaging in novel clinical applications, and processing financial signals in markets worldwide. I have been particularly fortunate to find collaborators willing to do new things in those areas, inspired by mathematical criteria. Wiener must have envisioned that mathematical scientists would someday be so fortunate, but he was able to experience only limited opportunities of this kind in his own lifetime.

Wiener's vision has "caught on"; while his enthusiasm for the convergence of mathematics, computing, and signals must have seemed odd to mathematicians sixty years ago, today there are many mathematicial scientists who implicitly assume this convergence as a central ingredient in their world view. The journals *Inverse Problems* and the *SIAM Journal of Imaging Science* are two venues where mathematical scientists are engaged actively in this convergence. I personally am very fortunate to have had students, coauthors, and postdocs who were as inspired as I was by this same convergence. I'd like to mention three mentors: John Tukey, who foresaw the data-drenched world of today and the importance of data analysis; Yves Meyer, who inspired me to work in multiscale analysis through his eloquent writings and broad scientific attitude; and Raphy Coifman, who foresaw so many of the interactions between harmonic analysis and signal processing that we see today.

We are still only at the beginning of Wiener's adventure. The full convergence of mathematics, computing, and ubiquitous signal capture is still in the future. Perhaps future Wiener awardees will, from time to time, contribute in their own way to Wiener's adventure.

References

[1] Norbert Wiener, *Collected Works*, Vols. 1–3, The MIT Press, Cambridge, 1976, 1979, 1981.

[2] ———, *Collected Works,* Vol. 4: Cybernetics, Science, and Society; Ethics, Aesthetics, and Literary Criticism; Book Reviews and Obituaries. The MIT Press, Cambridge, 1985.

[3] Special issue on Norbert Wiener, 1894–1964, *Bull. Amer. Math. Soc.* **72** (1966) no. 1, part 2:1–125.

About the Prize

The Wiener Prize is awarded every three years to recognize outstanding contributions to applied mathematics in the highest and broadest sense (until 2001, the prize was awarded every five years). Established in 1967 in honor of Norbert Wiener (1894–1964), the prize was endowed by the Department of Mathematics of the Massachusetts Institute of Technology. The prize is given jointly by the AMS and the Society for Industrial and Applied Mathematics (SIAM). The recipient must be a member of one of these societies and a resident of the United States, Canada, or Mexico. The prize carries a cash award of US$5,000.

The recipient of the Wiener Prize is chosen by a joint AMS-SIAM selection committee. For the 2010 prize, the members of the selection committee were: James G. Glimm, Ronald Glowinski, and Nancy J. Kopell.

The previous recipients of the Wiener Prize are: Richard E. Bellman (1970), Peter D. Lax (1975), Tosio Kato (1980), Gerald B. Whitham (1980), Clifford S. Gardner (1985), Michael Aizenman (1990), Jerrold E. Marsden (1990), Hermann Flaschka (1995), Ciprian Foias (1995), Alexandre J. Chorin (2000), Arthur T. Winfree (2000), James Sethian (2004), and Craig Tracy and Harold Widom (2007).

2010 Veblen Prize

Tobias H. Colding and William P. Minicozzi and Paul Seidel received the 2010 Oswald Veblen Prize in Geometry at the 116th Annual Meeting of the AMS in San Francisco in January 2010.

Citation

The 2010 Veblen Prize in Geometry is awarded to Tobias H. Colding and William P. Minicozzi II for their profound work on minimal surfaces. In a series of papers, they have developed a structure theory for minimal surfaces with bounded genus in 3-manifolds, which yields a remarkable global picture for an arbitrary minimal surface of bounded genus. This contribution led to the resolution of long-standing conjectures and initiated a wave of new results. Specifically, they are cited for the following joint papers, of which the first four form a series establishing the structure theory for embedded surfaces in 3-manifolds:

"The space of embedded minimal surfaces of fixed genus in a 3-manifold. I. Estimates off the axis for disks", *Ann. of Math.* (2) **160** (2004), no. 1, 27–68.

"The space of embedded minimal surfaces of fixed genus in a 3-manifold. II. Multi- valued graphs in disks", *Ann. of Math.* (2) **160** (2004), no. 1, 69–92.

"The space of embedded minimal surfaces of fixed genus in a 3-manifold. III. Planar domains", *Ann. of Math.* (2) **160** (2004), no. 2, 523–572.

"The space of embedded minimal surfaces of fixed genus in a 3-manifold. IV. Locally simply connected", *Ann. of Math.* (2) **160** (2004), no. 2, 573–615.

"The Calabi-Yau conjectures for embedded surfaces", *Ann. of Math.* (2) **167** (2008), no. 1, 211–243.

In the final paper cited here, the authors show that a complete embedded minimal surface of finite genus is properly embedded, proving the embedded version of the Calabi-Yau conjectures.

Biographical Sketch

Tobias Holck Colding was born in Copenhagen, Denmark, and got his Ph.D. in 1992 at the University of Pennsylvania under Chris Croke. He was on the faculty at the Courant Institute of New York University in various positions from 1992 to 2008 and since 2005 has been a professor at MIT. He was also a visiting professor at MIT from 2000 to 2001 and at Princeton University from 2001 to 2002 and a postdoctoral fellow at MSRI (1993–94). He is the recipient of a Sloan fellowship and has given a 45-minute invited address to the ICM in 1998 in Berlin. He gave an AMS invited address in Philadelphia in 1998 and the 2000 John H. Barrett Memorial Lectures at University of Tennessee. He also gave an invited address at the first AMS-Scandinavian International Meeting in Odense, Denmark, in 2000, and an invited address at the Germany Mathematics Meeting in 2003 in Rostock. He gave the 2008 Mordell Lecture at the University of Cambridge and will give the 2010 Cantrell Lectures at the University of Georgia. Since 2008 he has been a Fellow of the American Academy of Arts and Sciences, since 2006 a foreign member of the Royal Danish Academy of Sciences and Letters, and also since 2006 an honorary professor of the University of Copenhagen.

William P. Minicozzi II was born in Bryn Mawr, Pennsylvania, in 1967. He graduated from Princeton University in 1990 and received his Ph.D. from Stanford University in 1994 under the direction of Richard M. Schoen. After graduating, he spent a year at the Courant Institute of New York University as a visiting member. In 1995 he went to the Johns Hopkins University, where he was the J. J. Sylvester Professor of Mathematics from 2002 until 2007 and is currently a Krieger-Eisenhower Professor in the School of Arts and Sciences.

Minicozzi received a National Science Foundation postdoctoral fellowship in 1995 and an Alfred

Tobias Holck Colding

William P. Minicozzi

Paul Seidel

P. Sloan Foundation Research Fellowship in 1998. He gave an invited address at the 2006 International Congress of Mathematicians in Madrid and a London Mathematical Society Spitalfields Lecture in 2007, and he will give the thirty-fifth University of Arkansas Spring Lecture Series in 2010 and an AMS invited address in Syracuse in 2010. He currently lives in Maryland with his wife, Colleen, and three children, Tim, Nina, and Jason.

Response

From Tobias Holck Colding: I am greatly honored to be named along with Bill and Paul as a recipient of the 2010 Veblen Prize. I am particularly indebted to Bill, who has been an absolute delight to work with on a number of different topics. I would also like to take the opportunity to thank my other collaborators and, in particular, Jeff Cheeger and the Courant Institute and my many friends there where much of the work mentioned here was done.

From William P. Minicozzi: I am greatly honored to be named, along with Toby Colding and Paul Seidel, as a recipient of the Oswald Veblen Prize. Working with Toby has been a great experience, beginning in 1994 at Courant with our work on harmonic functions, continuing on to the work on minimal surfaces cited here, our work on finite time extinction in Ricci flow, and a number of other projects. It is very satisfying to see this work recognized.

I have been lucky to have the support of family and colleagues over the years. I would especially like to thank my wife, Colleen, for her love and support. I am deeply indebted to Toby for his vision for what's important, his contagious enthusiasm for geometry, and his boundless optimism. Finally, I would like to thank my thesis advisor, Rick Schoen, and my Johns Hopkins colleagues, Bernie Shiffman, Chris Sogge, Joel Spruck, and Steve Zelditch, for their support early in my career.

Citation

The 2010 Veblen Prize in Geometry is awarded to Paul Seidel of MIT for his fundamental contributions to symplectic geometry and, in particular, for his development of advanced algebraic methods for computation of symplectic invariants.

Seidel's work also greatly influenced developments in nearby subjects, such as gauge theory and low-dimensional topology. Specifically, the Veblen Prize is awarded for the following work of Seidel:

The paper "A long exact sequence for symplectic Floer cohomology", *Topology* **42** (2003), no. 5, 1003–1063, in which Seidel studied the effect of a symplectic Dehn twist (which he himself had previously defined) on Floer homology.

The book *Fukaya Categories and Picard-Lefschetz Theory*, European Math. Soc. (EMS), Zurich, 2008. In this research monograph Seidel developed new explicit tools for computing the Fukaya category of a symplectic manifold in terms of Picard-Lefschetz theory. These techniques allowed him (in a separate paper) to verify Kontsevich's homological mirror symmetry conjecture in the case of a $K3$ surface, thus providing the first really substantial evidence for this important conjecture.

The paper (joint with I. Smith) "The symplectic topology of Ramanujan's surface", *Comment. Math. Helv.* **80** (2005), no. 4, 859–881. In this paper, the authors give the first examples of exotic symplectic structures on Euclidean space which are convex at infinity.

The paper (joint with K. Fukaya and I. Smith) "Exact Lagrangian submanifolds in simply-connected cotangent bundles", *Invent. Math.* **172** (2008), no. 1, 1–27. In this paper the authors proved a homological version of Arnold's conjecture about the topology of exact Lagrangian submanifolds of a cotangent bundle. (Similar results have been obtained independently by Nadler.)

Biographical Sketch

Paul Seidel was born in Florence, Italy, in 1970. He did his undergraduate studies at the University of Heidelberg with Albrecht Dold and his graduate studies at Oxford University with John Roe and Simon Donaldson. He has held visiting positions at the Institute for Advanced Study, the Max Planck Institut in Bonn, and ETH Zurich. For three years he was *chargé de recherche* at CNRS, affiliated with École Polytechnique. He held faculty positions at Imperial College London and at the University of Chicago. His current position is professor of mathematics at MIT. He has received a European Mathematical Society Prize (2000). In 2002 he was selected as a speaker for the International Congress of Mathematicians. He is married to another mathematician, Ju-Lee Kim, and they have one daughter (Ilaria).

Response

It's an honor to be selected as one of the recipients of the Veblen Prize. I'd like to interpret this more broadly as a sign of appreciation for the part of mathematics that I've been working in, which is the study of symplectic topology using cohomological methods. This approach is possible thanks to breakthroughs made in the 1980s and early 1990s. I have no firsthand experience, but I think the pioneers who made those breakthroughs must have had a very hard time of it. We remain indebted to them for creating such a wonderful intellectual space for us to work and play in. I won't try to list them since the boundaries of the area are somewhat fuzzy and perceived influences can be very subjective. Personally, I learned many ideas from listening to Donaldson and Kontsevich, from collaborators (Khovanov, Thomas, Smith, Fukaya, Abouzaid, and Maydanskiy), or simply from people who walked into my office some day. By the way, if you've ever tried to explain an interesting piece of mathematics to me and found that I wasn't receptive to it, I hereby apologize to you! I know I have unfortunately missed some real opportunities in that way.

Looking ahead, I think the field is in good shape, as the tools provided to us by pseudoholomorphic curve theory are being systematically explored. Here are some current developments which I find encouraging (without necessarily being directly involved in them). First, the long-standing idea of using handle decompositions to understand the symplectic topology of Stein manifolds is becoming increasingly effective. In another direction, for closed symplectic manifolds which contain large families of pseudo-holomorphic spheres such as toric varieties, we are gradually getting a picture of how their symplectic geometry decomposes into simpler pieces. Next, there is a historically close connection with low-dimensional topology, which continues to pay off. Finally, our techniques have matured to the point where they can fruitfully interact with more distant areas. Through such interactions (and guided by ideas from mirror symmetry, in many cases), concepts from algebraic geometry and representation theory have become applicable in new ways. Still, right now there remains a hard nucleus of questions about symplectic structures on closed higher-dimensional manifolds, which has only barely been touched. I look forward to the moment when further development of the existing methods, or a completely new idea, will allow us to penetrate more deeply.

About the Prize

The Veblen Prize is awarded every three years for a notable research memoir in geometry or topology that has appeared during the previous five years in a recognized North American journal (until 2001 the prize was usually awarded every five years). Established in 1964, the prize honors the memory of Oswald Veblen (1880–1960), who served as president of the AMS during 1923–1924. It carries a cash award of US$5,000.

The Veblen Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2010 prize, the members of the selection committee were: Yakov Eliashberg, Bruce A. Kleiner, and Peter S. Ozsvath.

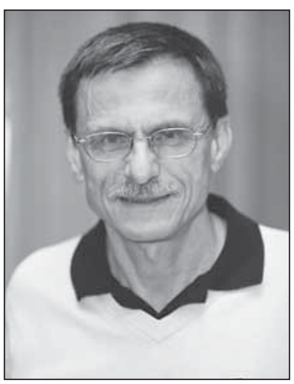
Previous recipients of the Veblen Prize are: Christos D. Papakyriakopoulos (1964); Raoul H. Bott (1964); Stephen Smale (1966); Morton Brown and Barry Mazur (1966); Robion C. Kirby (1971); Dennis P. Sullivan (1971); William P. Thurston (1976); James Simons (1976); Mikhael Gromov (1981); Shing-Tung Yau (1981); Michael H. Freedman (1986); Andrew Casson (1991); Clifford H. Taubes (1991); Richard Hamilton (1996); Gang Tian (1996); Jeff Cheeger (2001); Yakov Eliashberg (2001); Michael J. Hopkins (2001); David Gabai (2004); Peter Kronheimer, Tomasz Mrowka, Peter Ozsváth, Zoltán Szabó (2007).

2010 E. H. Moore Prize

Sorin Popa received the 2010 E. H. Moore Research Article Prize at the 116th Annual Meeting of the AMS in San Francisco in January 2010.

Citation

The E. H. Moore Research Prize for 2010 is awarded to Professor Sorin Popa of UCLA for his article "On the superrigidity of malleable actions with spectral gap", *J. Amer. Math. Soc.* **21** (2008), no. 4, 981–1000. This article represents a major breakthrough in the author's remarkable program concerning von Neumann rigidity, orbit equivalence, and strong rigidity of ergodic measure preserving actions of countable groups. In the article, Popa uncovers a substitute for Kazhdan's property (T) hypothesis that appeared to be crucial in previous work on the subject by Connes, Popa, and others. The new condition, which involves spectral gaps, allows one to address a surprisingly general class of groups.



Sorin Popa

Popa's article also presents several applications of the new techniques to this large class of groups. For example, a superrigidity result in the case of Bernoulli actions shows that orbit equivalence implies conjugacy; this means that such groups are determined by the orbits of their Bernoulli actions. As a consequence, a large class of groups admit uncountably many nonorbit equivalent ergodic actions. The author proves a strong von Neumann rigidity theorem that shows that every isomorphism between the group measure space factors associated with free ergodic measure-preserving actions of such groups arises from a conjugacy of actions. This is in sharp contrast to the case of an amenable group, in which all ergodic measure-preserving actions are orbit equivalent and share the same group measure space factor.

Experts in the field remarked that before Popa's work, "such results were inconceivable in von Neumann algebras" and that "even recognizing some properties of the groups from the isomorphism of their group measure space algebras was notoriously hard". They further indicated that "a unique tensor product decomposition result in the setting of type II factor von Neumann algebras answers a thirty-five year old problem of Alain Connes" and said that Popa's work has "completely changed the landscape of operator algebras".

Biographical Sketch

Sorin Popa received his Ph.D. in 1983 from the University of Bucharest, Romania, with Dan Voiculescu as his adviser. From 1978 to 1987 he was a researcher in the mathematics department of INCREST in Bucharest. After spending a year as a visiting professor at UCLA, he assumed his present position of professor of mathematics in 1988. Popa also held a professorship at the University of Geneva from 1996 to 1998. He was a visiting professor at IHES (1991–1992), the Université de Paris 7 (1996), CNRS, and College de France (2004), and he was a frequent visitor at the University of Rome II and Odense University. Popa was an invited speaker at ICM 1990 in Kyoto and a plenary speaker at ICM 2006 in Madrid. He has received a number of awards, including a Guggenheim Fellowship (1995) and, most recently, the 2009 Ostrowski Prize. He is a coeditor of the *Pacific Journal of Mathematics* and serves on the editorial board of the *Journal of the AMS* and the *Journal of Operator Theory*. Popa's area of interest is functional analysis and operator algebras (von Neumann and C*-algebras) and the aspects of group theory and ergodic theory that pertain to operator algebras.

Response

I am deeply honored and elated to receive the E. H. Moore Research Article Prize. This honor adds to the extreme satisfaction I had when I actually obtained the results back in 2006. The article came after years of intense work and several previous papers in which I developed some new techniques for proving rigidity results in orbit equivalence relations and von Neumann algebras (II_1 factors) arising from measure-preserving actions of countable groups on probability spaces. The techniques required a deformability assumption on the algebras involved, such as *malleability*, a property that Bernoulli actions have. They also seemed to depend crucially on assuming some version of property (T), a fact that drastically limited the applications. The cited paper removed this latter assumption completely, merely using spectral gap rigidity, a property which is often automatically satisfied. This allowed many surprising applications, including a *cocycle superrigidity* result with arbitrary targets for Bernoulli actions of nonamenable product groups, and a result showing that any isomorphism of II_1 factors arising from such group actions comes from a conjugacy of the actions. Further striking applications of these ideas and techniques were obtained since then in my separate joint work with Narutaka Ozawa and Stefaan Vaes, respectively; and in subsequent work by Ionut Chifan, Cyril Houdayer, Adrian Ioana, and Jesse Peterson. I am grateful to them all for the fresh insight and creativity they brought to this direction of research.

About the Prize

The Moore Prize is awarded every three years for an outstanding research article that appeared in one of the primary AMS research journals: *Journal of the AMS, Proceedings of the AMS, Transactions of the AMS, AMS Memoirs, Mathematics of Computation, Electronic Journal of Conformal Geometry and Dynamics*, or *Electronic Journal of Representation Theory*. The article must have appeared during the six calendar years ending a full year before the meeting at which the prize is awarded. The prize carries a cash award of US$5,000.

The prize honors the extensive contributions of E. H. Moore (1862–1932) to the AMS. Moore founded the Chicago section of the AMS, served as the Society's sixth president (1901–1902), delivered the Colloquium Lectures in 1906, and founded and nurtured the *Transactions of the AMS*.

The Moore Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2010 prize, the members of the selection committee were: Carolyn S. Gordon (chair), Sergiu Klainerman, Kenneth A. Ribet, Richard M. Schoen, and Efim I. Zelmanov.

The previous recipients of the Moore Prize are Mark Haiman (2004) and Ivan Shestakov and Ualbai Umirbaev (2007).

About the Cover *(continued from page 516)*

continue on beyond its laminar separation point. From p. 146 of Shapiro's book: "The question is whether this assisting viscous force applied by the outside flow is sufficiently large to counterbalance opposing forces due to friction at the wall and to the increase of pressure from nose to tail."

This explanation does not lead to precise predictions. Applying the Navier-Stokes equations in turbulence is notoriously difficult because the range of relevant scales is so large. The problem of explicitly simulating what happens on a computer is daunting, and it is only recently that anyone has claimed seriously to be able to do it—take a look at the *New York Times* article `http://www.nytimes.com/2008/11/30/sports/golf/30score.html`. A fascinating video illustrating the simulation made by the team referred to there can be found at `http://ecommons.library.cornell.edu/handle/1813/11586`. Technical details are given in the paper "Numerical investigation of the flow over a golf ball in the subcritical and supercritical regimes" by Clinton Smith et al., to appear later this year in the *International Journal of Heat and Fluid Flow*. One motivation for practical computation is that the golf ball is a relatively simple example of a ubiquitous phenomenon. But it is also true that golf is an enormously popular game, and anything promising to improve one's game is eagerly investigated.

It would be nice to have a qualitative account somewhere in between Shapiro's explanation and the detailed computation.

On the cover of this issue, it is apparent that until recently the placing of dimples was relatively simple, usually around latitudes on the ball. (The old balls possessed a natural equator since they were constructed by joining two separate halves.) But modern golf balls, such as the Callaway at lower right, are more sophisticated, placing dimples (in the image, mostly hexagonal ones) in accord with icosahedral symmetry. You can perceive this by locating the small pentagons on this ball in a field of hexagons. The symmetry of these patterns is discussed by Ian Stewart in the 1997 *Scientific American* article referenced by Doug Arnold.

We wish to thank Michael Riste of the BC Golf Museum in Vancouver for allowing us to photograph the museum's collection of golf balls; Jane Hooper Perroud of the Calloway Golf Company for granting permission to display the Calloway ball; and Kyle Squires, one of Clinton Smith's collaborators, for responding to our queries.

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

2010 Robbins Prize

Ileana Streinu received the David P. Robbins Prize at the 116th Annual Meeting of the AMS in San Francisco in January 2010.

Citation

The 2010 David P. Robbins Prize is awarded to Ileana Streinu of Smith College for her paper "Pseudo-triangulations, rigidity and motion planning", *Discrete Comput. Geom.* **34** (2005), no. 4, 587–635.

Ileana Streinu

In this remarkable work Streinu gives a combinatorial, algorithmic proof of the notorious "carpenter's rule problem", which asks whether any polygonal chain in the plane can be continuously straightened out. In such a process the edges are taken as rigid, but the vertices are joints; of course, no crossings are allowed at any time.

Streinu's proof is independent of, and quite different from, the earlier published differential proof of R. Connelly, E. D. Demaine, and G. Rote ("Straightening polygonal arcs and convexifying polygonal cycles", *Discrete Comput. Geom.* **30** (2003), no. 2, 205–239). This deservedly celebrated paper and Streinu's paper both do, however, arise in part from the idea of Rote's that a polygon could be convexified by motions which cause points on the perimeter to move away from one another.

The idea for Streinu's proof came from her careful examination of computer experiments in which the basic feasible solutions to convexification problems were coded as graphs. Further experimentation (using Mathematica®) allowed Streinu to identify patterns in these graphs and eventually to connect them with pseudo-triangulations and ideas from rigidity theory. The ultimate result was an explicit, efficient, and discrete algorithm for the carpenter's rule problem and a beautiful and highly original paper.

Biographical Sketch

Ileana Streinu received a Ph.D. in computer science from Rutgers University and a doctorate in mathematics from the University of Bucharest, Romania, both in 1994. Since then, she has taught at Smith College in Massachusetts, where she is the Charles N. Clark Professor of Computer Science and Mathematics, and at the University of Massachusetts, Amherst, where she holds a 2008–2011 Five Colleges 40th Anniversary Professor appointment. She had visiting positions at the Technical University in Berlin, Ecole Normale Supérieure in Paris, Stanford University, Kyoto University, LORIA Nancy, and Universitat Politecnica de Catalunya in Barcelona, and she is a recipient of the 2004 Moisil Award of the Romanian Academy in theoretical computer science.

Streinu's mathematical interests include discrete and computational geometry, rigidity theory, kinematics, matroids, and graph theory. Her recent work extends in multidisciplinary directions, ranging from robotics and origami to the emerging fields of bio- and nanogeometry, in which she is pursuing mathematical questions arising in studies of flexibility, rigidity, and motions for macromolecules.

Response

It is a great honor to receive the Robbins Prize acknowledging my algorithmic solution to the carpenter's rule problem.

Through its simple statement, the problem exercised a fascination on all who encountered it. I learned about it from Sue Whitesides, who brought it up at a problem-solving workshop she organized in 1998. When, in 1999, at a Discrete Geometry meeting in Switzerland, Günter Rote proposed the use of expansive motions, he also suggested a proof plan that contained most of the ingredients of what was to become the celebrated Connelly, Demaine, and Rote proof of the carpenter's rule theorem. This connection with rigidity theory and Maxwell's theory of lifted polyhedra marked a turning point in my research interests. I am grateful to all the colleagues who worked on this problem for the inspiration and the challenges they generated, which caused me to look deeper and in different directions. The emergence of pseudo-triangulations, with their clean combinatorics and unexpected rigidity properties, was a rewarding surprise. I am convinced that so much more about them, and their three-dimensional relatives, still remains to be discovered.

I am deeply grateful to the selection committee and the AMS for having awarded me this distinction, and to my family, friends, and collaborators (especially to Ciprian S. Borcea, who is all of these) for their support.

Funding by NSF and by DARPA's "Mathematical Challenges", generous support from Smith College and UMass Amherst, and sabbatical visiting positions have enabled periods of extended, uninterrupted "thinking time" that are so important for any mathematical work.

About the Prize

The Robbins Prize was established in 2005 in memory of David P. Robbins by members of his family. Robbins, who died in 2003, received his Ph.D. in 1970 from the Massachusetts Institute of Technology. He was a long-time member of the Institute for Defense Analysis Center for Communications Research and a prolific mathematician whose work (much of it classified) was in discrete mathematics.

The prize is given for a paper that (1) reports on novel research in algebra, combinatorics, or discrete mathematics, (2) has a significant experimental component, (3) is on a topic broadly accessible, and (4) provides a simple statement of the problem and clear exposition of the work. The US$5,000 prize is awarded every three years.

The Robbins Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2010 prize, the members of the selection committee were: Louis J. Billera, Carol E. Fan, David J. Saltman, John R. Stembridge, and Peter M. Winkler (chair).

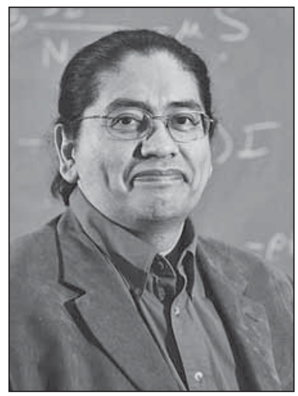
The previous recipients of the Robbins Prize are Samuel Ferguson and Thomas C. Hales (2007).

2010 Award for Distinguished Public Service

Carlos Castillo-Chavez received the 2010 Award for Distinguished Public Service at the 116th Annual Meeting of the AMS in San Francisco in January 2010.

Citation

Carlos Castillo-Chavez is a Joaquin Bustoz Jr. Professor of Mathematical Biology and a Regents Professor at Arizona State University. At Arizona State he is the director of the Ph.D. program in applied mathematics in the life and social sciences, executive director of the Arizona State Mathematical, Computational and Modeling Sciences Center, and director of the Institute for Strengthening Understanding of Mathematics and Science (SUMS). The Sciences Center strives to create a dynamic community of quantitative scientists and mathematicians driven to contribute to the solution of problems in the biological, environmental, and social sciences. The SUMS mathematics and science honors program has trained over 2,000 Arizona high school students from economically disadvantaged backgrounds over the past twenty-four years. He is also the founder and director of the Mathematical and Theoretical Biology Institute. This summer program provides sequential research experiences, at the undergraduate and graduate levels, in the field of applied mathematics and its applications to the biological and social sciences for disadvantaged students from across the country. Castillo-Chavez has had a major impact with his efforts and activities in improving the representation in the broad mathematical sciences of the nation's traditionally underrepresented and economically disadvantaged students. He continues his activities in research and education at a very high level and is a most worthy recipient of the AMS Distinguished Public Service Award.



Carlos Castillo-Chavez

Biographical Sketch

Carlos Castillo-Chavez is a Regents Professor and a Joaquin Bustoz Jr. Professor at Arizona State University. Castillo-Chavez's research program is carried out at the interface of the mathematical and natural and social sciences. His research has focused on the role of adaptive social landscapes on disease dynamics and its evolution. Castillo-Chavez and other collaborators' contributions are tied into the study of questions of interest in fields of ecology, epidemiology, evolutionary biology, and homeland security. Their research highlights the relevance and criticality of computational, mathematical, modeling, and statistical approaches in the study of the dynamics and control of addiction, childhood diseases, dengue, foot and mouth disease, HIV, influenza, and tuberculosis at the population level. Their research has also contributed to the study of cross-immunity in the context of influenza and behavior dispersal, and movement on disease evolution.

Carlos Castillo-Chavez has coauthored nearly 200 publications, including the 2001 textbook *Mathematical Models in Population Biology and Epidemiology*. His edited volume (with Tom Banks) on the use of mathematical models in homeland security, published in SIAM's Frontiers in Applied Mathematics series (2003), provided the first collection of mathematical studies on bioterrorism. The volumes *Mathematical and Statistical Approaches to AIDS Epidemiology* (Springer, 1989), *Mathematical Approaches for Emerging and*

Reemerging Infectious Diseases (An Introduction and Models, Methods, and Theory), Mathematical Studies on Human Disease Dynamics: Emerging Paradigms and Challenges (American Mathematical Society, 2006), and *Mathematical and Statistical Estimation Approaches in Epidemiology* (Springer-Verlag, 2009) highlight some of his interests in the applications of mathematics to the study of emerging and reemerging diseases.

Castillo-Chavez is an external faculty member at the Santa Fe Institute and an adjunct professor at Cornell University. Castillo-Chavez joined Cornell's faculty in 1988, was promoted to associate professor in 1991, and to full professor in 1997. He joined Arizona State University's faculty in 2004. Castillo-Chavez is the founding director of the Mathematical, Computational and Modeling Sciences Center, the graduate field in applied mathematics in the life and social sciences, the executive director of the Mathematical and Theoretical Biology Institute (MTBI) and the Institute for Strengthening the Understanding of Mathematics and Science (SUMS), all at ASU. These institutes provide sequential intense summer experiences from high school to the postdoctoral level. These experiences are aimed at students from economically disadvantaged groups with the goal of increasing their number in the mathematical sciences. SUMS's efforts were recognized with a Presidential Mentorship Award in 2002, and the American Mathematical Society recognized MTBI's program as a "Mathematics Program That Makes a Difference" in 2007.

Castillo-Chavez's efforts to promote diversity in the mathematical sciences at Cornell University culminated in the establishment of the David Blackwell and Richard Tapia Distinguished Lecture Series in 2000, an event that soon was transformed into the David Blackwell and Richard Tapia Award, thanks to the additional efforts of David Eisenbud.

Castillo-Chavez is the recipient of several awards, including a Presidential Faculty Fellowship Award (1992); a Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring (1997); the 2002 Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) Distinguished Scientist Award; the 2003 Richard Tapia Award; and the 2007 AAAS Mentor Award. He held the position of Stanislaw M. Ulam Distinguished Scholar at Los Alamos National Laboratory (CNLS) in 2003; was named honorary professor by China's Xi'an Jiaotong University (2004); and became a fellow of the American Association for the Advancement of Science (AAAS) in 2007.

Castillo-Chavez received his B.S., M.S., and Ph.D. degrees from the University of Wisconsin at Stevens Point (1974), Milwaukee (1977), and Madison (1984), respectively. Fred Brauer and Simon Levin were, respectively, his Ph.D. and postdoctoral advisors. Both of them continue to be his mentors. Castillo-Chavez has advised seventeen Ph.D. students, including seven U.S. underrepresented minorities (US-URM) and six women. He has served as the mentor of seventeen postdoctoral students, a group that includes two US-URM and five women. He has cosupervised twenty-four master's degree students and mentored dozens of undergraduates each summer since 1996.

As a member of the steering committee of the Committee for the Review of the Evaluation Data on the Effectiveness of NSF-Supported and Commercially Generated Mathematics Curriculum Materials, Castillo-Chavez was a coauthor and contributor to the corresponding NRC report from 2002–2004. He was a member of the Arizona Governor's P–20 Council's Mathematics Alignment Team in 2008–2009. He is currently a member of the scientific mathematical sciences advisory boards at the National Institute for Mathematical and Biological Synthesis (NIMBioS), at the Statistical and Applied Mathematics Sciences Institute (SAMSI), and at the Banff International Research Station (BIRS). In addition, he chairs or cochairs diversity advisory boards at the Mathematical Biosciences Institute (MBI) and at the Society for Industrial and Applied Mathematics (SIAM). He is a member of the National Research Council's Board of Higher Education and Workforce (BHEW).

Castillo-Chavez, a native of Mexico, immigrated in 1974 and is the proud father of a Chicano (Carlos William) and two Chicanas (Gabriela Citlalli and Melissa Ann). Carlos William is about to complete a Ph.D. in mathematics education at Arizona State University under the supervision of Pat Thompson; Melissa is on her way to earning a master's degree in creative writing at Fordham University; and Gabriela is enamored of her sixth-grade mathematics and science classes, volleyball, Shakespeare, and music. His wife, Nohora, a native of Colombia, recently completed a B.S. in mathematics education while raising Gabriela. She plans to join the profession of junior high school mathematics teachers. The Castillo-Chavez children speak Spanish and are infinitely proud of their American, Mexican, and Colombian heritages.

Response

When it comes down to public service, perhaps Martin Luther King said it best: "Life's most urgent question is: what are you doing for others?" I am profoundly moved by the AMS's decision to recognize my epsilon contributions to the mathematical sciences and some of its communities with the 2010 Distinguished Public Service Award. The importance that the AMS places on public service, as demonstrated by the establishment of this award two decades ago, resonates even more in this time of crisis. The importance of providing opportunities and multiple successful pathways to all U.S. aspiring mathematicians must be continuously carried out, not only to preserve the intellectual capacity that we have but also to broaden and enrich the mathematical community through the systematic inclusion in the wonderful and empowering world of mathematics of Americans who have been traditionally underrepresented.

I became a member of the profession twenty-five years ago after completing a Ph.D. in mathematics under the supervision of Fred Brauer at the University of Wisconsin–Madison. My life in Mexico, a country that I left thirty-five years ago, made me intensely aware of the role of initial conditions in a world full of inequities. Finding ways of combining my love of mathematics, my mathematical training, and my deep desire to increase the opportunities for minorities by reducing the impact of initial conditions has driven my decisions ever since.

The near absence of U.S. minority students in the mathematical sciences is the result perhaps of preconceived notions of who can do mathematics, or the lack of systemic access of these students to advanced mathematics training at the elementary, middle, or high school levels and the pressures of giving back to our communities as soon as possible. The successes of Jaime Escalante at Garfield High School in East Los Angeles (immortalized by the movie *Stand and Deliver*) and the victory of Carl Hayden's Robotics High School Team over MIT in the third annual Marine Advanced Technology Education Center's Remotely Operated Vehicle Competition in 2004 are not miracles but clear evidence of the untapped and immense potential at each and every public and private school in the land. Why do we lose so many?

The Mathematical and Theoretical Biology Institute's (MTBI) summer program encourages students to self-organize into small groups around problems identified as important and relevant by the group members. Soon one finds students working on ways of ameliorating the global impact of HIV or exploring the role that poverty has on the transmission dynamics of tuberculosis. Four Latinas just about to start their senior year in college chose to investigate the role of peer pressure on the dynamics of bulimia in 2001. As a result, the first paper on dynamics of bulimia at the population level was coauthored by them in 2003 (*Journal of Mathematical Psychology* **47** (2003), 515–526). Two of these students/authors completed their Ph.D.s, a third will earn her Ph.D. in May while raising her three children (a group that includes twins), and the fourth has started a Ph.D. in biostatistics.

The citation that comes with this recognition implicitly acknowledges the contributions of a large number of individuals. William Yslas Velez (University of Arizona) instigated the start of this effort through his letter to the AMS on 24 August 1994 on NSA's policy. The program was put in place with the support of Jim Schatz (NSA), Barbara Deuink (NSA), Don M. Randel (now at the Andrew W. Mellon Foundation), Ted Greenwood (Alfred P. Sloan Foundation), and the National Science Foundation. Countless mathematicians have come to Ithaca or Tempe ready to spend up to eight weeks collaborating with undergraduates on the challenging questions posed by them. Shirley Eva Sanchez, while an undergraduate, asked "What is the impact of alcohol on the brain?" She will soon complete a Ph.D. at the interface of the neurosciences and mathematics. Fred Brauer, Tom Banks, Erika Camacho, Christopher Kribs-Zaleta, Baojun Song, Steve Tennenbaum, and Steve Wirkus have been involved in this program for over a decade. My current research collaborators, former graduate students, and postdocs have always played a central role in comentoring the more than 400 students who have participated in MTBI. Carlos Bustamante, Richard Durrett, Richard Rand, Steve Strogatz, and Roald Hoffmann supported these efforts summer after summer at Cornell. Marilyn Carlson, Sharon Crook, Gerardo Chowell, Marco Janssen, Nicolas Lanchier, Yang Kuang, Alex Mahalov, Svetlana Roudenko, Sergei Suslov, and Pat Thompson have played the equivalent role at ASU. Over 2,200 high school students have been trained during the past twenty-four summers at the Mathematics Science Honors Program, Joaquin Bustoz Jr.'s baby. Joaquin recruited me with the expectation that together we would make an even bigger impact. Unfortunately, he died tragically in a car accident four months before my arrival.

My deans, director Sander van der Leeuw, provost Elizabeth Capaldi, former provost Milton Glick, and president Michael M. Crow have always supported these efforts. The Mathematical, Computational and Modeling Sciences' staff runs these programs year after year facing myriad challenges that somehow get resolved. I thank them all. The mentorship I received and continue to receive from my former academic advisers, Fred Brauer and Simon Levin, has made all the difference in the world.

Meeting President Michael Crow's challenge of providing an excellent education within an environment of inclusion at a scale that is commensurate with the goals and mission of state institutions is essential if we are to meet the workforce challenges of the twenty-first century. The model of the New American University put forward by ASU's President Crow sets the intellectual framework and vision needed to scale up the learning-through-research model developed, implemented, and tested at Cornell University. Our Center's version, through its Mathematics Science Honors Program, integrates a model of mentorship from high school to the postdoctoral level.

My son Carlos William has contributed to the success of these programs for nearly a decade with his computing, modeling, and intellectual skills, and he has helped articulate the program successes via articles that we coauthored. My daughter Melissa participated in the program and, as a journalism major, coauthored two applied mathematics papers, including a highly cited paper on SARS that appeared in the *Journal of Theoretical Biology* **224** (2003), 1–8. My wife Nohora and daughter Gabriela have accepted and cherished these efforts even though they have limited our family time and made it nearly impossible to take vacations. Special thanks to Nohora, Carlos, Melissa, and Gabi for their support of my efforts, which I hope have made a contribution not only to mathematics but also to the growth of the students-researchers-citizens involved in this program. I want to reiterate my gratitude to the American Mathematical Society not only for this recognition but also for establishing an award that goes to the heart of Dr. King's question. I hope that my work has indeed helped others.

About the Award

The Award for Distinguished Public Service is presented every two years to a research mathematician who has made a distinguished contribution to the mathematics profession during the preceding five years. The purpose of the award is to encourage and recognize those individuals who contribute their time to public service activities in support of mathematics. The award carries a cash prize of US$4,000.

The Award for Distinguished Public Service is made by the AMS Council, acting on the recommendation of a selection committee. For the 2010 award, the members of the selection committee were: Richard A. Askey, C. H. Clemens, Carolyn R. Mahoney, Paul J. Sally, and Richard A. Tapia.

Previous recipients of the award are: Kenneth M. Hoffman (1990), Harvey B. Keynes (1992), I. M. Singer (1993), D. J. Lewis (1995), Kenneth C. Millett (1998), Paul J. Sally Jr. (2000), Margaret H. Wright (2002), Richard Tapia (2004), Roger Howe (2006), and Herbert Clemens (2008).

Mathematics People

Slade Receives CRM-Fields-PIMS Prize

Gordon Slade of the University of British Columbia has been awarded the 2010 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$9,500) and an invitation to give a lecture at each institute.

According to the prize citation, Slade was honored for "his outstanding work in rigorous statistical mechanics and probability. He is renowned for developing a technique known as the lace expansion into a systematic calculus, which he has applied to diverse and famous problems, including self-avoiding walk, percolation, branched polymers, random graphs, and numerical techniques for the exact enumeration of self-avoiding walks. His results address some of the most difficult problems in central areas of probability and statistical physics. These are questions motivated by physical problems which are easy to state (what is the average length of an n-step self-avoiding walk?) but notoriously difficult to solve."

Slade received his undergraduate degree from the University of Toronto in 1977 and his Ph.D. from the University of British Columbia in 1984. He has been a leader in Canadian mathematics. He was an organizer of the 1998–1999 thematic year in probability and its applications at the Fields Institute and coorganizer of the recent CRM-PIMS Program Challenges and Perspectives in Probability (2008–2009). He has served on scientific panels of the Fields Institute and PIMS and is currently a member of the editorial board of the *Canadian Journal of Mathematics*. He was invited to the 1994 International Congress of Mathematicians and gave an invited lecture in 2004 at the St. Flour Summer School.

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, Joel S. Feldman, Allan Borodin, and Martin Barlow.

—From a Fields Institute announcement

PECASE Awards Announced

Four mathematical scientists are among more than one hundred young researchers to receive 2009 Presidential Early Career Awards for Scientists and Engineers (PECASE). Scott Sheffield of the Massachusetts Institute of Technology was nominated by the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF). Justin K. Romberg of the Georgia Institute of Technology, Joel A. Tropp of the California Institute of Technology, and Patrick J. Wolfe of Harvard University were nominated by the Department of Defense (DOD).

The recipients were selected from nominations made by nine participating federal agencies. Each awardee receives a five-year grant to further his or her research and educational efforts.

—Elaine Kehoe

Packard Fellowships Awarded

Three researchers whose work involves the mathematical sciences have been awarded Fellowships for Science and Engineering from the David and Lucile Packard Foundation for 2009. Seth Sullivant of North Carolina State University will use the fellowship "to introduce tools from algebraic geometry, combinatorics, and symbolic computation to address fundamentally discrete problems in evolutionary biology, causal inference, and disclosure limitation." Joshua Plotkin of the University of Pennsylvania works in evolutionary biology and will use the fellowship "to develop realistic mathematical models and to use them to quantify the forces that shape genetic variation in nature." Justin Romberg of the Georgia Institute of Technology works in electrical and computer engineering and will use the fellowship award "to develop theory, algorithms, and hardware for next-generation acquisition systems by exploiting underlying signal structures."

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

Lupercio Awarded ICTP/IMU Ramanujan Prize

Ernesto Lupercio, a researcher at the Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV) in Mexico, has been awarded the 2009 ICTP/IMU Ramanujan Prize "for his outstanding contributions to algebraic topology, geometry and mathematical physics." According to the prize citation, "he is an expert in the theory of orbifolds (spaces with singularities arising from finite symmetric groups). He has fundamental results on K-theory, gerbes, and Chas-Sullivan type string topology operations." He was also honored for his contributions to mathematics in Mexico "through his energy, enthusiasm, and collaborations with young researchers."

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

—From an ICTP announcement

AAAS Fellows Elected

Nine mathematicians have been elected as new fellows to the Section on Mathematics of the American Association for the Advancement of Science (AAAS). In addition, one researcher whose work involves the mathematical sciences has been elected to the Section on Information, Computing, and Communication. The new fellows in the Section on Mathematics are: Bjorn Birnir, University of California, Santa Barbara; Sylvia Trimble Bozeman, Spelman College; Alfred Hales, Institute for Defense Analyses; Suzanne Lenhart, University of Tennessee, Knoxville; Jeffery D. McNeal, Ohio State University; Robert E. Megginson, University of Michigan; Juan C. Meza, Lawrence Berkeley National Laboratory; Philippe Tondeur, University of Illinois, Urbana-Champaign; and Alan Tucker, State University of New York, Stony Brook. Elected to the Section on Information, Computing, and Communication was Narsingh Deo, University of Central Florida.

—From an AAAS announcement

Mathematics Opportunities

DMS Workforce Program in the Mathematical Sciences

The Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) welcomes proposals for the Workforce Program in the Mathematical Sciences. The long-range goal of the program is increasing the number of well-prepared U.S. citizens, nationals, and permanent residents who successfully pursue careers in the mathematical sciences and in other NSF-supported disciplines. Of primary interest are activities centered on education that broaden participation in the mathematical sciences through research involvement for trainees at the undergraduate through postdoctoral educational levels. The program is particularly interested in activities that improve recruitment and retention, educational breadth, and professional development.

The submission period for unsolicited proposals is **May 15–June 15, 2010**. For more information and a list of cognizant program directors, see the website `http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503233`.

—From a DSM announcement

Call for Proposals for 2011 NSF-CBMS Regional Conferences

To stimulate interest and activity in mathematical research, the National Science Foundation (NSF) intends to support up to seven NSF-CBMS Regional Research Conferences in 2011. A panel chosen by the Conference Board of the Mathematical Sciences will make the selections from among the submitted proposals.

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

Support is provided for about thirty participants at each conference, and both established researchers and interested newcomers, including postdoctoral fellows and graduate students, are invited to attend. The proposal due date is **April 23, 2010.** For further information on submitting a proposal, consult the CBMS website, `http://www.cbmsweb.org/NSF/2011_call.htm`, or contact: Conference Board of the Mathematical Sciences, 1529 Eighteenth Street, NW, Washington, DC 20036; telephone: 202-293-1170; fax: 202-293-3412; email: `lkolbe@maa.org` or `rosier@georgetown.edu`.

—From a CBMS announcement

NSF-CBMS Regional Conferences, 2010

With funding from the National Science Foundation (NSF), the Conference Board of the Mathematical Sciences (CBMS) will hold six NSF-CBMS Regional Research Conferences during the summer of 2010. These conferences are intended to stimulate interest and activity in mathematical research. Each five-day conference features a distinguished lecturer who delivers ten lectures on a topic of important current research in one sharply focused area of the mathematical sciences. The lecturer subsequently prepares an expository monograph based on these lectures. Support for about thirty participants will be provided for each conference. Both established researchers and interested newcomers, including postdoctoral fellows and graduate students, are invited to attend.

Information about an individual conference may be obtained by contacting the conference organizer. The conferences to be held in 2010 are as follows.

May 17–21, 2010: The Mathematics of Diffusions. Wei-Ming Ni, lecturer. Tulane University. Organizer: Xuefeng Wang, 504-862-3451, xdw@math.tulane.edu; conference website: math.tulane.edu/~xdw/cbms/cbms.html.

May 17–21, 2010: Nonlinear Water Waves with Applications to Wave-Current Interactions and Tsunamis. Adrian Constantin, lecturer. University of Texas, Pan American. Organizers: Lokenath Debnath, 956-381-3459, debnathl@utpa.edu; and Andras Balogh, 956-381-2119, abalogh@utpa.edu; conference website: www.math.utpa.edu/cbms2010.html.

May 25–29, 2010: Quiver Varieties and Crystal Bases of Quantum Affine Algebras. Hiraku Nakajima, lecturer. North Carolina State University. Organizer: Naihuan Jing, 919-513-3584, jing@unity.ncsu.edu; conference website: http://www4.ncsu.edu/~jing/conf/CBMS/cbms10.html.

July 12–16, 2010: The Mutually Beneficial Relationship of Matrices and Graphs. Richard Brualdi, lecturer. Iowa State University. Organizers: Leslie Hogben, 515-451-1505, lhogben@iastate.edu; and Bryan L. Shader, 307-766-6826, bshader@uwyo.edu; conference website: http://orion.math.iastate.edu/lhogben/CBMS/.

August 9–13, 2010: Recent Advances in the Numerical Approximation of Stochastic Partial Differential Equations. Peter E. Kloeden, lecturer. Illinois Institute of Technology. Organizers: Jinqiao Duan, 312-567-5335, duan@iit.edu; Igor Cialenco, 312-567-3131, igor@math.iit.edu; and Fred J. Hickernell, 312-567-8983, fred@math.iit.edu; conference website: http://mypages.iit.edu/~duan/SPDE2010.html.

August 16–20, 2010: Bayesian Nonparametric Statistical Methods: Theory and Applications. Peter Müller, lecturer. University of California Santa Cruz. Organizers: Abel Rodriguez, 831-459-5278, abel@ams.ucsc.edu; and Athanasios Kottas, 831-459-5536, thanos@ams.ucsc.edu; conference website: www.ams.ucsc.edu/CBMS-NPBayes.

—From a CBMS announcement

NSF Integrative Graduate Education and Research Training

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

The preliminary proposal deadline for the 2010 IGERT competition is **March 29, 2010.** The deadline for full proposals is **September 30, 2010;** full proposals may be sent by invitation only. Further information may be found at the website http://www.nsf.gov/pubs/2010/nsf10523/nsf10523.htm?WT.mc_id=USNSF_25.

—From an NSF announcement

Project NExT: New Experiences in Teaching

Project NExT (New Experiences in Teaching) is a professional development program for new and recent Ph.D.'s in the mathematical sciences (including pure and applied mathematics, statistics, operations research, and mathematics education). It addresses all aspects of an academic career: improving the teaching and learning of mathematics, engaging in research and scholarship, and participating in professional activities. It also provides the participants with a network of peers and mentors as they assume these responsibilities. In 2010 about seventy faculty members from colleges and universities throughout the country will be selected to participate in a workshop preceding Mathfest, the Mathematical Association of America (MAA) summer meeting; in activities during the summer MAA meetings and the Joint Mathematics Meetings in January; and in an electronic discussion network. Faculty for whom the 2010–2011 academic year will be the first or second year of full-time teaching (post-Ph.D.) at the college or university level are invited to apply to become Project NExT Fellows.

Applications for the 2010–2011 fellowship year will be due on **April 16, 2010.** For more information, see the Project NExT website, http://archives.math.utk.edu/projnext/, or contact Aparna Higgins, director, at Aparna.Higgins@notes.udayton.edu. Project NExT is a program of the MAA. Major funding is provided by the ExxonMobil Foundation and the Dolciani-Halloran Foundation, with additional funding from the Educational Advancement Foundation, the American Mathematical Society, the American Statistical Association, the National Council of Teachers of Mathematics, the American Institute of Mathematics, the Association for Symbolic Logic, the Association of Mathematics Teacher Educators, Texas Instruments, the W. H. Freeman Publishing Company, John Wiley & Sons, MAA Sections, and the Mathematical Association of America.

—From a Project NExT announcement

For Your Information

Cornell University Library Engages Institutions in Supporting arXiv

In a move to expand support for sustaining arXiv, Cornell University Library is broadening the funding base for the online scientific repository. Nearly 600,000 e-prints—research articles published online in physics, mathematics, statistics, computer science, and related disciplines—now reside in arXiv, which is an open-information source for hundreds of thousands of scientific researchers.

arXiv will remain free for readers and submitters, but the Library has established a voluntary, collaborative business model to engage institutions that benefit most from arXiv.

"Keeping an open-access resource like arXiv sustainable means not only covering its costs but also continuing to enhance its value, and that kind of financial commitment is beyond a single institution's resources," said Oya Rieger, Associate University Librarian for Information Technologies. "If a case can be made for any repository being community supported, arXiv has to be at the top of the list."

The 200 institutions that use arXiv most heavily account for more than 75 percent of institutional downloads. Cornell is asking these institutions for financial support in the form of annual contributions, and most of the top twenty-five have already committed to helping arXiv.

Institutions that have already pledged support include: California Institute of Technology; University of California, Berkeley; University of Cambridge; CERN—European Organization for Nuclear Research (Switzerland); Centre National de la Recherche Scientifique (France); Columbia University; DESY—Deutsches Elektronen-Synchrotron (Germany); Durham University (UK); Eidgenössische Technische Hochschule Zürich; Fermilab; Harvard University; University of Illinois at Urbana-Champaign; Imperial College London; Los Alamos National Laboratory; Massachusetts Institute of Technology; Max Planck Society (Germany); University of Michigan; University of Oxford; University of Pennsylvania; Princeton University; SLAC National Accelerator Laboratory; Texas A&M University.

The proposed funding model is viewed as a short-term strategy, and the Library is actively seeking input on a long-term solution. Currently, Cornell University Library supports the operating costs of arXiv, which are comparable to the costs of the university's collection budget for physics and astronomy. As one of the most influential innovations in scholarly communications since the advent of the Internet, arXiv's original dissemination model represented the first significant means to provide expedited access to scientific research well ahead of formal publication.

Researchers upload their own articles to arXiv, and they are usually made available to the public the next day. arXiv, founded by physics professor Paul Ginsparg, has about 400,000 users and serves more than 2.5 million article downloads per month. Its 101,000 registered submitters live in nearly 200 countries.

For details about the operating principles of the new structure, visit the FAQ at `http://arxiv.org/help/support/faq`. For questions about supporting arXiv, contact consortia representatives or the arXiv office at Cornell University Library at `support@arxiv.org`.

—Cornell University Library news release

Inside the AMS

National Contest of Who Wants to Be a Mathematician

Evan O'Dorney, a home-schooled junior from Danville, California, who won the National Spelling Bee in 2007, was the big winner in the national contest of Who Wants to Be a Mathematician at the Joint Mathematics Meetings. Evan won US$5,000 for himself and US$5,000 for the Berkeley Math Circle, in which he is an active participant. He has also participated in the International Mathematical Olympiad the past two years—winning silver medals each time—and hopes to attend Harvard University and eventually become a math professor. Evan was one of ten contestants nationwide who participated in the contest, which consisted of two semifinals of five contestants each. Ben Zauzmer, a junior at Upper Dublin High School in Pennsylvania, won the other semifinal and went head-to-head with Evan in the finals. Although Ben lost to Evan in the finals, he was very gracious in defeat, telling a local reporter, "Evan did a great job and he really deserves it. He is an impressive mathematician, and it was a lot of fun up there." Read about the contest at `http://www.ams.org/wwtbam/national/jmm2010.html`.

Evan O'Dorney wins Who Wants to Be a Mathematician contest.

—Annette Emerson and Mike Breen
AMS Public Awareness Office
`paoffice@ams.org`

Deaths of AMS Members

M. V. Bodnarescu, from Essen, Germany, died on October 25, 2009. Born on November 30, 1921, he was a member of the Society for 23 years.

Steve Fisk, professor from Bowdoin College, died on January 31, 2010. Born on May 18, 1946, he was a member of the Society for 33 years.

Mary-Elizabeth Hamstrom, professor emerita, University of Illinois at Urbana-Champaign, died on December 2, 2009. Born on May 24, 1927, she was a member of the Society for 61 years.

James F. Hannan, professor, Michigan State University, died on January 26, 2010. Born on September 14, 1922, he was a member of the Society for 61 years.

Walter J. Harrington, professor emeritus, North Carolina State University, Raleigh, died on June 2, 2008. Born on November 9, 1916, he was a member of the Society for 70 years.

Rodney W. Logan, professor from Frankston, Australia, died on November 5, 2009. Born on May 11, 1934, he was a member of the Society for 42 years.

Ferris E. McCormick, from Manassas, VA, died on August 5, 2009. Born on August 16, 1946, he was a member of the Society for 37 years.

Michael E. Moody, vice president for academic affairs and dean of faculty at Olin College, died on January 21, 2010. Born on May 23, 1952, he was a member of the Society for 12 years.

Masahiro Nakamura, from Ashiya, Japan, died on November 9, 2007. Born on January 11, 1919, he was a member of the Society for 36 years.

Frederick H. Steen, retired, Allegheny College, died on January 13, 2010. Born on November 26, 1907, he was a member of the Society for 74 years.

Layton O. Thompson, retired, Marshall University, died on December 11, 2002. Born on December 21, 1915, he was a member of the Society for 54 years.

Myron E. White, professor emeritus, Stevens Institute of Technology, died on August 19, 2008. Born on May 1, 1920, he was a member of the Society for 66 years.

Dale Woods, retired, from Truman State University, MO, died on October 24, 2008. Born on November 1, 1922, he was a member of the Society for 41 years.

Joseph W. Woythaler, from Peru, NY, died on April 1, 2004. Born on August 29, 1921, he was a member of the Society for 40 years.

Eduardo H. Zarantonello, professor from Mendoza, Argentina, died on January 13, 2010. Born on June 14, 1918, he was a member of the Society for 67 years.

Reference and Book List

*The **Reference** section of the* Notices *is intended to provide the reader with frequently sought information in an easily accessible manner. New information is printed as it becomes available and is referenced after the first printing. As soon as information is updated or otherwise changed, it will be noted in this section.*

Contacting the *Notices*

The preferred method for contacting the *Notices* is electronic mail. The editor is the person to whom to send articles and letters for consideration. Articles include feature articles, memorial articles, communications, opinion pieces, and book reviews. The editor is also the person to whom to send news of unusual interest about other people's mathematics research.

The managing editor is the person to whom to send items for "Mathematics People", "Mathematics Opportunities", "For Your Information", "Reference and Book List", and "Mathematics Calendar". Requests for permissions, as well as all other inquiries, go to the managing editor.

The electronic-mail addresses are `notices@math.wustl.edu` in the case of the editor and `notices@ams.org` in the case of the managing editor. The fax numbers are 314-935-6839 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines

March 29, 2010: Preliminary proposals for NSF Integrative Graduate Education and Research Training (IGERT) program. See "Mathematics Opportunities" in this issue.

March 31, 2010: Nominations for 2010 TWAS Prizes. See `http://www.twas.org/`.

April 15, 2010: Applications for fall 2010 semester of Math in Moscow. 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`. For information on AMS scholarships see `http://www.ams.org/outreach/mimoscow.html` or write to: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email `student-serv@ams.org`.

April 16, 2010: Applications for Project NexT Fellowships. See "Mathematics Opportunities" in this issue.

April 23, 2010: Proposals for 2010 NSF-CBMS Regional Conferences. See "Mathematics Opportunities" in this issue.

May 1, 2010: Applications for May review for National Academies Postdoctoral and Senior Research Associateship Program. See `http://sites.nationalacademies.org/`

Where to Find It

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

PGA/RAP/PGA_050491 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.

May 1, 2010: Applications for the fall 2010 program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship program of the National Academies. See http://sites.nationalacademies.org/PGA/policyfellows/index.htm or contact The National Academies Christine Mirzayan Scence 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.

May 1, 2010: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; or email: awm@awm-math.org. The postal address is: Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

May 15–June 15, 2010: Proposals for DMS Workforce Program in the Mathematical Sciences. See "Mathematics Opportunities" in this issue.

June 1, 2010: Applications for NSF's Enhancing the Mathematical Sciences Workforce in the Twenty-First Century (EMSW21) program. See http://www.nsf.gov/pubs/2005/nsf05595/nsf05595.htm.

July 31, 2010: Nominations and applications for the 2010 Monroe H. Martin Prize. Contact R. Roy, Director, Institute for Physical Science and Technology, University of Maryland, College Park, Maryland 20742-2431.

August 1, 2010: Applications for August review for National Academies Postdoctoral and Senior Research Associateship Program. See http://sites.nationalacademies.org/PGA/RAP/PGA_050491 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.

September 30, 2010: Full proposals for NSF Integrative Graduate Education and Research Training (IGERT) program. See "Mathematics Opportunities" in this issue.

October 1, 2010: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.org. The postal address is: Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

November 1, 2010: Applications for November review for National Academies Postdoctoral and Senior Research Associateship Program. See http://sites.nationalacademies.org/PGA/RAP/PGA_050491 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.

Mathematical Sciences Education Board, National Research Council

Jan de Lange, Freudenthal Institute, The Netherlands

Keisha M. Ferguson, Pattengill Elementary School, Ann Arbor, MI

Louis Gomez, Northwestern University

Javier Gonzalez, Pioneer High School, Whittier, CA

Sharon Griffin, Clark University

Phillip A. Griffiths (chair), Institute for Advanced Study

Arthur Jaffe, Harvard University

Jeremy Kilpatrick, University of Georgia

Julie Legler, St. Olaf College

W. James Lewis, University of Nebraska, Lincoln

Kevin F. Miller, University of Michigan, Ann Arbor

Marge Petit (vice chair), Consultant, Fayston, VT

Donald Saari, University of California, Irvine

Nancy J. Sattler, Terra State Community College, Freemont, OH

Richard J. Schaar, Texas Instruments

Frank Wang, Oklahoma School of Science and Mathematics

MSEB Staff

David R. Mandel, Director

The contact information is: Mathematical Sciences Education Board, National Academy of Sciences, 500 Fifth Street, NW, 11th Floor, Washington, DC 20001; telephone: 202-334-2353; fax: 202-344-2210; email: cfeinq@nas.edu; World Wide Web http://www7.nationalacademies.org/MSEB/1MSEB_Membership.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.

The Archimedes Codex: How a Medieval Prayer Book Is Revealing the True Genius of Antiquity's Greatest Scientist, by Reviel Netz and William Noel. Da Capo Press, October 2007. ISBN 978-03068-1580-5. (Reviewed September 2008.)

The Calculus of Friendship: What a Teacher and Student Learned About Life While Corresponding About Math, by Steven Strogatz. Princeton University Press, August 2009. ISBN-13: 978-06911-349-32.

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: 978-15602-5992-3. (Reviewed May 2009.)

Chez les Weils (French), by Sylvie Weil. Buchet-Chastel, January 2009. ISBN-13: 978-22830-236-93.

Crocheting Adventures with Hyperbolic Planes, by Daina Taimina. A K Peters, March 2009. ISBN-13: 978-15688-145-20.

Decoding the Heavens: A 2,000-Year-Old Computer—and the Century-Long Search to Discover Its Secrets, by Jo Marchant. Da Capo

Press, February 2009. ISBN-13: 978-03068-174-27.

Ernst Zermelo: An Approach to His Life and Work, by Heinz-Dieter Ebbinghaus. Springer, April 2007. ISBN-13: 978-3-540-49551-2. (Reviewed August 2009.)

Gaming the Vote (Why Elections Aren't Fair and What We Can Do About It), by William Poundstone. Hill and Wang, February 2009. ISBN-13: 978-08090-489-22.

The Housekeeper and the Professor, by Yoko Ogawa. Picador, February 2009. ISBN-13: 978-03124-278-01.

How to Think Like a Mathematician: A Companion to Undergraduate Mathematics, by Kevin Houston. Cambridge University Press, March 2009. ISBN-13: 978-05217-197-80.

Leonhard Euler and His Friends: Switzerland's Great Scientific Expatriate, by Luis-Gustave du Pasquier (translated by John S. D. Glaus). CreateSpace, July 2008. ISBN: 978-14348-332-73.

Lewis Carroll in Numberland: His Fantastical Mathematical Logical Life: An Agony in Eight Fits, by Robin Wilson. W. W. Norton & Company. ISBN-13: 978-03930-602-70.

**Logicomix: An Epic Search for Truth,* by Apostolos Doxiadis and Christos Papadimitriou. Bloomsbury USA, September 2009. ISBN-13:978-15969-145-20.

Logic's Lost Genius: The Life of Gerhard Gentzen, by Eckart Menzler-Trott, Craig Smorynski (translator), Edward R. Griffor (translator). AMS-LMS, November 2007. ISBN-13: 978-0-8218-3550-0.

The Mathematical Mechanic: Using Physical Reason to Solve Problems, by Mark Levi. Princeton University Press. ISBN: 978-0691140209.

Mathematicians: An Outer View of the Inner World, by Mariana Cook, Princeton University Press, June 2009. ISBN13: 978-0-691-13951-7.

Mathematicans Fleeing from Nazi Germany: Individual Fates and Global Impact, by Reinhard Siegmund-Schultze. Princeton University Press, July 2009. ISBN 978-0-691-14041-4.

Mathematicians of the World, Unite!: The International Congress of Mathematicians: A Human Endeavor, by Guillermo P. Curbera. A K Peters, March 2009. ISBN-13: 978-15688-133-01.

Mathematics and Common Sense: A Case of Creative Tension, by Philip J. Davis. A K Peters, October 2006. ISBN 1-568-81270-1. (Reviewed June/July 2009.)

Mathematics Emerging: A Sourcebook 1540–1900, by Jacqueline Stedall. Oxford University Press, November 2008. ISBN-13: 978-01992-269-00.

Mathematics in Ancient Iraq: A Social History, by Eleanor Robson. Princeton University Press, August 2008. ISBN-13: 978-06910-918-22. (Reviewed March 2010.)

Mathematics in India, by Kim Plofker. Princeton University Press, January 2009. ISBN-13: 978-06911-206-76. (Reviewed March 2010.)

Mathematics in 10 Lessons: The Grand Tour, by Jerry P. King. Prometheus Books, May 2009. ISBN: 978-1-59102-686-0.

The Mathematics of Egypt, Mesopotamia, China, India, and Islam: A Sourcebook, by Victor J. Katz et al. Princeton University Press, July 2007. ISBN-13: 978-0-6911-2745-3.

The Millennium Prize Problems, edited by James Carlson, Arthur Jaffe, and Andrew Wiles. AMS, June 2006. ISBN-13: 978-08218-3679-8. (Reviewed December 2009.)

More Mathematical Astronomy Morsels, by Jean Meeus. Willmann-Bell, 2002. ISBN 0-943396743.

The Numbers Game: The Commonsense Guide to Understanding Numbers in the News, in Politics, and in Life, by Michael Blastland and Andrew Dilnot. Gotham, December 2008. ISBN-13: 978-15924-042-30.

The Numerati, by Stephen Baker. Houghton Mifflin, August 2008. ISBN-13: 978-06187-846-08. (Reviewed October 2009.)

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. (Reviewed June/July 2009.)

A Passion for Discovery, by Peter Freund. World Scientific, August 2007. ISBN-13: 978-9-8127-7214-5.

Perfect Rigor: A Genius and the Mathematical Breakthrough of the Century, by Masha Gessen. Houghton Mifflin Harcourt, November 2009. ISBN-13: 978-01510-140-64.

Picturing the Uncertain World: How to Understand, Communicate, and Control Uncertainty Through Graphical Display, by Howard Wainer, Princeton University Press, April 2009. ISBN-13: 978-06911-375-99.

**Pioneering Women in American Mathematics: The Pre-1940 Ph.D.'s,* by Judy Green and Jeanne LaDuke. AMS, December 2008. ISBN-13:978-08218-437-65.

Plato's Ghost: The Modernist Transformation of Mathematics, by Jeremy Gray. Princeton University Press, September 2008. ISBN-13: 978-06911-361-03. (Reviewed February 2010.)

The Princeton Companion to Mathematics, edited by Timothy Gowers (June Barrow-Green and Imre Leader, associate editors). Princeton University Press, November 2008. ISBN-13: 978-06911-188-02. (Reviewed November 2009.)

Proofs from THE BOOK, by Martin Aigner and Günter Ziegler. Expanded fourth edition, Springer, October 2009. ISBN-13: 978-3-642-00855-9

Pythagoras' Revenge: A Mathematical Mystery, by Arturo Sangalli. Princeton University Press, May 2009. ISBN-13: 978-06910-495-57.

Recountings: Conversations with MIT Mathematicians, edited by Joel Segel. A K Peters, January 2009. ISBN-13: 978-15688-144-90.

Roger Boscovich, by Radoslav Dimitric (Serbian). Helios Publishing Company, September 2006. ISBN-13: 978-09788-256-21.

Sacred Mathematics: Japanese Temple Geometry, by Fukagawa Hidetoshi and Tony Rothman. Princeton University Press, July 2008. ISBN-13: 978-0-6911-2745-3.

Solving Mathematical Problems: A Personal Perspective, by Terence Tao. Oxford University Press, September 2006. ISBN-13: 978-0-199-20560-8. (Reviewed February 2010.)

Sphere Packing, Lewis Carroll, and Reversi, by Martin Gardner. Cambridge University Press, July 2009. ISBN: 978-0521756075.

Strange Attractors: Poems of Love and Mathematics, edited by Sarah Glaz and JoAnne Growney. A K Peters, November 2008. ISBN-13: 978-15688-134-17. (Reviewed September 2009.)

The Strangest Man, by Graham Farmelo. Basic Books, August 2009. ISBN-13: 978-04650-182-77.

**Symmetry in Chaos: A Search for Pattern in Mathematics, Art, and Nature*, by Michael Field and Martin Golubitsky. Society for Industrial and Applied Mathematics, second revised edition, May 2009. ISBN-13: 978-08987-167-26.

Teaching Statistics Using Baseball, by James Albert. Mathematical Association of America, July 2003. ISBN-13: 978-08838-572-74. (Reviewed in this issue.)

Tools of American Math Teaching, 1800–2000, by Peggy Aldrich Kidwell, Amy Ackerberg-Hastings, and David Lindsay Roberts. Johns Hopkins University Press, July 2008. ISBN-13: 978-0801888144. (Reviewed January 2010.)

The Unfinished Game: Pascal, Fermat, and the Seventeenth-Century Letter That Made the World Modern, by Keith Devlin. Basic Books, September 2008. ISBN-13: 978-0-4650-0910-7.

What Is a Number?: Mathematical Concepts and Their Origins, by Robert Tubbs. Johns Hopkins University Press, December 2008. ISBN-13: 978-08018-901-85.

Why Does E=mc²? (And Why Should We Care?), by Brian Cox and Jeff Forshaw. Da Capo Press, July 2009. ISBN-13: 978-03068-175-88.

Zeno's Paradox: Unraveling the Ancient Mystery Behind the Science of Space and Time, by Joseph Mazur. Plume, March 2008 (reprint edition). ISBN-13: 978-0-4522-8917-8.

Leroy P. Steele Prizes

Call for Nominations

The selection committee for these prizes requests nominations for consideration for the 2011 awards. Further information about the prizes can be found in the November 2009 *Notices*, pp. 1326–1345 (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 2011 the prize for Seminal Contribution to Research will be awarded for a paper in applied mathematics.

Nominations with supporting information should be submitted to the Secretary, Robert J. Daverman, American Mathematical Society, 302A Aconda Court, Department of Mathematics, University of Tennessee, Knoxville TN 37996-0614. Include a short description of 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 make final decisions on the awarding of prizes.

Deadline for nominations is May 31, 2010.

AMS
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Associate Treasurer

The American Mathematical Society is seeking applications and nominations of candidates for the post of Associate Treasurer. An Associate Treasurer is an officer of the Society and is appointed by the Council to a two-year term. In this case the first term will run 01 February 2012–31 January 2014. Reappointments are possible and desirable. All necessary expenses incurred by an Associate Treasurer in performance of duties for the Society are reimbursed, including travel and communications.

Duties

The primary responsibilities of an Associate Treasurer, like those of the treasurer, are to administer or to supervise the administration of fiscal policies laid down by the Trustees. To monitor the receipt and expenditure of funds and the care of investments. To monitor budgets and trends of finance over periods of years. To review salary policy and its applications to individuals. The Associate Treasurer has all the duties of the Trustees in general. The Associate Treasurer watches over the finances of *Mathematical Reviews* and over the administration of salary policy up to department head.

Applications

An Associate Treasurer is appointed by the Council upon recommendation of the Executive Committee and Board of Trustees. Applications, consisting of a CV and a letter expressing interest and relevant background, should be sent to:

AT Search Committee
c/o Sandy Golden
Office of the AMS Secretary
Department of Mathematics
302A Aconda Court
University of Tennessee
Knoxville, TN 37996-0614

email: golden@math.utk.edu

Applications received by 31 July 2010 will be assured full consideration.

The American Mathematical Society is an Equal Opportunity Employer.

Mathematics Calendar

April 2010

* 2 **Gravitational Lensing Workshop**, University of South Florida, Tampa, Florida.

Description: The bending of light due to gravitational effects is one of the famous predictions of Einstein's theory of general relativity, confirmed in 1919. In gravitational lensing, this phenomenon is used to reconstruct the source of light from the images observed. The mathematical formulation of this problem has recently lead to surprising new results in complex analysis . This workshop will explore recent developments in this fascinating subject at the intersection between astrophysics, general relativity and mathematics.

Information: `http://shell.cas.usf.edu/~dkhavins/workshop.html`.

* 5 **The Mathematical Enterprise: A Minority Perspective–A Talk**, MIT, Cambridge, Massachusetts.

Description: William Yslas Vélez will give a talk entitled "The Mathematical Enterprise: A Minority Perspective" on Monday, April 5, 2010, 4:30 p.m., Room 4-370, MIT. (Refreshments will be available at 4:00 p.m. in Room 4-349.)

Information: `http://math.mit.edu/news/seminars.html`.

* 14–16 **International Workshop on "Variational, Topological and Set-valued Methods for Nonlinear Differential Problems"**, Engineering Faculty, University of Messina, Italy.

Description: In the last years, the development of several methods for the study of nonlinear differential problems has played a fundamental role in various fields of research, such as: mechanics engineering, neural networks, economy, and a lot of others. The conference includes talks and communications by several experts in these research areas.

Topics: Variational theory, set-valued analysis, nonlinear analysis. The conference provides an excellent opportunity to overview the status and perspectives of some of the most promising research directions in these fields of mathematical analysis.

Information: `http://ww2.unime.it/ingegneria/VTSMENDIP10/`.

* 14–17 **Ischia Group Theory 2010**, NH Ischia Thermal SPA Resort (ex Jolly Hotel) of Ischia (Naples, Italy).

Description: The meeting will consist of talks given by invited speakers and a permanent poster exhibition. The scientific session will be dedicated to the memories of M. Silvia Lucido on Thursday and Karl W. Gruenberg on Friday. The social programme will consist of a concert, the trip to the gardens La Mortella on Thursday morning, and the conference dinner on Friday evening.

Main Speakers: D. Chillag, Israel; F. De Giovanni, Italy; L. Di Martino, Italy; D. Dikranjan, Italy; M.J. Evans, U.S.A.; G. Glauberman, U.S.A.; M. Herzog, Israel; O. Kegel, Germany; E.I. Khukhro, Russia–U.K.; M. Lewis, U.S.A.; A. Lucchini, Italy; N.Yu. Makarenko, Russia–France; G. Malle, Germany; A. Maroti, Hungary; G. Navarro, Spain; P.P. Palfy, Hungary; D.J.S. Robinson, U.S.A.; P. Shumyatsky, Brazil; H. Smith, U.S.A., Y.P.

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 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. 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/`.

Sysak, Ukraine; O. Talelli, Greece; M.C. Tamburini, Italy; G. Traustason, U.K.; A. Turull, U.S.A.; J.S. Wilson, U.K.; L. Wilson, U.S.A.; A. Zalesski, U.K.

Information: http://www.dmi.unisa.it/ischia2010.

* 15–18 **Third Texas Southmost Geometry and Topology Conference**, The University of Texas at Brownsville, Brownsville, Texas.

Description: This workshop is a unique opportunity for geometry and topology researchers to meet, share their specialized knowledge and learn from others. Professors from Japan, Russia, Netherlands, and various American and Canadian Universities will be presenting their latest results.

Program Committee: Tadeusz Dobrowolski, Włodzimierz Kuperberg, Jerzy Mogilski, Oleg Musin, Igor Pak.

Event sponsors: The University of Texas at Brownsville Mathematics Department.

Information: http://blue.utb.edu/gt2010/.

* 22–23 **Virtual properties of 3-manifolds**, UQAM, Montreal, Canada.

Description: Dani Wise will give a series of talks April 19–21 (before the workshop) on his work on separability for hyperbolic groups with quasiconvex hierarchies. The workshop proper will run for two days (April 22–23) and will focus on topics related to the virtual positive first Betti number conjecture and virtual fibering conjectures for 3-manifolds. Michel Boileau will be giving the Montreal-area mathematics colloquium on Friday, April 23 to close the event.

Information: http://www.cirget.uqam.ca/3manifolds/index_e.shtml.

* 30–May 2 **4th Annual Graduate Student Probability Conference**, Duke University, Durham, North Carolina.

Description: This conference is organized by a group of graduate students from Duke University and UNC-Chapel Hill under the supervision of Jonathan Mattingly and Amarjit Budhiraja. It is intended to provide graduate students and postdoctoral fellows with an opportunity to speak on an area of interest within probability.

Information: http://www.math.duke.edu/~tkolba/GSPC/.

May 2010

* 2–6 **Mal'tsev Meeting 2010**, Sobolev Institute of Mathematics SB RAS, Novosibirsk, Russia.

Description: Mal'tsev Meeting is a series of annual conferences. In 2010, it honours Yurii Leonidovich Ershov on occasion of his 70th birthday. The topics of the conference include computability theory, group theory, mathematical logic, ring theory, theoretical computer science, universal algebra, and related areas of mathematics.

Information: http://www.math.nsc.ru/conference/malmeet/10/index.html.

* 3–7 **CFL condition—80 years gone by...**, Rio de Janeiro State University–UERJ, Rio de Janeiro, Brazil.

Description: This congress celebrates 80 years of the benchmark article published by Courant, Friedrichs and Lewy in 1928 and which has redrawn the approach to numerical algorithms for PDEs.

Information: http://www.ime.uerj.br/cfl80.

* 17–21 **NSF/CBMS Regional Research Conference in the Mathematical Sciences, Nonlinear Water Waves with Applications to Wave-Current Interactions and Tsunamis**, The University of Texas-Pan American, Edinburg, Texas.

Description: The Mathematics Department at the University of Texas-Pan American will host an NSF/CBMS regional research conference on Nonlinear Water Waves with Applications to Wave-Current Interactions and Tsunamis during the week of May 17–21, 2010. Participation is open to scientists working at research level on theoretical and practical aspects of the conference's topic. Some limited support is available for travel and local expenses. Underrepresented groups are strongly encouraged to apply.

Principal speaker: Professor Adrian Constantin, Chair of Partial Differential Equations at the University of Vienna, Austria.

Additional Invited Lectures: Will also be featured by other leading experts, including Professors J. Bona, A. Degasperis, J. Escher, A. S. Fokas, R. Johnson, W. Strauss, J. F. Toland, E. Varvaruca, and possibly others.

Information: http://www.math.utpa.edu/nsf-cbms2010.html.

* 21–29 **From Carthage to the World: The Isoperimetric Problem of Queen Dido and its Mathematical Ramifications**, May 21–22, 2010: Tunis Science City, Tunis, Tunisia (Intensive Course); May 24-29, 2010: Barcelo Hotel, Gammarth, Carthage, Tunisia (International Conference).

Description: This conference aims to bring together experts on classical isoperimetric inequalities, sharp functional inequalities, and spectral inequalities for a week-long conference in Carthage, Tunisia, where the mathematical problem named after Queen Dido, the founder of Carthage, originated. The week-long gathering will serve as a training ground for young researchers and graduate students, incorporating an intensive program on techniques of rearrangement, spectral analysis, and geometric inequalities. The conference will serve as a means to bring together the many trends within isoperimetry.

Co-Sponsors: American Mathematical Society, European Mathematical Society, Tunisian Mathematical Society, CNRS, CIMPA. Funded by NSF, OISE, CNRS, SMT, Tunisian Ministry of Higher Education.

Application Deadline/Partial Travel Funding: March 15, 2010. Grad students, women, and researchers from underrepresented groups are encouraged to apply. Research articles will be peer reviewed and published.

Information: http://math.arizona.edu/~dido.

* 24–29 **International conference "Geometry in Odessa 2010"**, Odessa National Academy of Food Technologies, Odessa, Ukraine.

Description: The Conference is organized in the following sections: 1. Geometrical structures on manifolds. 2. Geometry of differential equations and Monge-Ampere equations. 3. Differential invariants and group methods. 4. Geometrical methods in mathematical physics. 5. Quantum geometry and quantization of DEs. 6. Topological aspects of differential geometry. 7. Geometrical control theory. 8. Geometry in the large. 9. Nonclassical logics, topology and mathematical linguistics. 10. Methods of geometry teaching.

Information: http://conf.d-omega.org/eng/.

June 2010

* 4–6 **Topology and Geometry in Dimension Three: Triangulations, Invariants, and Geometric Structures**, Oklahoma State University, Stillwater, Oklahoma.

Description: This conference will highlight ongoing research focused on finding direct connections between topological structures on 3-manifolds (triangulations in particular) and geometric structures. It will also bring together researchers working on new invariants and hyperbolic geometry applied to 3-manifolds. This conference is in honor of William Jaco, on the occasion of his 70th birthday.

Information: http://www.math.okstate.edu/jacofest/.

* 5–10 **36th International Conference "Applications of Mathematics in Engineering and Economics" (AMEE'10)**, Technical University Leisure House, Sozopol, Bulgaria.

Description: The main goal of this series of conferences is to bring together experts and young talented scientists from Bulgaria and abroad to discuss the modern trends and to ensure exchange of ideas in various applications of mathematics in engineering, physics, economics, biology, etc. The invited talks and contributed papers will be published after peer reviewing by the Conference Proceedings Series of the American Institute of Physics (AIP)

Organizing Committee: Encourages the taking part of students and postgraduates and intends to organize a separate youth session.

Local Organizing Committee: Ketty Peeva, Vesela Pasheva, Adriana Georgieva, Nikola Kaloyanov, Krasimira Prodanova and Yana Stoyanova.

International Programme Committee: Ralitza Kovacheva (Bulgaria), Stefanka Chukova (New Zealand), Lubomir Dechevsky (Norway), Vladimir Georgiev (Italy), Michail Konstantinov (Bulgaria), Raytcho Lazarov (USA), Svetozar Margenov (Bulgaria) and Bernadette Miara (France).
Information: `http://www.tu-sofia.bg/ENG/fpmi/amee/`.

* 7–11 **2010 Annual Canadian Operator Algebra and Operator Theory Symposium**, University of New Brunswick, Fredericton, New Brunswick, Canada.
Description: The 38th installment of a well-established operator algebras meeting. The Canadian Math Societies Summer meeting is in the same city (Fredericton, NB) right before this meeting, so it is quite feasable to attend both (or alternatively one can attend both GPOTS and the COASy.)
Organizer: Andrew Dean; email: `andrew.j.dean@lakeheadu.ca`; Dan Kucerovsky; email: `dan@math.unb.ca`.
Information: `http://www.math.unb.ca/~dan/coas2010/coas2010Main.htm`.

* 7–11 **Conference Géométrie Algébrique en Liberté (GAeL) XVIII**, Coimbra, Portugal.
Description: GAeL, Géométrie Algébrique en Liberté, is a conference organised by and for researchers in algebraic geometry at the beginning of their scientific career. The conference gives Ph.D. students and postdocs the opportunity to lecture, often for the first time, in front of an international audience. In addition, selected international experts deliver mini-courses on topics at the cutting-edge of important new developments in algebraic geometry.
Senior Speakers: Olivier Debarre (Ecole Normale Supérieure) TBA; Bernd Sturmfels (University of California, Berkeley) Convex Algebraic Geometry; Gerard van der Geer (Universiteit van Amsterdam) Cycle Classes on Abelian Varieties.
Information: email: `severian.mit.edu/gael`.

* 7–18 **IMA New Directions Short Course: New Mathematical Models in Economics and Finance**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.
Description: The IMA will host an intensive short course designed to efficiently provide researchers in the mathematical sciences and related disciplines the basic knowledge prerequisite to undertake research in mathematical finance and economics. The course will be taught by Rene Carmona, Department of Operations Research & Financial Engineering, Princeton University; Nizar Touzi, Ecole Polytechnique, Paris; and Guillaume Carlier, Ceremade, University Paris, Dauphine. The primary audience for the course is mathematics faculty. Some background in probability and stochastic processes are expected. Participants will receive full travel and lodging support during the workshop.
Information: `http://www.ima.umn.edu/2009-2010/ND6.7-18.10/`.

* 7–25 **IMA PI Summer Program for Graduate Students: Computational Wave Propagation**, Michigan State University, East Lansing, Michigan.
Description: Michigan State University will be the host of the Institute for Mathematics and its Applications (IMA) Summer Graduate Program in Mathematics. The course will concentrate on Computational Wave Propagation. The program will focus on presenting some of the fundamental concepts and techniques currently used in computational wave propagation and related applications. It will provide a unique and timely synthesis of disciplines which will better position graduate students as future researchers for the next step to work on computational wave propagation.
Information: `http://www.ima.umn.edu/2009-2010/PISG6.7-25.10/`.

* 14–18 **Harmonic Analysis and Applications-A Conference in honor of the 70th birthday of Richard Wheeden**, Mathematical Research Institute of the University of Seville (IMUS), University of Seville, Seville, Spain.
Description: The Mathematical Research Institute of the University of Seville (IMUS) will hold a conference June 14-18th, 2010, at Seville, on the topic of Harmonic Analysis and Applications to pay tribute to Professor Richard Wheeden and acknowledge his many contributions to Harmonic Analysis and related fields like P.D.E.
Information: `http://congreso.us.es/rwheeden/`.

* 14–18 **Vector Bundles on Algebraic Curves (VBAC 2010)—New Invariants and Stability Conditions**, Mathematics Department, Inst. Superior Tecnico, Lisbon, Portugal.
Deadlines: For those contributing a talk the deadline for registration is: March 1st, 2010. For other participants: April 30, 2010.
Information: `http://www.vbac2010.net/`.

* 21–25 **AIM Workshop: Control and optimization of open quantum systems for information processing**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to identifying and exploring hybrid methods to improve protection of quantum information processing against decoherence by integrating elements of dynamical decoupling, optimal control, and quantum error correction.
Information: `http://aimath.org/ARCC/workshops/quantumcontrol.html`.

* 21–25 **Functions and Operators**, The Faculty of Mathematics and Computer Science of the Jagiellonian University, Lojasiewicza 6, Krakow, Poland.
Description: During the conference we intend to celebrate Professor Franciszek Hugon Szafraniec's 70th birthday and a special session will be devoted to his scientific contribution.
Topics: Functions (reproducing kernel Hilbert spaces, orthogonal polynomials, special functions etc.), operators (bounded and unbounded operators with dilation theory in particular, operator algebras and semigroups etc.), interconnected issues (positive definite functions, moment problems, commutative and noncommutative harmonic analysis, mathematical physics etc.).
Information: `http://www.im.uj.edu.pl/fao2010/krakow.html`.

* 28–30 **FAN 2010: Fluid dynamics, Analysis, and Numerics 2010. A conference in honor of J. Thomas Beale**, Duke University, Durham, North Carolina.
Description: The conference will focus on research in mathematical fluid dynamics, spanning areas from rigorous analysis of nonlinear partial differential equations to numerical analysis and modeling of related physical systems. This includes: (1) Analysis of PDEs for fluid dynamics: rigorous results for regularity, existence, uniqueness for Navier-Stokes and Euler, problems with free-surfaces and surface tension, convergence of vortex methods and splitting methods, (2) Fluid motion driven by interfaces: computational methods and analysis of problems with moving interfaces and (3) Computational methods for fluid dynamics. Thomas Beale has made important contributions to many problems in these areas. The conference will feature talks by a list of invited speakers and an extended poster session for contributed research presentations by conference participants.
Information: `http://www.math.duke.edu/conferences/FAN2010/`.

* 28–July 9 **Operads and Universal Algebra**, Chern Institute of Mathematics, Nankai University, Tianjin, China.
Description: An operad is a device that describes algebraic structures of different varieties in various categories. Instead of studying elements in a particular kind of algebra, the theory of operads studies operations that one can perform on this algebra. Operads and universal algebra have similar origins and ideas. Yet they have their own distinct methods and applications. There are recent interests to understand better the connection between these two important areas of mathematics. We will hold a two-week conference on operad theory, emphasizing the relationship with universal algebra. The first half of

the conference will consist of mini-courses that prepare the graduate students and non-experts for the more specialized talks in the second half of the conference. The overall goal of the conference is to bring the participants to the forefront of the current research in these areas.
Information: http://andromeda.rutgers.edu/~liguo/OUA10/operadua.html.

July 2010

* 12–16 **Soria Summer School on Computational Mathematics Algebraic Geometric Modelling in Information Theory (AGMINT)**, Soria, Spain.
Description: The S3CM: Soria Summer School on Computational Mathematics is a series of annual international schools mostly intended for Master's, Ph.D. students, and Postdocs working on computational mathematics.
Topic: This year the meeting will be devoted to the topic Algebraic Geometric Modelling in Information Theory (AGMINT). See the list of courses in the Web page for further description. It will take place in the Campus of Soria of the Universidad de Valladolid (Spain) and they are hosted by SINGACOM reseach group. Application details are posted in the Web.
Information: http://www.singacom.uva.es/oldsite/Actividad/s3cm/s3cm10/.

* 19–23 **AIM Workshop: Components of Hilbert Schemes**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to understanding the irreducible component structure of Hilbert schemes.
Information: http://aimath.org/ARCC/workshops/hilbertschemes.html.

* 19–23 **XIX Oporto Meeting on Geometry, Topology and Physics**, Faro, Portugal.
Description: The aim of the Oporto meetings is to bring together mathematicians and physicists interested in the inter-relation between geometry, topology and physics and to provide them with a pleasant and informal environment for scientific interchange. As in previous years, the meeting is focussed on the short courses given by the main speakers. The talks are at the advanced graduate or postdoctoral level, and should be of interest to all researchers wishing to learn about recent developments in the overlap between geometry, topology and physics. The remaining participants are invited to submit titles and abstracts for contributed talks, relevant to the main topic of the meeting.
Main Topic: Categorification.
Main Speakers: Sabin Cautis (Columbia University), Mikhail Khovanov (Columbia University), Aaron Lauda (Columbia University), Catharina Stroppel (Univ. of Bonn), Dylan Thurston (Columbia University), Ben Webster (MIT).
Information: http://www.fct.ualg.pt/omgtp/.

* 29–30 **ICDEM 2010 Second International Conference on Data Engineering and Management 2010**, Bishop Heber College, Tiruchirappalli, Tamil Nadu, India.
Description: The second ICDEM conference addresses research issues in modeling, designing, building, managing, and evaluating advanced data-intensive systems, applications and technologies. We invite the submission of original research contributions and industrial papers in all areas of Data, Information and Knowledge Engineering and Management.
Information: All submissions in PDF must be prepared in Springer LNCS. For further details, contact Dr. Rajkumar Kannan: email: icdem2010@gmail.com; http://www.bhc.edu.in; http://www.demfoundation.org.

August 2010

* 9–13 **AIM Workshop: Mahler's conjecture and duality in convex geometry**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to duality problems in convex geometry, which deal with relations between convex bodies and their polar bodies.
Information: http://aimath.org/ARCC/workshops/mahlerduality.html.

* 9–13 **Workshop on Fluid Motion Driven by Immersed Structures**, Fields Institute, Toronto, Ontario, Canada.
Description: There is tremendous interest in the development and application of advanced computational techniques for simulating the motion of an incompressible fluid driven by flexible immersed structures, in large part owing to the multitude of applications in physiology and biology. The workshop will include two tutorials targeted to graduate students and junior mathematicians, with the goal of providing training opportunities to young scientists. The meeting will be organized around three main themes: * Formulation and analysis of the underlying governing equations. * Algorithmic and computational issues related to increasing accuracy and efficiency through use of adaptivity, novel time-stepping schemes and parallelism. * Applications to problems in the biological, physical and engineering sciences.
Information: http://www.fields.utoronto.ca/programs/scientific/10-11/fluid_motion/index.html.

September 2010

* 6–9 **XIX International Fall Workshop on Geometry and Physics**, Oporto, Portugal.
Description: The Fall Workshops, held yearly since 1992, bring together Spanish and Portuguese geometers and physicists, along with an ever increasing number of participants from outside the Iberian peninsula. The meetings aim to provide a forum for the exchange of ideas between researchers of different fields in Differential Geometry, Applied Mathematics and Physics, and always include a substantial number of enthusiastic young researchers amongst the participants.
Confirmed speakers: (Minicourses) Ingemar Bengtsson (Univ. Stockholm), Philip Candelas (Univ. Oxford).
Invited Speakers: Andrew Swann (Univ. Southern Denmark); Anna Fino (Univ. degli Studi di Torino); Boris Khesin (Univ. Toronto); Charles Torre (Utah State Univ.); Marcos Mariño (Univ. Geneva); Peter Gothen (Univ. Porto); Sergei Merkulov (Univ. Stockholm).
Information: http://cmup.fc.up.pt/cmup/fallworkshop/.

* 9–12 **The Second Asian Conference on Nonlinear Analysis and Optimization (NAO-Asia2010)**, Royal Paradise Hotel & Spa, Patong Beach, Phuket, Thailand.
Description: The purpose of this conference is to bring together leading Asian researchers to achieve an international or higher level on the research of the Nonlinear Analysis, the Convex Analysis, and the Optimization. We announce this conference for all Asian researchers and students related to these fields to exchange the recent achievements, to share the current problems, and to encourage other researchers who have an interest in these fields.
Information: http://www.sci.nu.ac.th/mathematics/NAO-Asia2010/?page=home.

* 13–15 **Optimal Discrete Structures and Algorithms (ODSA 2010)**, University of Rostock, Rostock, Germany.
Description: The ODSA 2010 conference continues the ODSA series following previous conferences in 1997, 2000, and 2006. The conference aims at the interactions between several aspects of Discrete Mathematics, Mathematical Optimization, Theoretical Computer Science, and their applications. In particular, the scope of the conference includes combinatorial optimization and algorithms on discrete structures, extremal problems in posets, design theory, coding theory, and graph theory.
Information: http://www.math.uni-rostock.de/odsa/.

* 13–17 **AIM Workshop: Emerging applications of complexity for CR mappings**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will focus on the evolving notion of complexity in CR Geometry.
Information: http://aimath.org/ARCC/workshops/crmappings.html.

* 15–18 **Algebra, Geometry, and Mathematical Physics**, Technical University of Crete, Chania, Crete, Greece.
Description: The AGMP meeting will focus on contemporary topics in algebra, geometry and mathematical physics, with an emphasis on the interface between them. It also promotes corresponding international scientific collaboration.
Information: http://www.agmf.ee/agmp10.

* 20–25 **DYSES2010 (V Meeting of Dynamics of Socio-economic Systems Society)**, University of Sannio, Faculty of Economic and business sciences, Benevento, Italy.
Description: The primary aim of this meeting is to bring together scientists working on the development of models able to prospect and to evaluate social end economical situations to future. Mathematical techniques include, but are not limited to, temporary series of prediction, time series forecasting, inference procedures, stochastic and/or dynamic systems, modeling of biological systems, optimization, develop of computational and knowledge-model based representations of human, organizational, cultural, and societal structures, uncertainty measures, multicriteria decision methods and any other method able to predict future behavior of these particular systems are welcome.
Information: http://www.dyses2010.unisannio.it.

* 27–30 **54th Annual Meeting of the Australian Mathematical Society**, The University of Queensland, Brisbane, Queensland, Australia.
Description: The 54th Australian Mathematical Society annual meeting will cover all aspects of mathematics. Special sessions include: algebra and number theory; applied DEs; combinatorics; computational math; control theory; dynamical systems; financial math; geometry and topology; harmonic analysis; math education; math in biology and medicine; mathematical physics; optimisation and applications; probability and statistics.
Plenary speakers are: James Borger, ANU; Jonathan Borwein, Newcastle; Wolfgang Dahmen, RWTH Aachen; Larry Forbes, Tasmania (ANZIAM Lecturer); Jan de Gier, Melbourne; Vladimir Gaitsgory, South Australia; Ben Green, Cambridge; Michael Hopkins, Harvard; Thomas Lam, Michigan (ECR Lecturer); Elizabeth Mansfield, Kent; Cheryl Praeger, Western Australia (Hanna Neumann Lecturer).
Information: http://www.smp.uq.edu.au/austms2010/.

* 28–October 1 **Convex Optimization and Algebraic Geometry**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Overview: The problems and algorithms to be discussed in this workshop arise from fields as diverse as functional analysis, control theory, probability theory, statistics, numerical algebraic geometry, combinatorics, multilinear algebra, and applications in engineering and life sciences. Of particular interest will be the development of computational benchmarks and the integration of numerical optimization software with symbolic algebra packages.
Organizing Committee: William Helton, Monique Laurent, Pablo Parrilo, Bernd Sturmfels, Rekha Thomas.
Application/Registration: An application and registration form is available at: http://www.ipam.ucla.edu/programs/opws1. Applications received by July 19, 2010, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. You may also simply register and attend without IPAM funding.
Information: http://www.ipam.ucla.edu/programs/opws1/.

October 2010

* 4–8 **AIM Workshop: Parameter identification in graphical models**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, is devoted to identifiability problems in graphical statistical models.
Information: http://aimath.org/ARCC/workshops/graphparameter.html.

* 7–10 **International Conference on Algebra in honor of the 70th Birthday of Professor Shum Kar-Ping**, Gajah-Mada University, Yogjakarta, Indonesia.
Topics: Semigroup Theory, Group Theory, Ring Theory, Lie and Hopf Algebras, Graph Theory, Universal Algebras and Combinatorics.
International Organizing Committee: Tan Eng-Che (Singapore, Chairman), Mohamad Akram. (Pakistan), Rosihan Bin Mohammad Ali (Malaysia), Chen Yuqun (China), Cheung Wingsum (Hong Kong), Fong Yuen (Taiwan), Guo Xiuyun (China), Wanida Hemakul (Thailand), Le Tuan Hoa (Vietnam), Li Pjak Hwee (Taiwan), Sapna Jain (India), Li Tsiu Kwaen (Taiwan), Li Xinhua (China), Qasier Mushtag (Pakistan), Ng Siu-Hung (USA), Nittiya Pabhapote (Thailand), G.C. Rao (India), Ren Xueming (China), Chan Roath (Cambodia), Ling San (Singapore), M.K. Sen (India), Polly W. Sy (Philippine), T. Vasanthi (India), S.P. Mahila Visvavidyalayam (India), Wang Ngai-Ching (Taiwan), Dong Chung Ying (USA), Zhou Yiqing (Canada).
Scientific Committee: Cho-Ho Chu (London), Yuqi Guo (Chongqing), Michel Jambu (Nice), Pavel Kolnesikov (Novosibirsk), Antony To-Ming (Alberta), Laszlo Marki (Budapest), Alexander V. Mikhalev (Moscow), Siu-Hung Ng (Ammes, Iowa), Claude Procesi (Rome), Lance Small (UC San Diego), Kyoji Saito (Kyoto), Agata Smoktuowicz (Edinburg), Eng-Che Tan (Singapore), Robert Wisbauer (Duesseldorf), Changchong Xi (Beijing), Jiping Zhang (Beijing), Efim Zelmanov (San Diego, Chairman).
Information: http://www.ugm.ac.id/ica2010.

* 11–15 **Numerical Methods for Continuous Optimization**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Overview: This workshop brings together experts on techniques currently being used or that could be used to solve sparse/structured problems and other problem classes of recent interest. We mention in particular techniques for conic optimization formulations, fast gradient and subgradient methods, stochastic approximation techniques, and semismooth Newton and other methods that use second-order information. The workshop will also involve nonlinear programming researchers.
Organizing Committee: Steven Wright, Don Goldfarb, Renato Monteiro, Yurii Nesterov, Michael Overton, Kim Toh.
Application/Registration: An application and registration form is available at: http://www.ipam.ucla.edu/programs/opws2. Applications received by August 16, 2010, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. You may also simply register and attend without IPAM funding.
Information: http://www.ipam.ucla.edu/programs/opws2/.

* 18–22 **IMA Workshop: Computing with Uncertainty: Mathematical Modeling, Numerical Approximation and Large Scale Optimization of Complex Systems with Uncertainty**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.
Description: Mathematical and computational models for an increasing number of complex systems in basic sciences, engineering and, increasingly, also in life sciences and socioeconomic modeling, involve uncertainty: the input data could be random parameters expressing information that may only be revealed in the future, or simply reflect measurement error or inherent variability. Uncertainty can also arise on a more primitive level due to insufficient knowledge about particular components of the system under consideration. We then not only

confront descriptive issues but also have to question the validity of the prescriptive implications we might derive from the solutions of such mathematical models in the presence of uncertainty. With the prodigious increase in computational capabilities, already seen and expected to continue, and accompanied by a corresponding increase in data, new strategies in mathematical and computational modeling as well as system optimization will be required.

Information: http://www.ima.umn.edu/2010-2011/W10.18-22.10/.

* 26–29 **Discrete Optimization**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

Overview: This workshop will bring together experts on the different facets of discrete optimization with the goal of further improving the cross-fertilization of ideas and techniques. Topics will include combinatorial algorithms and characterizations, polyhedral combinatorics and integer programming, graph theory, matroids and other fundamental combinatorial structures, and nonlinear approaches and problems.

Organizing Committee: Michel Goemans, Sanjeev Arora, Gerard Cornuejols, Jesus De Loera, Friedrich Eisenbrand, Matthias Koeppe.

Application/Registration: An application and registration form is available at: http://www.ipam.ucla.edu/programs/opws3. Applications received by August 30, 2010, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. You may also simply register and attend without IPAM funding.

Information: http://www.ipam.ucla.edu/programs/opws3/.

November 2010

* 1–5 **IMA Workshop: Numerical Solutions of Partial Differential Equations: Novel Discretization Techniques**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.

Description: This workshop will survey novel discretization techniques in numerical partial differential equations that address the computational challenges posed by higher dimensions, higher orders, complex spaces, complex geometries, nonlinearities and multiscales. The focus is on new and fundamental methodologies that impact diverse areas of numerical partial differential equations.

Topics: Discontinuous Galerkin methods, finite element exterior calculus, higher order methods, isogeometric analysis, mimetic finite difference methods, multiscale methods, reduced basis methods, sparse grids, and others.

Information: http://www.ima.umn.edu/2010-2011/W11.1-5.10/.

* 5–6 **IMA Special Event: Finite Element Circus Featuring a Scientific Celebration of Falk, Pasciak, and Wahlbin**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota

Description: The Finite Element Circus is a conference series with a rich history, focusing on new developments in the finite element method (FEM) and applications. FEM plays a crucial role in simulation of engineering, physical, biological, and other scientific phenomena. A driving force for its success has been its mathematical analysis, which has led to novel competitive methods and significant improvements to existing methods. In line with IMA's annual theme, the Fall 2010 Circus will be held at the IMA.

Information: http://www.ima.umn.edu/2010-2011/SW11.5-6.10/.

* 16–19 **Modern Trends in Optimization and Its Application**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

Overview: The workshop explores the robust optimization field, looking at ways to describe uncertainty, approximate the decision, or addressing dynamic problems where the uncertainty is partially revealed as time evolves. The workshop also includes several case studies in various application domains, ranging from signal processing, machine learning, communications, graph theory, circuit design, to finance and economics, logistics and operations research.

Organizing Committee: Aharon Ben-Tal, Dimitris Bertsimas, Jason Cong, Laurent El Ghaoui, Arkadi Nemirovski.

Application/Registration: An application and registration form is available at: http://www.ipam.ucla.edu/programs/opws4. Applications received by Sept. 20, 2010, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. You may also simply register and attend without IPAM funding.

Information: http://www.ipam.ucla.edu/programs/opws4.

* 29–December 3 **IMA Workshop: Numerical Solutions of Partial Differential Equations: Fast Solution Techniques**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.

Description: The amount of time required to solve the large scale problems arising from numerical partial differential equations is a major concern in using mathematical models based on partial differential equations. Various fast solution techniques, such as adaptive methods, domain decomposition methods and multilevel methods, have been developed to address this issue. This workshop will survey new developments and challenges in these and other fast solution techniques.

Information: http://www.ima.umn.edu/2010-2011/W11.29-12-3.10/.

December 2010

* 17–21 **The 15th Asian Technology Conference in Mathematics (ATCM 2010)**, University of Malaya, Kuala Lumpur, Malaysia.

Description: The theme of ATCM 2010 is "Linking Applications with Mathematics and Technology". 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. There will be over 400 participants coming from over 30 countries around the world.

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.

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

* 19–21 **"Mathematical Sciences for Advancement of Science and Technology" (MSAST 2010)**, IMBIC Hall, Salt Lake, Kolkata (Calcutta), India.

Description: The 4th International Conference is organized by the Institute for Mathematics, Bioinformatics, Information Technology and Computer Science (IMBIC). Authors are requested to submit the full original papers related to the Theme of the Conference: "Mathematical Sciences for Advancement of Science and Technology" with an abstract indicating the motivation of the problem, its method of solution and important results to the Secretary of IMBIC. All the papers are to be screened for presentation in the Conference.

Information: All correspondences in respect of the conference are to be addressed to Dr. Avishek Adhikari, Secretary, IMBIC, AH 317, Salt Lake City, Sector II, Kolkata 700091, West Bengal, India; email: avishek.adh@gmail.com; http://imbic.org/forthcoming.html.

January 2011

* 10–14 **IMA Workshop: High Performance Computing and Emerging Architectures**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.

Description: Recently, computational science has been offered the prospect of vast increases in capability, thanks to a paradigm shift in hardware architectures. The IT industry has sidestepped the bottlenecks it faced (memory, power, complexity) by opting for on-chip parallelism. This brought first the multi-core model, and now promises many-core as the future. In addition, we have a great opportunity in the tremendous computing power of graphics processors (GPUs). With this opportunity, however, comes the challenge of adapting the large toolbox of scientific computing to the unstoppable changes in computer architectures. The latest studies indicate that some algorithms have more potential than others for extracting performance from modern many-core architectures. A difficult task involves reformulating algorithms to adapt to the hardware in a resource-conscious way. This workshop will discuss the algorithms and their formulations for extracting performance of the modern architectures.

Information: `http://www.ima.umn.edu/2010-2011/W1.10-14.11/`.

February 2011

* 28–March 4 **IMA Workshop: Computing in Image Processing, Computer Graphics, Virtual Surgery, and Sports**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.

Description: This workshop focuses on the processing, modeling and simulation of image data, and in particular, data that is related to humans and human activities. The main core areas consist of image processing, computer graphics, virtual surgeries, and sport sciences. The modern world is full of image data that is not only gathered from the real world via various imaging mechanisms, but also produced through computer simulations in a wide range of virtual settings. In order for this image-based information to be useful, tasks such as cleaning up the images, segmenting special features from images, and comparing either the extracted features or the image data itself are essential. These tasks involve processing data that live in a wide range of dimensions, from two-dimensional image data to very high-dimensional data (e.g., the space of images), and require in depth mathematical analysis, modeling, and numerical algorithms.

Information: `http://www.ima.umn.edu/2010-2011/W2.28-3.4.11/`.

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

April 2011

* 11–15 **IMA Workshop: Societally Relevant Computing**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.

Description: Simulation and computation play a critical role in important societal problems. Examples include the role of anthropogenic emissions on climate and ocean circulation; the prediction of earthquakes and tsunamis; the prediction of paths and storm surges of hurricanes; designing infrastructure that is capable of withstanding disasters, such as floods and terrorist attacks; the design and long term durability of major infrastructure, such as bridges, tunnels, etc; the spread and containment of disease and epidemics, etc. These systems exhibit extreme complexity: there are a myriad of different issues that are critical and must be accurately addressed. Models contain and interface large numbers of physical effects. All of these problems represent grand challenge computer problems that require pushing the limits of technology, both with regards to algorithms and machines as well as the development of the physical models themselves.

Information: `http://www.ima.umn.edu/2010-2011/W4.11-15.11/`.

May 2011

* 1–August 31 **MITACS International Focus Period on Advances in Network Analysis and its Applications**, Locations throughout Canada.

Description: Starting in May 2010, MITACS (`http://www.mitacs.ca`) plans to hold an international focus period in Canada entitled, "Advances in Network Analysis and its Applications". The focus period will be run over one year and will consist of a number of scientific events including workshops, summer schools, industry-academic forums, short courses and public lectures around the topic of network analysis. MITACS would like to invite you to attend and participate in what will be a stimulating and productive series of events.

Focus Period Topics: Financial networks for risk assessment, Network security and cryptography, Social Networks, Biological networks and systems biology, Wireless and mobile computing, Internet and network economics.

Lead Organizer: Evangelos Kranakis, Carleton University.

Information: The focus period will be held at various Locations throughout Canada (see website for details: `http://www.mitacsfocusperiods.ca`).

June 2011

* 6–10 **IMA Workshop: Large-scale Inverse Problems and Quantification of Uncertainty**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.

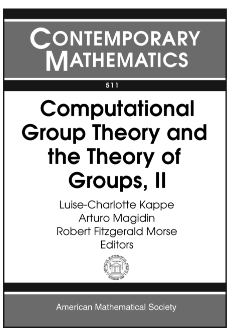
Description: Many classes of problems in computational science and engineering are characterized by a cycle of experiment design, observation, parameter/state estimation, prediction, and decision-making. The critical steps in this process involve: (1) modeling of the physical processes via, for example, PDEs; (2) estimating unknown parameters in the model from observational data via solution of an inverse problem; (3) propagation of input uncertainties through the model to issue predictions; and (4) determination of an optimal control or decision-making strategy that takes into account the uncertain outputs. The estimation of unknown model parameters or state from observational data, together with a model linking inputs to outputs, constitutes an inverse problem; it is called a statistical inverse problem when at least one of the components in this process is modeled as random. Data assimilation and joint inversion are two particular settings that have a wide range of applications.

Information: `http://www.ima.umn.edu/2010-2011/W6.6-10.2011/`.

New Publications Offered by the AMS

To subscribe to email notification of new AMS publications, please go to http://www.ams.org/bookstore-email.

Algebra and Algebraic Geometry



Computational Group Theory and the Theory of Groups, II

Luise-Charlotte Kappe, *Binghamton University, NY*, **Arturo Magidin**, *University of Louisiana at Lafayette, LA*, and **Robert Fitzgerald Morse**, *University of Evansville, IN*, Editors

This volume consists of contributions by researchers who were invited to the Harlaxton Conference on Computational Group Theory and Cohomology, held in August of 2008, and to the AMS Special Session on Computational Group Theory, held in October 2008.

This volume showcases examples of how computational group theory can be applied to a wide range of theoretical aspects of group theory. Among the problems studied in this book are classification of p-groups, covers of Lie groups, resolutions of Bieberbach groups, and the study of the lower central series of free groups. This volume also includes expository articles on the probabilistic zeta function of a group and on enumerating subgroups of symmetric groups.

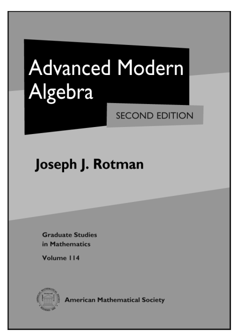
Researchers and graduate students working in all areas of group theory will find many examples of how computational group theory helps at various stages of the research process, from developing conjectures through the verification stage. These examples will suggest to the mathematician ways to incorporate computational group theory into their own research endeavors.

This item will also be of interest to those working in applications.

Contents: B. Benesh, The probabilistic Zeta function; **B. Eick** and **T. Rossmann**, Periodicities for graphs of p-groups beyond coclass; **G. Ellis**, **H. Mohammadzadeh**, and **H. Tavallaee**, Computing covers of Lie algebras; **D. F. Holt**, Enumerating subgroups of the symmetric group; **D. A. Jackson**, **A. M. Gaglione**, and **D. Spellman**, Weight five basic commutators as relators; **P. Moravec** and **R. F. Morse**, Basic commutators as relations: a computational perspective; **L.-C. Kappe** and **G. Mendoza**, Groups of minimal order which are not n-power closed; **L.-C. Kappe** and **J. L. Redden**, On the covering number of small alternating groups; **A. Magidin** and **R. F. Morse**, Certain homological functors of 2-generator p-groups of class 2; **M. Röder**, Geometric algorithms for resolutions for Bieberbach groups; **F. Russo**, Nonabelian tensor product of soluble minimax groups; **J. Schmidt**, Finite groups have short rewriting systems.

Contemporary Mathematics, Volume 511

May 2010, 200 pages, Softcover, ISBN: 978-0-8218-4805-0, LC 2009047805, 2000 *Mathematics Subject Classification:* 20-06, 20B40, 20B35, 17B55, 18G10, 20F12, 20F18, 20H15, 20J99, 20P05, **AMS members US$55**, List US$69, Order code CONM/511



Advanced Modern Algebra

Second Edition

Joseph J. Rotman, *University of Illinois at Urbana-Champaign, IL*

About the First Edition:

…a highly welcome enhancement to the existing textbook literature in the field of algebra.

— Zentralblatt fur Mathematik

This book is designed as a text for the first year of graduate algebra, but it can also serve as a reference since it contains more advanced topics as well. This second edition has a different organization than the first. It begins with a discussion of the cubic and quartic equations, which leads into permutations, group theory, and Galois theory (for finite extensions; infinite Galois theory is discussed later in the book). The study of groups continues with finite abelian groups (finitely generated groups are discussed later, in the context of module theory), Sylow theorems, simplicity of projective unimodular groups, free groups and presentations, and the Nielsen–Schreier theorem (subgroups of free groups are free).

The study of commutative rings continues with prime and maximal ideals, unique factorization, noetherian rings, Zorn's lemma and applications, varieties, and Gröbner bases. Next, noncommutative rings and modules are discussed, treating tensor product, projective, injective, and flat modules, categories, functors, and natural transformations, categorical constructions (including direct and inverse limits), and adjoint functors. Then follow group representations: Wedderburn–Artin theorems, character theory, theorems of Burnside and Frobenius, division rings, Brauer groups, and abelian categories. Advanced linear algebra treats canonical forms for matrices and the structure of modules over PIDs, followed by multilinear algebra.

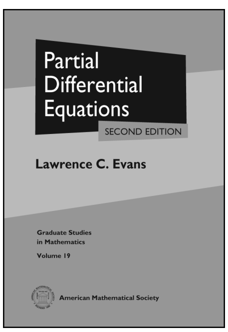
Homology is introduced, first for simplicial complexes, then as derived functors, with applications to Ext, Tor, and cohomology of groups, crossed products, and an introduction to algebraic K-theory. Finally, the author treats localization, Dedekind rings and algebraic number theory, and homological dimensions. The book ends with the proof that regular local rings have unique factorization.

Contents: Groups I; Commutative rings I; Fields; Groups II; Commutative rings II; Rings; Representation theory; Advanced linear algebra; Homology; Commutative rings III; Bibliography; Index.

Graduate Studies in Mathematics, Volume 114

August 2010, approximately 1015 pages, Hardcover, ISBN: 978-0-8218-4741-1, LC 2009052217, 2000 *Mathematics Subject Classification:* 11-XX, 12-XX, 13-XX, 15-XX, 16-XX, 18-XX, 19-XX, 20-XX, **AMS members US$79**, List US$99, Order code GSM/114

Differential Equations



Partial Differential Equations

Second Edition

Lawrence C. Evans, *University of California, Berkeley, CA*

This is the second edition of the now definitive text on partial differential equations (PDE). It offers a comprehensive survey of modern techniques in the theoretical study of PDE with particular emphasis on nonlinear equations. Its wide scope and clear exposition make it a great text for a graduate course in PDE. For this edition, the author has made numerous changes, including

- a new chapter on nonlinear wave equations
- more than 80 new exercises
- several new sections
- a significantly expanded bibliography

About the First Edition:

I have used this book for both regular PDE and topics courses. It has a wonderful combination of insight and technical detail. … Evans' book is evidence of his mastering of the field and the clarity of presentation.

—***Luis Caffarelli, University of Texas***

It is fun to teach from Evans' book. It explains many of the essential ideas and techniques of partial differential equations … Every graduate student in analysis should read it.

—***David Jerison, MIT***

I use Partial Differential Equations *to prepare my students for their Topic exam, which is a requirement before starting working on their dissertation. The book provides an excellent account of PDE's … I am very happy with the preparation it provides my students.*

—***Carlos Kenig, University of Chicago***

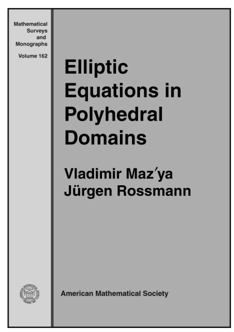
Evans' book has already attained the status of a classic. It is a clear choice for students just learning the subject, as well as for experts who wish to broaden their knowledge … An outstanding reference for many aspects of the field.

—***Rafe Mazzeo, Stanford University***

Contents: Introduction; *Representation formulas for solutions:* Four important linear partial differential equations; Nonlinear first-order PDE; Other ways to represent solutions; *Theory for linear partial differential equations:* Sobolev spaces; Second-order elliptic equations; Linear evolution equations; *Theory for nonlinear partial differential equations:* The calculus of variations; Nonvariational techniques; Hamilton–Jacobi equations; Systems of conservation laws; Nonlinear wave equations; Appendices; Bibliography; Index.

Graduate Studies in Mathematics, Volume 19

April 2010, 749 pages, Hardcover, ISBN: 978-0-8218-4974-3, LC 2009044716, 2010 *Mathematics Subject Classification:* 35-XX; 49-XX, 47Hxx, **AMS members US$74**, List US$93, Order code GSM/19.R



Elliptic Equations in Polyhedral Domains

Vladimir Maz′ya, *Linköping University, Sweden*, and **Jürgen Rossmann**, *Rostock University, Germany*

This is the first monograph which systematically treats elliptic boundary value problems in domains of polyhedral type. The authors mainly describe their own recent results focusing on the Dirichlet problem for linear strongly elliptic systems of arbitrary order, Neumann and mixed boundary value problems for second order systems, and on boundary value problems for the stationary Stokes and Navier–Stokes systems. A feature of the book is the systematic use of Green's matrices. Using estimates for the elements of these matrices, the authors obtain solvability and regularity theorems for the solutions in weighted and non-weighted Sobolev and Hölder spaces. Some classical problems of mathematical physics (Laplace and biharmonic equations, Lamé system) are considered as examples. Furthermore, the book contains maximum modulus estimates for the solutions and their derivatives.

The exposition is self-contained, and an introductory chapter provides background material on the theory of elliptic boundary value problems in domains with smooth boundaries and in domains with conical points.

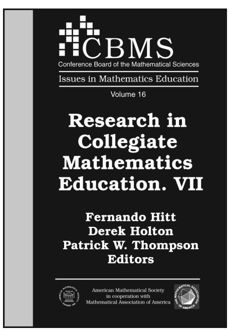
The book is destined for graduate students and researchers working in elliptic partial differential equations and applications.

Contents: Introduction; *The Dirichlet problem for strongly elliptic systems in polyhedral domains:* Prerequisites on elliptic boundary value problems in domains with conical points; The Dirichlet problem for strongly elliptic systems in a dihedron; The Dirichlet problem for strongly elliptic systems in a cone with edges; The Dirichlet problem in a bounded domain of polyhedral type; The Miranda-Agmon maximum principle; *Neumann and mixed* *boundary value problems for second order systems in polyhedral domains:* Boundary value problems for second order systems in a dihedron; Boundary value problems for second order systems in a polyhedral cone; Boundary value problems for second order systems in a bounded polyhedral domain; *Mixed boundary value problems for stationary Stokes and Navier-Stokes systems in polyhedral domains:* Boundary value problem for the Stokes system in a dihedron; Mixed boundary value problems for the Stokes system in a polyhedral cone; Mixed boundary value problems for the Stokes and Navier-Stokes systems in a bounded domain of polyhedral type; Historical remarks; Bibliography; Index; List of symbols.

Mathematical Surveys and Monographs, Volume 162

April 2010, 605 pages, Hardcover, ISBN: 978-0-8218-4983-5, LC 2009053203, 2000 *Mathematics Subject Classification:* 35J57, 35J58, 35J25, 35J40, 35J08, 35J05, 35Q30, **AMS members US$98**, List US$123, Order code SURV/162

General and Interdisciplinary



Research in Collegiate Mathematics Education. VII

Fernando Hitt, *Université du Québec á Montréal, QC, Canada*, **Derek Holton**, *University of Melbourne, Parkville, Victoria, Australia*, and **Patrick W. Thompson**, *Arizona State University, Tempe, AZ*, Editors

The present volume of *Research in Collegiate Mathematics Education*, like previous volumes in this series, reflects the importance of research in mathematics education at the collegiate level. The editors in this series encourage communication between mathematicians and mathematics educators, and as pointed out by the International Commission of Mathematics Instruction (ICMI), much more work is needed in concert with these two groups. Indeed, editors of RCME are aware of this need and the articles published in this series are in line with that goal.

Nine papers constitute this volume. The first two examine problems students experience when converting a representation from one particular system of representations to another. The next three papers investigate students learning about proofs. In the next two papers, the focus is instructor knowledge for teaching calculus. The final two papers in the volume address the nature of "conception" in mathematics.

Whether they are specialists in education or mathematicians interested in finding out about the field, readers will obtain new insights about teaching and learning and will take away ideas that they can use.

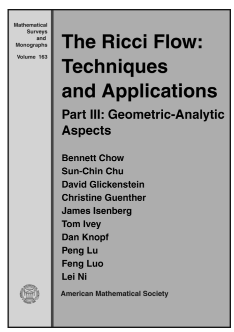
This series is published in cooperation with the Mathematical Association of America.

Contents: R. Zazkis and **N. Sirotic**, Representing and defining irrational numbers: Exposing the missing link; **M. C. Machín**, **R. D. Rivero**, and **M. Santos-Trigo**, Students' use of *Derive* software in comprehending and making sense of definite integral and area concepts; **L. Alcock**, Mathematicians' perspectives on the teaching and learning of proof; **L. Alcock** and **K. Weber**, Referential and syntactic approaches to proving: Case studies from a transition-to-proof course; **A. Brown**, **M. A. McDonald**, and **K. Weller**, Step by step: Infinite iterative processes and actual infinity; **D. T. Kung**, Teaching assistants learning how students think; **K. S. Sofronas** and **T. C. DeFranco**, An examination of the knowledge base for teaching among mathematics faculty teaching calculus in higher education; **N. Balacheff** and **N. Gaudin**, Modeling students' conceptions: The case of function; **V. Mesa**, Strategies for controlling the work in mathematics textbooks for introductory calculus.

CBMS Issues in Mathematics Education, Volume 16

April 2010, 261 pages, Softcover, ISBN: 978-0-8218-4996-5, 2000 *Mathematics Subject Classification:* 97Axx, 97Cxx, 97Dxx, 97Fxx, 97Ixx, 97Uxx, 97-XX, 00-XX, **AMS members US$47**, List US$59, Order code CBMATH/16

Geometry and Topology



The Ricci Flow: Techniques and Applications

Part III: Geometric-Analytic Aspects

Bennett Chow, *University of California, San Diego, La Jolla, CA*, **Sun-Chin Chu**, *National Chung Cheng University, Chia-Yi, Taiwan*, **David Glickenstein**, *University of Arizona, Tucson, AZ*, **Christine Guenther**, *Pacific University, Forest Grove, OR*, **James Isenberg**, *University of Oregon, Eugene, OR*, **Tom Ivey**, *College of Charleston, SC*, **Dan Knopf**, *University of Texas, Austin, TX*, **Peng Lu**, *University of Oregon, Eugene, OR*, **Feng Luo**, *Rutgers University, Piscataway, NJ*, and **Lei Ni**, *University of California, San Diego, La Jolla, CA*

The Ricci flow uses methods from analysis to study the geometry and topology of manifolds. With the third part of their volume on techniques and applications of the theory, the authors give a presentation of Hamilton's Ricci flow for graduate students and mathematicians interested in working in the subject, with an emphasis on the geometric and analytic aspects.

The topics include Perelman's entropy functional, point picking methods, aspects of Perelman's theory of κ-solutions including the κ-gap theorem, compactness theorem and derivative estimates, Perelman's pseudolocality theorem, and aspects of the heat equation with respect to static and evolving metrics related to Ricci flow. In the appendices, we review metric and Riemannian geometry including the space of points at infinity and Sharafutdinov retraction for complete noncompact manifolds with nonnegative sectional curvature. As in the previous volumes, the authors have endeavored, as much as possible, to make the chapters independent of each other.

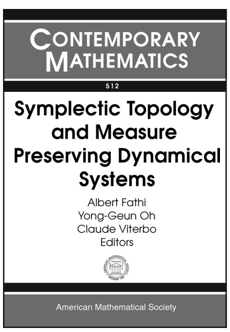
The book makes advanced material accessible to graduate students and nonexperts. It includes a rigorous introduction to some of Perelman's work and explains some technical aspects of Ricci flow useful for singularity analysis. The authors give the appropriate references so that the reader may further pursue the statements and proofs of the various results.

This item will also be of interest to those working in analysis.

Contents: Entropy, μ-invariant, and finite time singularities; Geometric tools and point picking methods; Geometric properties of κ-solutions; Compactness of the space of κ-solutions; Perelman's pseudolocality theorem; Tools used in proof of pseudolocality; Heat kernel for static metrics; Heat kernel for evolving metrics; Estimates of the heat equation for evolving metrics; Bounds for the heat kernel for evolving metrics; Elementary aspects of metric geometry; Convex functions on Riemannian manifolds; Asymptotic cones and Sharafutdinov retraction; Solutions to selected exercises; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 163

June 2010, approximately 525 pages, Hardcover, ISBN: 978-0-8218-4661-2, LC 2007275659, 2010 *Mathematics Subject Classification:* 53C44, 53C25, 58J35, 35K55, 35K05, 35K08, 35K10, 53C21, **AMS members US$90**, List US$113, Order code SURV/163



Symplectic Topology and Measure Preserving Dynamical Systems

Albert Fathi, *École Normale Supérieure de Lyon, France*, **Yong-Geun Oh**, *University of Wisconsin, Madison, WI*, and **Claude Viterbo**, *École Polytechnique, Palaiseau, France*, Editors

The papers in this volume were presented at the AMS-IMS-SIAM Joint Summer Research Conference on Symplectic Topology and Measure Preserving Dynamical Systems held in Snowbird, Utah in July 2007.

The aim of the conference was to bring together specialists of symplectic topology and of measure preserving dynamics to try to connect these two subjects. One of the motivating conjectures at the interface of these two fields is the question of whether the group of area preserving homeomorphisms of the 2-disc is or is not simple. For diffeomorphisms it was known that the kernel of the Calabi invariant is a normal proper subgroup, so the group of area preserving diffeomorphisms is not simple. Most articles are related to understanding these and related questions in the framework of modern symplectic topology.

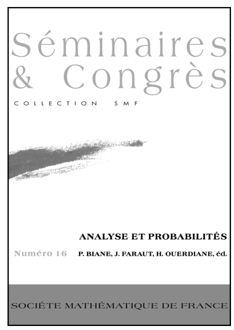
Contents: **A. Banyaga**, A Hofer-like metric on the group of symplectic diffeomorphisms; **M. Entov** and **L. Polterovich**, C^0-rigidity of Poisson brackets; **F. Le Roux**, Six questions, a proposition and two pictures on Hofer distance for Hamiltonian diffeomorphisms on surfaces; **J. N. Mather**, Order structure on action minimizing orbits; **D. McDuff**, Loops in the Hamiltonian group: A survey; **Y.-G. Oh**, The group of Hamiltonian homeomorphisms and continuous Hamiltonian flows.

Contemporary Mathematics, Volume 512

May 2010, 177 pages, Softcover, ISBN: 978-0-8218-4892-0, LC 2009051896, 2000 *Mathematics Subject Classification:* 57R17, 37J05, 28D05, 37A15, **AMS members US$55**, List US$69, Order code CONM/512

New AMS-Distributed Publications

Analysis



Analyse et Probabilités

Philippe Biane, *École Normale Supérieure, Paris, France*, **Jacques Faraut**, *Université Pierre et Marie Curie, Paris, France*, and **Habib Ouerdiane**, *Université de Tunis, El Manar, Tunisia*, Editors

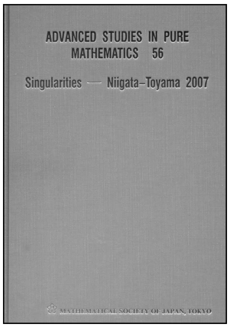
The International Congress on Analysis and Probability, held in Hammamet, Tunisia, in 2003, was organized under the aegis of the French Mathematical Society and the Tunisian Mathematical Society. The aim of this conference was to present recent developments in analysis, mainly in harmonic analysis and probability, stressing their interplay. The papers in this volume, originating from talks given at this conference, are related to stochastic analysis, harmonic analysis, and partial differential equations.

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: **T. Deck**, Holomorphic functionals of complex processes; **U. C. Ji** and **N. Obata**, Generalized white noise operator fields and quantum white noise derivatives; **S. H. Djah**, **H. Gottschalk**, and **H. Ouerdiane**, Feynman graphs for non-Gaussian measures; **G. Di Nunno**, On orthogonal polynomials and the Malliavin derivative for Lévy stochastic measures; **G. Di Nunno** and **B. Øksendal**, The Donsker delta function, a representation formula for functionals of a Lévy process and application to hedging in incomplete markets; **U. Franz**, Boolean convolution of probability measures on the unit circle; **J. Faraut**, Loi du demi-cercle de Wigner et polynômes de Laguerre; **P. Krée**, Problèmes liés aux contrôles de taille legendriens. I. Premiers résultats généraux et premières interactions; **S. B. Saïd** and **B. Ørsted**, On contractions of hypergeometric functions associated with root systems; **S. B. Saïd** and **B. Ørsted**, On Fock spaces and $sl(2)$-triples for Dunkl operators; **S. Mustapha**, Principe SAK de Fefferman et puissances d'opérateurs pseudo-différentiels; **N. Belhaj Rhouma**, **M. Bezzarga**, and **M. Mosbah**, On the solutions of noncooperative system of elliptic equations in $\mathbb{R}^d$.

Séminaires et Congrès, Number 16

July 2009, 232 pages, Softcover, ISBN: 978-2-85629-238-9, 2000 *Mathematics Subject Classification:* 33C45, 33C67, 46G20, 47G30, 60G07, 60H07, 60H40, **Individual member US$63**, List US$70, Order code SECO/16



Singularities—Niigata–Toyama 2007

Jean-Paul Brasselet, *CNRS, Marseille, France*, **Shihoko Ishii**, *Tokyo Institute of Technology, Japan*, **Tatsuo Suwa**, *Niigata University, Japan*, and **Michel Vaquie**, *Université de Toulouse, France*, Editors

This volume constitutes the proceedings of the Fourth Franco–Japanese Symposium on Singularities held at Toyama in August 2007 and also the Workshop on Singularities held at Niigata prior to this symposium. Research on singularities is widely expanding and is now applied in various areas in mathematics and other sciences. Experts in singularities from many different fields have contributed their articles, mostly on original results and some surveys. The reader will learn about the vividly developing domains and will be inspired by many different approaches to singularities.

This item will also be of interest to those working in algebra and algebraic geometry.

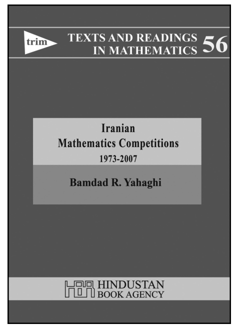
Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Contents: T. Ashikaga and **K.-I. Yoshikawa**, A divisor on the moduli space of curves associated to the signature of fibered surfaces (with an appendix by Kazuhiro Konno); **K. Konno**, Appendix to "A divisor on the moduli space of curves associated to the signature of fibered surfaces" by T. Ashikaga and K.-I. Yoshikawa; **T. Asuke**, On the Fatou–Julia decomposition of transversally holomorphic foliations of complex codimension one; **J.-P. Brasselet**, Characteristic classes along the Japanese singularity road; **A. Degtyarev**, On irreducible sextics with non-abelian fundamental group; **A. Degtyarev** and **M. Oka**, A plane sextic with finite fundamental group; **C. Eyral** and **M. Oka**, A proof of a conjecture of Degtyarev on non-torus plane sextics; **G. Gonzalez-Sprinberg**, On Nash blow-up of orbifolds; **K. Hasegawa**, Complex and Kähler structures on compact homogeneous manifolds—their existence, classification and moduli problem; **H. Ishida** and **H. Tokunaga**, Triple covers of algebraic surfaces and a generalization of Zariski's example; **S. Ishii**, Smoothness and jet schemes; **M. Ishikawa**, On the contact structure of a class of real analytic germs of the form $f\bar{g}$; **M. Oka**, Topology of abelian pencils of curves; **O. Riemenschneider**, Simple analytic proofs of some versions of the abstract Prime Number Theorem; **I. Shimada**, Non-homeomorphic conjugate complex varieties; **M. Shubladze**, On the middle Betti number of certain singularities with critical locus a hyperplane; **T. Suwa**, Čech–Dolbeault cohomology and the $\bar{\partial}$-Thom class; **S. Tajima**, **Y. Nakamura**, and **K. Nabeshima**, Standard bases and algebraic local cohomology for zero dimensional ideals; **S. Yokura**, A universal bivariant theory and cobordism groups.

Advanced Studies in Pure Mathematics, Volume 56

November 2009, 408 pages, Hardcover, ISBN: 978-4-931469-55-6, 2000 *Mathematics Subject Classification:* 32Sxx; 14B05, 14B07, 14J17, **AMS members US$58**, List US$72, Order code ASPM/56

General and Interdisciplinary



Iranian Mathematics Competitions, 1973–2007

Bamdad R. Yahaghi, *University of Golestan, Iran*

This book presents a collection of problems from an annual competition for college students organized by the Iranian Mathematical Society. The author has compiled problems from these competitions between 1973 to 2007 and provided solutions to most of them.

Students from Iran have done very well in international mathematics competitions and, to some extent, that is a reflection on the training they receive in special courses. Students of mathematics everywhere, whether preparing for competitions or for advanced studies, can sharpen their skills by solving the problems in this book. The book will be a valuable resource for teachers as well.

A publication of Hindustan Book Agency. Distributed on an exclusive basis by the AMS in North America. Online bookstore rights worldwide.

Contents: Part 1. Problems; Part 2. Solutions; Part 3. Problem Index; Index.

Hindustan Book Agency

January 2010, 300 pages, Hardcover, ISBN: 978-81-85931-99-9, 2000 *Mathematics Subject Classification:* 00A07, 97U40, **AMS members US$37**, List US$46, Order code HIN/45

Classified Advertisements

Positions available, items for sale, services available, and more

CALIFORNIA

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875

The Department of Mathematics at the University of California, Irvine invites applications from outstanding candidates for multiple positions, including: Lecturer with Potential Security of Employment, Visiting Assistant Professors (VAP), and a newly endowed chair—the UCI Excellence in Teaching Endowed Chair in Mathematics. The VAP position is a temporary teaching and research position for up to three years. The endowed chair is a tenured faculty position. The LPSOE position is a tenure-track teaching position designed to meet the long-term instructional needs of the university.

Applicants must hold a Ph.D. Tenure-track/tenured position candidates should have demonstrated excellence in research and teaching. The level of appointment will be commensurate with qualifications and experience. An excellent record of teaching and outreach activities is required for LPSOE candidates. VAP candidates must show strong promise in research and teaching. Please see the advertisement on `MathJobs.org` for a full list of qualifications for each position.

Applications are welcome at any time. The review process starts February 1, 2010, and will continue until positions are filled. Please visit: `http://www.mathjobs.org` for details on positions and the application process.

The University of California, Irvine, is an Equal Opportunity Employer committed to excellence through diversity and strongly encourages applications from all qualified applicants, including women and minorities. UCI is responsive to the needs of dual career couples, is dedicated to work-life balance through an array of family-friendly policies, and is the recipient of an NSF ADVANCE Award for gender equity.

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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 2011. 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$38,000. 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 June 30, 2010.

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KOREA

Korea Institute for Advanced Study (KIAS)
Postdoctoral Research Fellowships

The School of Mathematics at the Korea Institute for Advanced Study (KIAS) invites applicants for the positions at the level of postdoctoral research fellows in pure and applied mathematics. KIAS, founded in 1996, is committed to the excellence of research in basic sciences (mathematics, theoretical physics, and computational sciences) through high-quality research programs and a strong faculty body consisting of distinguished scientists and visiting scholars. Applicants are expected to have demonstrated exceptional research potential, through the doctoral dissertation and beyond. The annual salary ranges from approximately ₩32,000,000–₩46,000,000 (equivalent

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 2010 rate is $3.25 per word. 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: May 2010 issue–February 26, 2010; June/July 2010 issue–April 28, 2010; August 2010 issue–May 28, 2010; September 2010 issue–June 28, 2010; October 2010 issue–July 29, 2010; November 2010 issue–August 30, 2010.

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.

to US$29,000–US$42,000). In addition, research fund in the amount of approximately ₩7,000,000–₩10,000,000 (equivalent to US$6,400–US$9,000) is provided each year. Appointments may start as early as September 1, 2010. The initial appointment will be for two years with a possibility of renewal for two additional years. Those interested are encouraged to contact a faculty member in their research areas at: `http://www.kias.re.kr/en/about/members.jsp`. Also, for more information please visit: `http://www.kias.re.kr/en/notice/job_opportunity.jsp`. Applicants should send a cover letter specifying the research area, a curriculum vita with a list of publications, and a summary of research plan, and arrange three recommendation letters to be sent to:

School of Mathematics,
Mr. Kang Won Lee; `kwlee@kias.re.kr`
KIAS, 207-43 Cheongnyangni 2-dong
Dongdaemun-gu, Seoul,
130-722, Korea

Email applications are strongly encouraged. We review the applications twice a year; the deadlines are June 30 and December 31.

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SLOVENIA

UNIVERSITY OF NOVA GORICA
Mathematics Department

University of Nova Gorica (Slovenia) invites applications for a one-year tenure-track assistant professor (or higher) position in mathematics with a possible continuation to a tenured position starting in September 2010. A Ph.D. in mathematics or a related area is required and preference will be given to candidates with some postdoctoral experience. Applicants with research interests in all areas of mathematics will be considered. Interested applicants should submit the following: curriculum vitae, including the list of publications; outline of teaching philosophy; a statement of research objectives; and three letters of reference, at least one of which addresses the applicant's teaching ability and potential. Application materials should be sent to Prof. Gvido Bratina, University of Nova Gorica, Vipavska, 13, 5000, Nova Gorica, Slovenia or to: `gvido.bratina@ung.si`. Informal enquiries can be made at any time to: Professor Gvido Bratina; email: `gvido.bratina@ung.si`.

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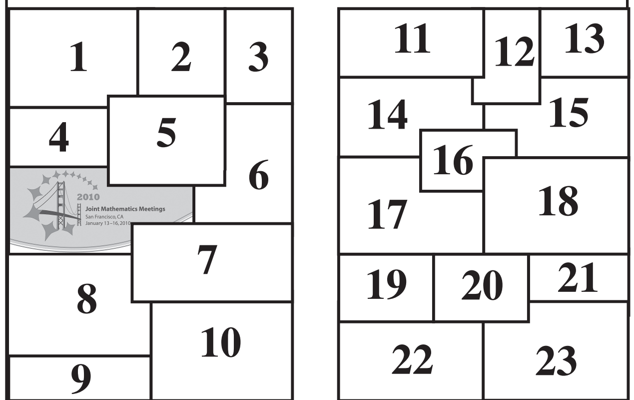
2010 San Francisco, CA, Joint Mathematics Meetings Photo Key



(Page 496) (Page 497)

1. AMS Booth, Exhibits area.
2. Employment Center entrance.
3. AMS Colloquium Lecturer Richard Stanley.
4. Distinguished Public Service Award winner Carlos Castillo-Chavez.
5. AMS executive directors, l. to r.: John Ewing (1995–2009), Donald McClure (present), and William Jaco (1988–1995).
6. AMS banquet.
7. Email Center.
8. Who Wants to Be a Mathematician host Mike Breen.
9. Prizewinner, Mathematical Art Exhibit.
10. Special Session talk.
11. Contestants, Who Wants to Be a Mathematician.
12. Exhibitor displaying his wares.
13. MAA-AMS Graduate Student Fair.
14. Opening Day, JMM Exhibits.
15. Employment Center.
16. Robbins Prize winner Ileana Streinu.
17. MAA booth, Exhibits area.
18. Officials at opening of Exhibits area—l. to r.: Gerard Venema (MAA), Tina Straley (MAA), Robert Daverman (AMS), Donald McClure (AMS), David Bressoud (MAA), George Andrews (AMS), Martha Siegel (MAA).
19. Douglas Arnold (SIAM) presents Morgan Prize to winner Scott Kominer.
20. Veblen Prize winner Paul Seidel.
21. George Andrews presents Steele Prize for Lifetime Achievement to William Fulton.
22. Mathematical Art Exhibition.
23. Future mathematicians?

International Congress of Mathematicians Hyderabad, India August 19–27, 2010

www.icm2010.org.in

Second Announcement

The Executive Organizing Committee of the International Congress of Mathematicians, on behalf of the International Mathematical Union, extends an open invitation to attend the Congress being held in Hyderabad, India, during the period 19th to 27th August, 2010.

The International Congress of Mathematicians (ICM), is the most important international mathematical conference held once every four years. Mathematicians from every continent gather to take stock of the state of their subject and to determine possible future directions. The Indian mathematical community is proud to host the next ICM at Hyderabad—the first time the ICM will be held in India. As in the past the ICM 2010 will be a major mathematical event bringing together mathematicians from all over the world seeking to demonstrate that mathematics plays a vital role in science and society.

This announcement contains useful information about the Congress including the list of plenary and invited speakers, instructions for registrations and submission of abstracts, information on accommodation in Hyderabad, the cultural programs during the Congress, and a list of the satellite conferences.

Contents

A. Location of the Congress

A1. Venue

Hyderabad International Convention Centre
Novotel and HICC Complex (Near Hitec City)
P.O. Bag 1101, Cyberabad Post Office
Hyderabad-500 081, India
Telephone: + 91 40 66824422/ 66134422
Fax: + 91 40 66844422
Mob: + 91 97033 32725
Email: garora@hicc.com

The Hyderabad International Convention Centre (HICC) is a state-of-the-art convention facility with comprehensive facilities for large international conventions, exhibitions and smaller meetings. All required services—a five-star hotel, wi-fi facilities, speaker preparation rooms, ample registration area, break-out rooms, restaurants, foreign exchange ATM—are available at the venue.

A.2 Access

This convention centre is located within the newly-developed Cybercity that has facilities and offices of some of the world's leading consulting and software companies. The new Rajiv Gandhi International airport is well-connected to the city by many roads and an expressway. It is about 40 minutes' drive from HICC. The main railway station at Secunderabad is 12 kms away and is a 40 minutes' drive. There are many taxi services on call. Connection from Hyderabad Airport to the Conference centre: Taxis/Cabs are available at the Airport and cost about Rs.550; they take about 35 minutes to reach the Conference Centre by the Outer Ring Road. By AERO EXPRESS (Airport Shuttle): These coaches operate on the route Airport - Shilparamam - Airport which would take about 60 mins one way in peak hours and 45 mins in normal traffic hours. These coaches will run one every hour from airport throughout the day. The fare is Rs. 150 (one way). The Convention Centre is a couple of kilometres from Shilparamam. Connection from Train Stations to Congress Centre: Taxis/cabs can be hired to reach Congress Centre—From Secunderabad Railway Station it costs about Rs. 450, from Nampally Railway Station it costs about Rs. 350, and from Kacheguda Railway Station it is about Rs. 400. The other option is to take MMTS train to reach hi-tech city station and from there to take an auto to reach Congress Centre. This would cost about Rs.60. Airport-hotel transfer will be arranged by the local organizers for all registered delegates who book their accommodation through us and who arrive on the 18th or 19th of August.

A.3 Secretariat

ICM 2010 Secretariat
Department of Mathematics and Statistics,
University of Hyderabad, Gachibowli,
Hyderabad 500 046, India.
Phone: +91 40 2313 4006 Fax: +91 40 2301 1089
Email: rtsm@uohyd.ernet.in

ICM 2010 Technical Secretariat
KW Conferences P Ltd.,
A 56/12 DLF Phase I,
Gurgaon 122002 India.
Phone: +91 124 4636700 Fax: + 91 124 410 2075
Email: icm2010@kwconferences.com

B. Important Dates

- January 1: Registration begins—currently on.
- Currently on: Submission of abstracts of short communications, posters and mathematical software.
- February 15: Last date for applications for financial support for Indians.
- March 15: Deadline for submission of abstracts of short communications, posters and mathematical software.
- March 31: Last date for informing successful Indian applicants for financial support.
- March 31: Deadline for international participants to apply for free local hospitality.
- May 15: Deadline for registration at a reduced rate.
- August 16–17: General Assembly at Bangalore
- August 10: Online registration closes.
- August 18: Over the counter registration at HICC, 9 am to 8 pm.
- August 19–27: ICM in Hyderabad

C. Scientific Program

C1. Plenary and Special Lectures

- The ABEL LECTURE sponsored by the Norwegian Academy of Sciences will be delivered by S. R. Srinivasa Varadhan, USA.
- The EMMY NOETHER LECTURE, one of the "special activities" of an ICM, will be delivered by Idun Reiten, Norway.

On the recommendation of the Program Committee appointed by the International Mathematical Union, the Organizing Committee of the ICM 2010 has invited 20 outstanding mathematicians to give one-hour plenary lectures. Their names and affiliations are as follows.

1. David Aldous - University of California at Berkeley, U.S.A.
2. Artur Avila - IMPA, Rio de Janeiro, Brazil
3. R. Balasubramanian - IMSc, Chennai, India
4. Jean-Michel Coron - Université Pierre et Marie Curie, Paris, France
5. Irit Dinur - Hebrew University, Jerusalem, Israel
6. Hillel Furstenberg - Northwestern University, U.S.A.
7. Thomas J.R. Hughes - University of Texas at Austin, U.S.A.
8. Peter Jones - Yale University, U.S.A.
9. Carlos Kenig - University of Chicago, U.S.A.
10. Ngo Bao Chau - Institute for Advanced Studies, Princeton, U.S.A.
11. Stanley Osher - U.C.L.A., U.S.A.
12. R. Parimala - Emory University, U.S.A.
13. A.N. Parshin - Steklov Mathematical Institute, Moscow, Russia
14. Shige Peng - Shandong University, P.R. of China
15. Kim Plofker - Union College, U.S.A.
16. Nokalai Reshetikhin - University of California at Berkeley, U.S.A.
17. Richard Schoen - Stanford University, U.S.A.
18. Cliff Taubes - Harvard University, U.S.A.
19. Claire Voisin - Institut de Mathématiques de Jussieu, Paris, France
20. Hugh Woodin - University of California at Berkeley, U.S.A.

The plenary lectures will be delivered in Hall 4 of the HICC. The opening ceremony will be in Halls 3 and 4. Each hall has about 2000 seats.

C2. Invited Section Lectures

On the recommendation of the Program Committee appointed by the International Mathematical Union, the Organizing Committee of the ICM 2010 has invited 167 outstanding mathematicians to give 45-minute sectional lectures. In these lectures the speakers highlight significant recent work in their respective areas. The list of sections are given below and the list of speakers can be found in `http://www.icm2010.org.in/program/invitedspeakers`. The numbers in brackets indicate the number of lectures.

1. Logic and Foundations (4).
2. Algebra (7).
3. Number Theory (11).
4. Algebraic and Complex Geometry (11).
5. Geometry (13).
6. Topology (12).
7. Lie Theory and Generalization (9).
8. Analysis (8).
9. Functional Analysis Applications (6).
10. Dynamical Systems and Ordinary Differential Equations (10).
11. Partial Differential Equations (10).
12. Mathematical Physics (10).
13. Probability and Statistics (13).
14. Combinatorics (9).
15. Mathematical Aspects of Computer Science (7).
16. Numerical Analysis and Scientific Computing (6).
17. Control Theory and Optimization (7).
18. Mathematics in Science and Technology (9).
19. Mathematics Education and Popularization of Mathematics (3).
20. History of Mathematics (3).

In addition there will be three panel discussions under section 19:

(1) Ethnomathematics, language and socio-cultural issues.
(2) Relations between the discipline and School Mathematics.
(3) Communicating mathematics to society at large.

There will be a general panel discussion on "The Pipeline Report" and a Round Table on "The use of metrics in evaluating research".

C3. Short Communications, Posters, and Mathematical Software

Registered participants will have the opportunity to present their mathematical work in the form of short communications, posters, or contributions on mathematical software. Only one of these three possibilities will be allowed for each participant.

Besides this formal framework, it will also be possible to organize ad hoc sessions during the Congress.

Short Communications
Short communications are oral presentations of mathematical work. Sessions will be organized according to the scientific sections of the ICM 2010. Each communication should last up to 15 minutes, including discussion. Rooms for short communications will be equipped with an overhead projector.

Poster

A poster is a display on some flat material, usually stiff paper or cardboard, synthesizing the main points of a mathematical work in a visually attractive layout that can be quickly grasped by other mathematicians.

The Local Program Committee strongly recommends scientific contributions in the form of posters. Poster sessions provide a pleasant interaction between colleagues, offering the possibility of discussion in an informal and relaxed atmosphere.

Poster sessions will take place in an exhibit area. They will also be organized according to the scientific sections of the ICM 2010. The precise panel location and timetable for authors to be present and available for questions and discussions will be communicated in due course. Posters will be affixed to ad-hoc vertical panels with two-sided adhesive tape provided by the organization. A panel of 1 m (height) × 2.50 m (width) will be allowed for each poster.

Authors should prepare their posters in advance. Their contribution to the success of the congress will be greatly appreciated.

Mathematical Software

The main purpose of the sessions on mathematical software is to give an overview of the state of the art, highlighting the current research and its main developments. They are aimed at attracting a broad audience, including researchers, students, teachers, etc., with a particular focus on software topics.

Sessions will be devoted to presenting mathematical software systems or mathematical applications, either of general scope or focused on particular areas. Implementations of especially designed algorithms solving particular mathematical problems of research interest are also welcome. Contributions should meet the highest standards. Mathematical originality, new solutions to relevant problems, or unusual fields of application will be appreciated. Within this framework, submission from any mathematical field using software systems will be considered; for instance, numerical analysis, computer algebra, optimization, mathematical visualization, mathematical education software, etc.

Systems that are available free of charge (e.g., public domain) are particularly welcome and clearly preferred. It should be emphasized that this is a scientific section of the Congress with no commercial aim. Established companies in software systems can offer their products in booths especially designed for commercial exhibitors.

Each contribution should last up to 15 minutes, including discussion. The room for contributions on mathematical software will be equipped with video projector and computer. It is the responsibility of contributors to obtain any required permission and license for material contained in their presentations.

C4. Instructions for Submissions of Abstracts

Participants can submit abstracts for short communications, posters, and mathematical software by following the instructions on the website `http://www.icm2010.org.in/article-submission/communications-posters`. The deadline for submissions is March 15, 2010. Only those who pay their registration fees by April 30, 2010, will be allowed to make presentations of their short communications, posters, and mathematical software at the Congress.

The Local Program Committee will notify authors of the acceptance or rejection of their contribution.

Abstracts of short communications should be written in English using the LaTeX (2e) template available on the Congress website. Authors should submit both a LaTeX file and a PDF file. The text of the abstract should contain a clear statement of the results and their context. The length using the LaTeX template should not exceed one page.

Abstracts of accepted communications will be published in the abstract booklet of the ICM 2010.

D. Publications

D1. Proceedings

Proceedings of the ICM 2010 will be published by Hindustan Book Agency (`http://www.hindbook.com`). The Proceedings will consist of three/four volumes containing articles based on plenary lectures and invited section lectures, the Abel and Noether lectures, as well as articles based on lectures delivered by the recipients of the Fields Medal, the Nevanlinna, Gauss, and Chern Prizes. The first volume will also contain the speeches at the opening and closing ceremonies and other highlights of the Congress. The Proceedings will also be produced on compact disks.

All registered participants will receive the Proceedings on CD's. Printed volumes can be ordered by paying an additional fee at the time of the registration. See `http://www.icm2010.org.in/registration` for instructions.

The invited section lectures will be collected on one or two CD's, and printed in two or three hardbound volumes. These will be handed over to the participants upon registration at the Congress venue. Plenary, special, and prize lectures will be collected on another CD and printed volume. These will be mailed to participants three months after the Congress. The organizers will make all attempts to make the scientific content of the Congress as widely available as possible by using all modern communication resources.

The editor of the ICM 2010 Proceedings is Rajendra Bhatia (Indian Statistical Institute, Delhi); the co-editors are Arup Pal (Indian Statistical Institute, Delhi), G. Rangarajan (Indian Institute of Science, Bangalore), V. Srinivas (T.I.F.R., Mumbai), M. Vanninathan (T.I.F.R.-C.A.M., Bangalore); and the technical editor is Pablo Gastesti (T.I.F.R., Mumbai).

D2. Abstracts

Abstracts of plenary lectures and invited section lectures at ICM 2010 will be collected in a booklet published by the Hindustan Book Agency, which will also be included in the package given to participants upon their registration at the Congress venue.

Abstracts of accepted contributions to be presented at short communications, poster sessions, or mathematical software sessions of ICM 2010 will be collected in a book issued by the same publisher and will also be included in the Congress registration package.

Electronic versions of abstracts will be available on the Congress website in advance.

D3. Program

A printed copy of the Congress program, containing the daily schedule of activities and other useful information, will be handed out to participants at the registration desk. An electronic version of the program will be available shortly before the Congress.

D4. The *Hyderabad Intelligencer*

As in the past, on the occasion of ICM 2010, Springer will bring out a special issue entitled *Hyderabad Intelligencer* which will gifted to the participants of the Congress. The issue, currently under preparation, will contain articles on mathematics in ancient and modern India and will have glimpses into the mathematical life of the country; it will also contain a variety of information about the city of Hyderabad and its surroundings that would be of interest to visitors.

Prof. S.G. Dani (T.I.F.R., Mumbai) is the editor of the issue. Dr. Priti Nanda is the editor at Springer India for the project.

E. Social Program

E1. Opening Ceremony

There will be an opening ceremony on the morning of the 19th followed by a coffee break. Prior registration is necessary to attend the opening ceremony as security will ask for your registration badge. Instructions on how to register are given in section I4.

E2. Banquet

There will be a banquet on the evening of the 20th in a hall right next to the venue, HICC, for all registered participants and registered accompanying people.

E3. Dance Performance

There will be a Bharat Natyam Dance Performance by Prof. C.V. Chandrasekhar of Chennai and his group on the evening of the 20th of August.

E4. Vocal Music Recital

There will be a vocal music recital of Hindustani Music on the evening of the 25th of August by Ustad Rashid Khan of Kolkata. He will be accompanied by a Tabla player and a Harmonium player.

E5. Tourist Program

Pre and Post Conference Tours

1. Pink City Tour—Jaipur—3 days and 2 nights. Hyderabad—Delhi (by air)—Jaipur—Delhi (by bus)—Hyderabad (by air).

Jaipur, founded in 1727, is the first well planned city of India and located in the desert. The trip covers Amber Fort, the Hawa Mahal, or palace of winds), Nahargarh Fort and the old city as also Sawai Jai Singh's observatory, Jantar Mantar.

The Delhi part of the trip includes visits to Qutub Minar, Humayun's Tomb and Bahai Temple, Rashtrapati Bhavan, Parliament House, and India Gate in Delhi.

2. Taj Mahal Tour—3 days and 2 nights. Delhi—Agra—Delhi (by bus or train). This opulent trip that takes in no less than five World Heritage Sites—the Agra Fort, Fatehpur Sikri, the incomparable Taj Mahal, Humayun's Tomb, and Qutub Minar.

The tour also covers the Bahai Temple, Parliament House, Rashtrapati Bhavan, and India Gate.

3. Golden Triangle Tour—4 days and 3 nights. Delhi—Agra—Jaipur—Delhi. Combines the two trips above. For details see `http://www.icm2010.org.in`.

4. Mumbai Aurangabad—3 nights and 2 days. Hyderabad—Mumbai—Aurangabad—Mumbai—Hyderabad (all by air).

Aurangabad is commonly used as a base for a visit to the World Heritage Sites of Ajanta and Ellora and Amber Fort. The city tour of Mumbai includes Gateway of India, Afghan Church, Marine Drive, Jain temple and Hanging Gardens, Chowpatty, Kamala Nehru Park, and also Mani Bhavan where Mahatma Gandhi stayed during his visits to Mumbai, Haji Ali Mosque, the 'Dhobi Ghat', Crawford market and Flora fountain.

5. Mysore and Bangalore—3 days and 2 nights. Bangalore—Mysore—Bangalore by bus.

In Bangalore: The Vidhan Soudha(the legislative assembly), Cubbon Park, Lal Bagh, Bangalore Palace, Venkatappa Art Gallery, Tipu's Palace and the adjoining fort, the Aquarium.

Srirangapatnam enroute to Mysore: Tipu's Palaces, Darya Daulat and Jumma Maseedi.
Excursion to Somnathpur—the Kesava and Somnath Temples.

Mysore: Maharaja Palace (1857), Chamundeswari Temple, the giant Nandi Monolith (1659).

6. Goa—3 days and 2 nights.
Panaji, Vasco da Gama, Margao. Beaches, Mangueshi Temple, Shantadurga Temple, Sahakari Spice Plantation, the Basilica of Bom Jesus and Se Cathedral.

7. Kerala God's Own Country—3 days and 2 nights.

Kochi, formerly known as Cochin: Jewish Synagogue, the Mattancherry Palace, Fort Cochin, St.Francis Church. Kumarakom: Bird Sanctuary, the Vembanad Lake, the largest backwater in Kerala, have an Ayurvedic massage. Alleppey: boating in the backwaters.

Single day and half day tours

(1) Half day Golconda and Qutab Shahi Tour.
(2) Half day Mecca Masjid, Salarjung Museum and Charminar Tour.
(3) Half day Pearl and Jewelry Shopping Tour.
(4) Half day Charminar heritage walk.
(5) Half day Kilwat heritage walk.
(6) Full day Nagarjuna Tour (Nagarjunkonda, Nagarjunasagar dam, Etipotala waterfall and Nagarjunkonda Museum).
(7) Full day Pochampalli Tour (see the weavers make cotton and silk material).
(8) Full day Ramoji Film City Tour.

General Information About Tours

The local tour costs include—
1. Transportation from HICC back in an air-conditioned coach.
2. Services of a guide.
3. Mineral water in coaches.
4. Lunch (for full day tours only).
5. Entrance fee wherever applicable.
The cost of camera fee, video camera fee wherever applicable is not included in the rates, and tickets for these must be purchased by the participants themselves.

E6. Activities for Accompanying Persons

Accompanying persons are invited to join the Congress tours described above. Please check the websites given below for further information on Hyderabad, and you can also contact the Congress Travel agent for assistance.

`http://www.andhratourism.com`
`http://www.tourisminap.com`
`http://www.bharatonline.com/andhra-pradesh/`
If there is enough demand a creche will also be arranged.

Contact details of Congress Travel agent: Sanjay Bhatt
Tel: +91 11 41653100 +91 11 41653100 Ext: 293
Fax: +91 11 41653101
Mobile no: +91 9818111361 +91 9818111361
email: `sanjaybhatt@iceindia.in`

F. Travel

F1. General Information

Air travel

Hyderabad is well-connected by air to several international destinations and Indian cities. It is an important junction for the Indian rail system as well.

Direct International Flights to Hyderabad:

The newly constructed Rajiv Gandhi International airport at Shamshabad, Hyderabad, is about 40 km from the heart of the city. It is served by the following international airlines:

Air India, Air Arabia, British Airways, Emirates, Lufthansa, Malaysian Airlines, Oman Air, Qatar Airways, Singapore Airlines, Thai Airways.

More airlines are expected to start their services to Hyderabad in the near future. Contact ICE or your travel agent for updated information.

Hyderabad via Indian Metro Cities:

The airports at the major metro cities of Delhi, Mumbai, Kolkata, and Chennai are well-connected with international destinations and offer convenient onward connections to Hyderabad. Bengaluru (Bangalore) also has international flights and is well-connected with Hyderabad. Twelve Indian cities have international airports that are served by major airlines of the world.

(1) Ahmedabad (AMD), (2) Amritsar (ATQ), (3) Bangaluru (BLR), (4) Chennai (MAA), (5) Delhi (DEL), (6) Goa (GOI), (7) Guwahati (GAU), (8) Hyderabad (HYD), (9) Kolkata (CCU), (10) Kochi (COK), (11) Mumbai (BOM), (12) Trivandrum (TRV)

(The names in brackets are the three-digit IATA codes of the cities).

For those who are planning to take pre or post congress tours to other parts of India or attend a satellite conference, it may make more sense to use Delhi or Mumbai as gateway cities. Please contact your travel agent or the official Destination Management Company—ICE to help you with planning your travel.

The international airports in the metro cities extend services ensuring that the traveller on business can continue working even during his wait for boarding an international connection, or when transferring between international flights. These facilities include restaurants, business centres, rest rooms, and telephone booths. Business centres are furnished with state-of-the-art equipment including word-processors and telefax. Airports also offer tourist duty-free handicrafts shopping, snack bars, nursery and baby care rooms, and an art gallery too for art lovers. Duty-free prices in the airport shops give good rates on international merchandise.

Transfer to city and hotels:

Complimentary transfers to Congress hotels are available for those have registered and booked through the Secretariat. There are also coaches available to various destinations in the city. There will be welcome desks at both the international and domestic terminals of Hyderabad (Shamshabad) International Airport on the 18th and 19th of August.

Taxis are available at the pre-paid taxi counter inside the airport. Rates vary from Rs10 to Rs15 per km depending on the size of the taxi. Rates can be higher between 10.00 pm and 6.00 pm.

Train travel:

Trains connect Hyderabad to all major cities in India. There are three main stations; Kacheguda, where one would take a train to Bangalore for instance; Hyderabad station (also known as Nampally station); but the most convenient station is the Secunderabad station. Taxis are available at the station and there is a pre-paid taxi counter as well. Reservations can be done online through `http://www.irctc.co.in`.

Buses:

Local city buses are very cheap but consequently VERY crowded. Luxury air conditioned inter city buses are available. There are, for instance, such buses running overnight from Hyderabad to Bangalore. The journey takes about 11 hours.

F2. Congress Agent

KW Conferences has been appointed by the Organizing Committee to handle registration for the Congress and reservation of accommodation etc. for Congress participants. Please send all correspondence related to the Congress to:

ICM 2010 Technical Secretariat
c/o KW Conferences P Ltd,
A 56/12 DLF Phase I,
Gurgaon 122002 India.
Phone: + 91 124 4636 7000 Fax: + 91 124 410 2071
email: `icm2010@kwconferences.com`

F3. Tourist Information

India is a fascinating combination of the old and the new. It is an astonishing land—knowledge, learning, natural wonders, mysticism, colour and a variety of cultures co-exist with a rapidly growing economy and pioneering technology. It has recently emerged as a global player in information technology, business process outsourcing, telecommunications, and pharmaceuticals. India's vastness challenges the imagination and creates a richness and diversity of experience. It is home to one sixth of the world's population. An amazing amalgam of different cultures and traditions, with its ancient and philosophical way of life, bounteous natural resources, and a history of spectacular art and culture, India has welcomed all—intriguing and holding them in her embrace. The Indian scriptures emphasize the point "Atithi Devo Bhava"—the Guest is a form of God—and you are sure to experience the warmest of welcomes and the most bountiful hospitality.

Climate

August is the monsoon or rainy season in India and the weather is fairly warm throughout the country. Rainfall is heavy only in certain parts like the coastal areas and the eastern parts of the country. August in Hyderabad is a pleasant time of year—with warm days frequently cooled by showers of rain. The maximum daytime temperature in mid-afternoon on a clear day is about 32°C. The temperature will be a few degrees lower if it is cloudy. Night temperatures range between 23°C and 25°C.

Rainfall during the last four years in the last half of August

	2009	2008	2007	2006	2005	2004
Aug 19	0	trace	7mm	3mm	trace	0
Aug 22	0	1mm	trace	trace	12mm	trace
Aug 25	13mm	0	11mm	12mm	0	0
Aug 27	19mm	trace	9mm	20mm	0	0

Clothing

Warm clothes are not required at all, and light cotton clothes are the most comfortable at this time of year. The sun can be strong and hats, sunshades, sunscreen lotions are recommended. Open shoes or sandals are comfortable as also walking shoes. A small folding umbrella will be useful and one will be given in the Congress bag.

Tourist Information

Relevant websites with useful information are:
`http://www.andhratourism.com`
`http://www.touristplacesinindia.com/hyderabad/`
`http://www.indianholiday.com`
`http://www.southindiatourtravel.com`
`http://www.fullhyd.com`

Credit Cards:

Visa and MasterCard credit cards are accepted in all three star and upward hotels in Hyderabad. The first two are accepted in most supermarkets, upmarket shops, and railway stations. You may do online air and train bookings using Visa and MasterCard credit cards. Normally bills below Rs100 cannot be paid by credit card though some shops have a higher minimum limit.

Currency:

The currency in India is the Rupee, which comes in denominations of 1, 2, 5, 10, 20, 50, 100, 500 and 1,000. Please use authorized money changers and banks to change currency. They will issue a certificate of exchange which is required at the time of re-conversion of any unused currency. Under the Foreign Exchange Management Act 1999, it is an offense to exchange foreign currency other than through authorized money changers or banks. You can check the conversion rate from your own currency to INR at `http://www.xe.com`.

Electricity:

Electrical supply in India is 220 volts, 50 Hz. Sockets accept plugs with two or three (grounded) round pins of British Standard 546 type.

F4. About Hyderabad

Hyderabad, with its own traditional civilization and culture, lies in the centre of India. It is the sixth largest city of India, and is the capital of the state of Andhra Pradesh. Attached to the city is its twin-city, Secunderabad, which is considered a part of Hyderabad. The twin cities of Hyderabad and Secunderabad are separated by the Husain Sagar, an artificial lake constructed during the reign of Ibrahim Quili Qutb Shah Wali in 1562 A.D.

The city is over 400 years old and is noted for its natural beauty, places of worship (Temples, Mosques, Churches, Gurudwaras, Buddhist Viharas) bazaars, bridges, hills and lakes. Perched on top of the Deccan Plateau 530 meters above sea level, it sprawls over an area of about 260 sq km.

A multitude of influences have shaped the character of the city. Its palaces and monuments, public buildings and gardens, traditional markets and streets have a history and architectural individuality of their own, making Hyderabad a city of enchantment.

History

The history of Hyderabad began with the establishment of the Qutb Shahi dynasty. Towards the end of the 16th century, inadequacy of water compelled Mohammed Quli, of the Qutb Shahi dynasty, to move from the fortress city of Golconda and establish the new city of Hyderabad with the Charminar at its centre. In 1687 it was overrun by the Mughal emperor Aurangzeb. Subsequent rulers of Hyderabad were viceroys, installed by the Mughal administration in Delhi. In 1724 the Hyderabad viceroy, Asif Jah, took advantage of waning Mughal power and declared Hyderabad an independent state with himself as leader.

The dynasty of the Nizams of Hyderabad began, and the traditions of Islam flourished. Hyderabad became a focus for arts, culture, and learning, and the centre of Islamic India. Its abundance of rare gems and minerals—the famed Jacob diamond is part of the Nizam's collection—furnished the Nizams with enormous wealth. The seven Nizams of the Asif Jah dynasty ruled the Deccan for nearly 224 years, right up to 1948. The rule of the seven Nizams saw the growth of Hyderabad both culturally and economically. Huge reservoirs, like the Nizam Sagar, Tungabadra, Osman Sagar, Himayath Sagar, and others were built. Survey work on Nagarjuna Sagar had also begun during this time. Hyderabad, under the Nizams, was the largest princely state in India. The State had its own currency, mint, railways, and postal system. There was no income tax.

Soon after India gained independence, Hyderabad State merged with the Union of India. On November 1, 1956, the map of India was redrawn into linguistic states, and Hyderabad became the capital of Andhra Pradesh.

Golconda Fort and Qutab Shahi Tombs: Founded in the 13th century and rebuilt by the Qutab Shahis, who made it their capital in 1525. It was they who laid out its splendid monuments and parks, and designed the famous acoustic system by which a handclap sounded at the gates can be heard right up at the citadel. Golconda Fort consists of four different forts inside a 10 km long outer wall. There are 87 bastions, eight gateways, four drawbridges and numerous temples, beautiful palaces and mosques—most of them in ruins though.

About a kilometre from the Golconda fort are the tombs of the Qutab Shahi rulers. The tombs are domed structures built on a square base surrounded by pointed arches. The galleries of the smaller tombs are of a single storey while the larger ones are usually two-storied. In the centre of each tomb is a sarcophagus that overlies the actual burial vault in a crypt below. The domes were originally overlaid with blue and green tiles of which now only a few pieces remain.

Mecca Masjid: Originally started by Sultan Mohammad Quli Qutab Shah, the Mecca Masjid was completed by the Mughal Emperor Aurangazeb in the 17th century. It is the largest mosque in the twin cities and can accommodate upto 10,000 worshippers at prayer.

Salar Jang Museum: The Salar Jung Museum—reputed to be the world's largest one-man collection, houses around 35,000 antiques and art objects collected by Salar Jung III, the former Prime Minister of the Nizam of Hyderabad. The 36 halls of the museum display an intriguing array of treasures. These include the finest crystal and porcelain, an assemblage of statues that include the veiled Rebecca, Margarita, Mephistopheles, miniature paintings, illuminated manuscripts, fabulous jeweled weapons, including the Empress Nurjehan's dagger and the Nawab's own diamond-encrusted sword, priceless collection of jade, ivory and bronzes and a fascinating variety of clocks. The most important historical exhibits are the turban and ivory chairs of Tipu Sultan of Mysore.

Charminar: You will also visit Charminar, located in the heart of the old city. This magnificent edifice built by Sultan Mohammad Quli Qutab Shah, is the unique symbol of Hyderabad. A small mosque is located on the roof of the edifice. All around the Charminar is a bustling bazaar of pearl and jewellery shops, perfume and attar dealers. Close by is the Laad Bazaar or the bangle alley with rows of shops selling lacquer and glass bangles.

Birla Temple: The various Birla mandirs constructed across the country were built by the industrialists Birlas. Sri Venkateswara, or Lord Lakshminarayana, is the deity of these temples. Strangely, however, these temples are known by the family that undertook the noble cause. The Birla Mandir in Hyderabad is built on the 280-foot-high hillock of Kalapahad. Birla Mandirs are constructed entirely using marbles. It is believed that it took 2000 tons of white marbles brought from the Indian state of Rajasthan to complete this holy place.

The intricate marble carvings blending the South Indian architecture, Utkal temple architecture and Rajastani architecture is simply amazing. The view from the highest level offers the viewer a spectacular view of the Hussain Sagar Lake and the Public Gardens and Lumbini Park. The temple is open between 7 am and 12 noon and between 3 pm and 9 pm.

Ramoji Film City: The Ramoji Film City is located about 35 kilometers from the Hyderabad city. A tour to the Ramoji Film Studio will tell you why is it acknowledged by the Guinness Book of World Records as one of the largest film studios in the world. The studio lives up to its name of a "city" as it is spread over a vast area of around 2500 acres. You feel as if you have entered a new city altogether with hills, gardens, lakes, and at the same time flanked with spotless modern buildings. The Ramoji Film City doubles both as a tourist attraction and major film-making facility. It is India's answer to the Universal Studios in Hollywood, in every aspect. Today, it is the film makers' first choice as it is a single-window, press-button facility that opens up an unlimited arena of creativity for every major and minor aspect of film production. Yet, everything in the studio is real, whether it is the 50 studio floors, outdoor locations, high-tech laboratories, state-of-the-art technology, and the lush green landscape and scenery.

Pochampalli: In Pochampalli of Nalgonda District adjoining Hyderabad, a unique method of tie and dye is used known as 'ikat'. Weavers in Andhra Pradesh have mastered the art of using cotton and silk alternately for warp (length) and weft (across). In the scenic weavers' village of Pochampalli, the act of weaving seems to be ritual for a weaver's family. Pochampalli began production of the the legendary 'telia rumals' as late as the beginning of the last century and began to export them to Iran and the Gulf. The weavers wove the first cotton saree of 60 counts, which proved to be very popular. Today the finest fabrics are woven in millions of patterns, every saree is unique and exclusive, there are no replicas. Not surprising that Pochampalli is a prosperous village with master weavers creating wonders in ikat and patola techniques which have made these fabrics world famous. The weaving of ikat furnishing is now done in the entire Nalgonda district and involves nearly 18,000 looms. Gorgeous Pochmapalli silks woven in the ikat patterns are in great demand worldwide, as incomparable fabrics, the prized handlooms of India.

Nagarjunkonda: 150 km from Hyderabad was discovered in 1926. The great Buddhist scholar, Nagarjuna, founded a Buddhist University here. On the tour of this ancient city, you will come across the remains of stupas, viharas, chaityas, and mandapas along with white marble carvings and sculptures depicting the life of the Buddha. Nagarjunakonda was one of the greatest center of Buddhist learning. The stupas here have dainty sculptures depicting scenes from the Buddha's life. The main stupa is called the Mahachaitya and contains the sacred relies of the Buddha, namely, a small tooth and an earring.

Pearls and Jewelry: Carrying on the ancient prosperous pearl trade, of the expensive, the exclusive, and the rarest in the world, Hyderabad still remains the pearl capital of India. Artisans have over the centuries become experts in segregating, categorizing, and polishing pearls to give them various attractive hues. Hyderabad is today a world leader in the pearl trade.

Eating Out

When it comes to eating out in Hyderabad, you'll be spoilt for choice with the many restaurants, pubs, cafes, and bars that frequent Hyderabad's streets. The only problem you are likely to encounter is being unable to make up your mind what to choose. You can find good restaurants, cafes and bars wherever you are, often in surprising places, so it's well worth taking time to explore.

The geographical location of Hyderabad has been a major influence on its varied cuisine, which ranges from the Hyderabadi style with its strong Mughlai influence, to a pure Andhra cuisine—hot and spicy. Hyderabad also has a good number of places for Chinese and Continental food. For a quick meal or a snack, one has a choice between western fast foods, pizza, burger, sandwich, and the Indian 'chats'. The city has its ubiquitous Irani Hotels, serving thousands of cups of tea each day. For the diet-unconscious, Hyderabad probably has the largest number of ice cream brands to offer. In addition, the city's main shopping areas are crowded with sweet shops offering a mind-boggling variety of sweet and snacks.

Hyderabadi Biryani: For those who want a taste of the royal menu, there are a variety of Biryanis (a rice and meat preparation, seasoned with spices and flavourings). There are 2 styles of preparing this variety; The Kachey Gosh Ki Biryani, where the meat is marinated in curd and then baked with rice, and the Pakkey Gosh Ki Biryani, where the meat is cooked with all the accompanying spices and then the rice is simmered with the resultant gravy redolent of mace, ittar and kewra in a sealed vessel with saffron and cardamom. It is accompanied by side dishes like Mirchi ka Salan, Dhai-Ki-Chatni, and Baghare Baingan.

Apart from this king of the delicacies, the entire Shahi Nizam cuisine is very popular for its rich and aromatic taste and has Kababs (meat pieces or minced meat cooked in many different styles such as Boti

Jhammi, kalmi, Shikampur, Sheek, Lagan-ke-kababs, Dum-ke-kababs), Khormas (either meat or vegetables cooked in a rich creamy gravy) and Lukhmi (pastry). Nahari is another speciality eaten very early in the morning and is a curried soup of sheep's trotters and tongue.

South Indian: The South Indian spread is well represented by the classic Gongura Mamasam, Royyalla Pulusu (sizzling prawn curry), Kakarakaya Pulusu (a bitter gourd preparation that uses a good dose of spice) and the more humble, but nevertheless lip-smacking, lentil-spinach dish of Palakura Pappu. Andhra Cuisine is distinct for its hot and spicy food with a range of chutneys, curries, meat preparations and pickles. One can also taste the cuisines of Karnataka (Udipi) and Tamil Nadu—the omnipresent dosas, idlis, and vadas.

Chinese and Asian Food: Hyderabad also boasts of a number of Chinese restaurants ranging from the inexpensive to the exclusive. Almost the whole of Hyderabad is dotted with Chinese restaurants serving some very authentic food. There are a couple of Japanese restaurants serving Sushi and Teppenyaki and Thai restaurants serving the Tom Yum soup with Phad Thai.

Continental Fare and Fast Foods: With a sizable ex-pat population there are many restaurants serving European and American cuisine. From the fabulous steaks at TGIFs, to the Lasagnes of Fusion 9 and the Pastas of Little Italy you have it all in Hyderabad. For somebody looking for a quick and filling snack, there are many western-style fast food joints which offer pizzas, burgers, sandwiches, etc.

Pubs: Although many restaurants around the city serve liquor, the pub culture is quite popular in Hyderabad. One of the largest pubs is named 10, Downing Street! Other places worth mentioning are: Touch, Poison, Zouk in Banjara Hills, Bottles and Chimneys (Begumpet), Excess, and F Bar (Madhapur).

G. Mail and Messages

All mail, telegrams, and faxes for ICM delegates should be addressed to KW Conferences at their address given above.

Personal Messages There will be a message board in the main foyer of the Hyderabad International Convention Centre (HICC), the venue of the Congress, where participants wishing to exchange personal messages can stick their messages.

E-Mail A Cybercafe will be provided in one of the halls of HICC where delegates can check their email. The venue HICC will also have wifi facility for those carrying their laptops. Access to the internet will be free.

H. Miscellaneous Information

H1. Language

Announcements, correspondence, and all official matters will be communicated in English. English is widely spoken in the city; most shops, supermarkets banks, etc. will have staff who can speak English.

H2. Invitation Letter

An official invitation letter will be sent by the Organizing Committee upon request. Requests should be addressed to the ICM 2010 Secretariat, Dept of Mathematics and Statistics, University of Hyderabad, Gachi Bowli, Hyderabad 500046, India or `rajattanicm@gmail.com`. It is recommended that the invitee's passport number is printed on the invitation letter and so this number should be provided in the request letter. This personal invitation is intended only to facilitate travel and visa arrangements to participants.

H3. Bank Services

Banks are open Monday through Friday from 10:30 am till 4 pm, though some banks work longer hours. There are many ATMs throughout the city which handle foreign accounts and dispense Indian currency. The convention centre also has an ATM facility. Money can be exchanged at most star-rated hotels. For instance the hotel Novotel adjacent to HICC will exchange money for you. Not all banks will convert foreign exchange for Rupees. Only those authorized to deal in foreign exchange will do so. Some travel agents like Cox and Kings or Thomas Cooke will also exchange money for you.

H4. General Information

Arrival—Departure

On arrival at the international airport, please go through the Green Channel if you have less than US$10,000 on your person and if you have no unaccompanied baggage. Please use the Red Channel if you have anything to declare or if you are carrying foreign currency in excess of US$10,000.

Passport and Visa Requirements

You are advised to contact the Indian Embassy/High Commission/Consulate in your country in order to obtain a visa of entry. Please apply for your visa in good time. Your travel agent may also be able to help you. You are advised to take a conference visa. Foreign visitors entering India must have a passport valid for at least 6 months after their date of entry in India, except in the case of nationals of Bhutan and Nepal who need only carry suitable means of identification. In case of difficulty in obtaining a visa, please contact the Technical Secretariat as per contacts given earlier.

Import Regulations

You may bring with you into India articles and gadgets for personal use, 200 cigarettes (or 50 cigars or 250 gms tobacco) and liquor and wines up to 1 litre. In case you are carrying any items of high value, please ask the customs officer for a Tourist Baggage Re-Export Form (TBRE) which you will have to show to customs at the time of your departure to show that you are re-exporting the items.

Export Regulations

On your return you may take back souvenirs, including Indian silk, wool, handicrafts, etc., without any limit, and gold and silver jewellery and handicrafts up to a value of INR 100,000. Please note that the export of antiques and art objects more than 100 years old is restricted and the export of wildlife products is prohibited.

Insurance and Liability

The organizers take no responsibility for any individual, medical, travel, or personal insurance. Participants are advised to secure their own insurance policies as necessary. While every attempt is made to ensure efficient, trouble-free hospitality, including hotel accommodation, sightseeing and tours, participants are advised that no liability accrues to the organizers in case of any necessary modifications such as changes to itineraries for tours owing to delays or cancelations of flights/other exigencies beyond the organizers' control.

Food and beverages

- Indian food is famed for its variety, spices, and taste. Hotels and restaurants serve all types of cuisine including continental, oriental, middle-eastern, Mediterranean and others.
- You are advised to drink only bottled water and check that the seal is intact when you receive it.
- You are advised to avoid raw vegetables, uncooked seafood, and peeled fruit.
- Avoid food and drinks from street vendors.

Shopping

Supermarkets and malls are open all days of the week from 10 am till 9 pm. Private shops are usually closed on Sundays though some areas of the city have different weekly off days.

Health

- Please consult with your physician regarding health precautions prior to visiting India.
- It is advisable to bring with you some mosquito repellant cream or spray. Repellant creams and vapours are also locally available.
- If you are coming from or have visited, Africa, Latin America, or an area infected with yellow fever within five days prior to your arrival in India, proof of inoculation against yellow fever is required.

International Direct Dialing

The Country Code for India is '91' followed by the Hyderabad City Code '40', followed by the telephone number, e.g. 91 40 XXXX XXXX.

Local Time

Indian Standard Time (IST) is GMT + 5 hrs.

Smoking Policy

All conference rooms, the convention centre, and public areas are no-smoking areas.

Tips

You are not compelled to tip anyone for any service rendered. The normal tip to your waiter in a restaurant is 10 percent.

I. Registration

- Registration is required in order to be admitted to the venue and for participation in the scientific program of the Congress and other ICM 2010 activities.
- Full registration entitles the participant to (1) the conference bag containing conference materials, the proceedings of the Congress on CD, free tea/coffee coupons for use during coffee breaks, and free lunch coupons. (2) free transport from the hotel/service apartment to the venue of the congress in the morning and return in the evening if accommodation is booked through the organizers and (3) admittance to the opening ceremony and other free cultural events hosted by the congress organizers.
- Students who have not completed their Ph.D. have the option of registering at a reduced student rate on presentation of an official student ID card from their university.
- Registration for accompanying persons includes a badge and admittance to the opening ceremony and other free cultural events hosted by the congress organizers.
- A badge will be given with the conference bag which must be carried by the participants at all times at the venue to the Congress, the HICC.

I1. Submission of Registration Forms

Registration forms will be available on the Congress website from January 1, 2010. Online submission of the registration form is encouraged. It will also be possible to retrieve a PDF file from the Congress website and submit it by fax or post. All registrations must be submitted on official registration forms. Please use a separate form for each participant.

Please use only one method for submission of your registration. Otherwise, multiple registrations may occur and such registrations may even be rejected by the operational system. Telephone requests cannot be accepted. The registration will be considered as binding when it is received by KW Conferences and payment of the total fees has been received. Participants wishing to reserve hotel accommodation and ticket reservations for the tourist program must be registered.

I2. Data Protection

Personal data of registered participants will be processed by the organizers of ICM 2010 only for the promotion of the Congress. By filling in the registration form, participants authorize ICM 2010 to use their data for the above mentioned purpose. Participants are entitled to change or erase their personal data through the ICM 2010 Secretariat.

I3. Secretariat and Registration Counter

Reception of participants will take place at the Conference Registration Counter, which is located on the ground floor right-side lobby of the Hyderabad International Convention Centre, where participants will be able to pick up their badges and conference material at the following hours:

Wednesday, August 18	9:00 - 20:00
Thursday, August 19	7:00 - 19:00
Friday, August 20	8:00 - 20:00
Saturday, August 21	8:00 - 20:00
Sunday, August 22	9:00 - 18:00
Monday, August 23	Closed
Tuesday, August 24	9:00 - 18:00
Wednesday, August 25	9:00 - 18:00

Registration Desk

At the registration desk, registered participants will be provided with badges, documents, and vouchers for all events that have been confirmed. These documents will not be mailed before the Congress. In the case of fees which have been forwarded late and have therefore not yet been credited to the account of ICM 2010 on the day of arrival, a copy of the remittance order must be presented.

On-Site Registration

Online registrations through the website will close after August 10, 2010. All registrations after that date must be done onsite at the onsite rate. Onsite Registration will open on August 18, 2010, at 9 am. The following credit cards will be accepted for on-site registration: VISA, MasterCard and American Express.

I4. Opening Ceremony

You must be registered in order to attend the opening ceremony. The ceremony will be held in the main halls of HICC. In order to attend the opening ceremony participants must have completed the registration process at the registration counter located on the ground floor right-side lobby of the Hyderabad International Convention Centre on August 18th or up to 60 minutes before the opening ceremony on August 19th.

I5. Registration Fees

1. Registration as a student requires an identification card from a university/academic institute.
2. The Registration Fees charged for different categories and date periods are below (in Rupees):

Date of Payment	Delegate	Accompanying Per.	Student	ICWM
Jan 1 to May 15	16,000	3,600	8,000	2,000
May 16 to Jun 30	18,000	4,400	9,000	3,000
Jul 1 to Aug 10	22,000	5,800	11,000	3,000
Aug 18 to Aug 25	22,000	5,800	11,000	3,000

The ICWM registration is in addition to the ICM registration for those who want to attend both. Those who want a printed copy of the proceedings will be required to pay Rs 5750.00 extra.

I6. Methods of Payment

All payments must be in Indian Rupees (INR) and made payable to KW Conferences Pvt. Ltd. The registration is not confirmed until the KW Conferences Pvt. Ltd. has received the full payment. Remember to state the participant's name and ICM 2010 on all payments! Payment must be remitted as follows:

- Online registration can be paid only by credit card.
- Fax or mail registration can be paid by bank transfer or credit card.
- On-site registration can be paid only by credit card or in cash in rupees.

Any bank charges which might be incurred must be met by participants themselves, and if still outstanding they will be charged upon registration at the registration counter in Hyderabad.

Invoices

If you need an invoice, please send a request in writing with your billing details together with the registration form.

I7. Cancellations

All cancellations must be sent to KW Conferences in writing (fax, letter, or e-mail).

- In case of cancellations before June 30, 2006, deposits will be refunded less 15% for bank and service charges.
- No refund will be made for cancellations received after June 30, 2010, or for registered participants who fail to attend the Congress.
- All refunds will be made within 10 days after the conference.

J. Accommodation

KW Conferences Pvt Ltd has reserved a number of rooms at different hotels spread over the city of Hyderabad. The hotels booked are in the categories (1) 5-star hotels (luxury class) (2) 4-star hotels (first class) (3) 3-star hotels (tourist class).

J1. Hotel Reservation and Online Booking

- Accommodation forms will be available on the Congress website from March 15th, 2010. Online submission of the accommodation form is encouraged. It will also be possible to retrieve a PDF file from the Congress website at `http://icm2010.com/accommodation.asp` and submit it by fax or post. Please use only one method when submitting your accommodation form; otherwise multiple reservations may occur and submissions may even be rejected by the operational system. Telephone reservations cannot be accepted.
- Only prepaid reservations will be processed. Full payment covering the entire stay is required to guarantee the booking. Online requests can be paid only by credit card. Fax or mail requests can be paid by credit card or bank transfer.
- Requests for hotel accommodation received after July 15, 2010, cannot be guaranteed.
- Reservations are made on a first-come-first-serve basis. Availability of rooms in each category is limited. Names of persons sharing rooms must be stated.
- Hotel Check In—If you plan to arrive at your hotel after 6 pm on the scheduled day of arrival please indicate your arrival time on your accommodation form in the remarks box as reserved rooms will be kept only until 6 pm.
- Hotel Check Out—Guests must vacate their rooms before noon on the day of departure.
- Before booking, please read the hotel reservation and cancellation policies carefully.

J2. Hotel Rates

Various categories of rooms are being secured at a variety of hotels in Hyderabad with special pre-negotiated rate for delegates. These rates will be listed by March 15th. Payment is required to be made for the whole period of booking. Rates are valid for participants for the duration of the Congress.

J3. Low Budget Accommodation

A number of rooms have been reserved in serviced apartments. "Serviced Apartment" is a new concept that has emerged in recent times and is very popular amongst international and domestic travellers. It is especially convenient for groups or small teams who take all the rooms of an entire apartment and then can enjoy the living room and dining areas as if at home. Serviced apartments offer most of the conveniences that a hotel would provide with a few exceptions such as bar and restaurant, swimming pool, and shopping arcade which are not there.

J4. Methods of Payment

All payments must be made in Indian Rupees and are payable to KW Conferences Pvt Ltd A56/12, DLF, Phase 1, GURGAON - 122 002, INDIA. No confirmation will be sent until KW Conferences Pvt Ltd has received full payment. Remember to state the participant's name and "ICM 2010" on all payments!

Payment must be remitted as follows:

(1) Fax or mail accommodation requests can be paid by bank transfer or credit card.

(2) Online accommodation requests can be paid only by credit card (Visa, Mastercard or American Express).

Any bank charges incurred must be met by Congress participants themselves, and if still outstanding they will be charged upon registration at the registration counter in Hyderabad.

Invoice

If you need an invoice, please send a request in writing with your billing details together with the accommodation form.

J5. Hotel Cancellation and Changes

- A handling fee of INR 2000 will be charged for any change in reservation up until July 15, 2010. After that date no further changes can be accepted.
- All cancellations must be sent to KW Conferences in writing (fax, letter or e-mail)
- In case of cancellations before June 30, 2010, fees will be refunded less 15
- No refund will be made for cancellations received after June 30, 2010, or for registered participants who fail to attend the Congress.
- All refunds will be made within 10 days after the conference.
- Accommodation vouchers, together with a receipt, will be forwarded when payment is received. Please keep these vouchers, as you will need them for check-in at your hotel.

K. Financial Support to Participants

- The International Mathematical Union and the Executive Committee of the ICM 2010 are making efforts to obtain financial support to enable as many mathematicians as possible from developing and economically disadvantaged countries other than India to participate at the ICM 2010. Applicants need not necessarily be from IMU member countries.

  The IMU and the Organizing Committee have established three different support categories:

1. Young mathematicians (below the age of 35) from developing and economically disadvantaged countries.
2. Senior mathematicians from developing and economically disadvantaged countries.
3. Mathematicians from neighbouring countries.
Eligible countries are listed on the website `http://www.icm2006.org/financialsupport`.

- Financial support is also available for Indian participants. For details see our website `http://www.icm2010.org.in`.
- The Executive Organizing Committee for ICM 2010 will, in addition to the above, be offering free local hospitality to a limited number of international participants. Local hospitality includes:

  (i) Transfer from the airport to place of accommodation on arrival on the 18th/19th of August and vice-versa on departure 27th/28th of August.

  (ii) Accommodation in a service apartment or guest house (details are at `http://www.icm2010.com/accommodation.asp?Login=True`) from the 18th to the 27th of August. You may have to share your accommodation.

  (iii) Daily transport from the place of accommodation to HICC, the venue of the ICM 2010 on all mornings (except Monday the 23rd) and return in the evening.

  (iv) A modest subsistence allowance for incidental expenses.

  Those desirous of availing this support should either send an email to `rajattanicm@gmail.com` or write to: ICM secretariat, Dept of Mathematics and Statistics, University of Hyderabad, Hyderabad 500046, India.

Requirements for Applicants

Applicants should preregister for the Congress. The nationality of the applicant as indicated in his passport must be included in the respective list of eligible countries for each of the above categories 1, 2, and 3.

Application Form

All participants who wished to apply for financial support were asked to complete the online application at `http://www.icm2010.org.in/financialsupport.`

Deadline

The deadline for receipt of applications in all five categories was January 1, 2010. Applicants will be informed of the decision of the selection committee by April 1, 2010.

L. Sponsors

The International Congress of Mathematicians is outstanding for several reasons:

(1) They gather mathematicians from all over the world.

(2) It is at these events when Fields Medals and other prizes are awarded.

(3) At these Congresses the state of the subject 0f mathematics is assessed in all its different areas.

(4) They provide a platform for many satellite events making India a focal point before, during and after the Congress.

Several institutions have already assigned their contribution to the ICM 2010. They are listed on the Congress website at `http://www.icm2010.org.in`. Companies and institutions willing to support ICM 2010 are invited to contact the Secretariat at the Dept of Mathematics and Statistics, University of Hyderabad, Gachi Bowli, Hyderabad 500046, India or send an email to `rajattanicm@gmail.com`.

M. Exhibition

Full information concerning the participation of exhibitors, floor plans and the reservation procedure is included in the Exhibitors Manual, which is available on the Congress website at. `http://www.icm2010.com/exh_location.asp` Companies and institutions interested in participating in the ICM 2010 exhibition or in other promotional opportunities are kindly requested to contact the Technical Secretariat at `eknath@kwconferences.com`.

N. Satellite Conferences

Satellite conferences/workshops are the most important scientific activities surrounding the celebration of every ICM. The Executive Organizing Committee for ICM 2010 is supporting 31 such conferences, 29 in India, one in Nepal and one in Singapore. The complete list of these conferences is:

1	CIMPA School of Number Theory in Cryptography and its Applications Dates: July 12-31, 2010 IMU Section(s): 94A60, 11	F. Pappalardi pappa@ mat.uniroma3.it K. Jha jhakn @ ku.edu.np jhaknh @ yahoo.co.in
2	Geometry, Topology and Dynamics of Character Varieties Venue: National University of Singapore Dates: July 19-23 (Workshop) and Aug 10-14 (Conference)	Ser Peow Tan mattansp@nus.edu.sg
3	Modular Forms Venue: Mahabalipuram, Tamil Nadu Dates: August 1-17, 2010 IMU Section(s): 3	M. Manickam mmmanickam@yahoo.com

4	Geometry, Topology and Dynamics in Negative Curvature Venue: Raman Research Inst., Bangalore Dates: August 2-7, 2010 IMU Section(s): 5,6,10	C. S. Aravinda aravinda@cmi.ac.in
5	Functional Analysis and Operator Theory Venue: I.S.I., Bangalore Dates: August 8-11, 2010 IMU Section(s): 9	T.S.S.R.K. Rao G. Misra tss@isibang.ac.in
6	Geometric Group Theory Venue: Goa University Dates: August 9-14, 2010 IMU Section(s): 5,6,7	B.Sury Pallavi Dani pdani@math.lsu.edu
7	Operator Algebras Venue: IMSc., Chennai Dates: August 9-13, 2010 IMU Section(s): 9	V. S. Sunder sunder@imsc.res.in
8	Harmonic and Quasiconformal Mappings Venue: IIT Madras, Chennai Dates: August 9-17, 2010 IMU Section(s): 8	S. Ponnusamy samy@iitm.ac.in
9	Galois Representations in Arithmetic and Geometry Venue: International Centre, Goa Dates: August 10-13, 2010 IMU Section(s): 3	Anupam Saikia a.saikia@iitg.ernet.in C. S. Dalawat dalawat@gmail.com
10	Algebraic and Combinatorial approaches to Representation Theory Venue: IISc, Bangalore Dates: August 12-16, 2010 IMU Section(s): 2,7,14	S. Viswanath svis@math.iisc.ernet.in
11	Algebraic Geometry Venue: University of Hyderabad Dates: August 13-16, 2010 IMU Section(s): 12	Jaya N. Iyer jniyer@imsc.res.in V. Lakshmibai
12	Geometric Topology and Riemannan Geometry Venue: IISc., Bangalore Dates: August 12-15, 2010 IMU Section(s): 5,6 S. Gadgil	gtrg2010@gmail.com siddhartha.gadgil@gmail.com H. Seshadri
13	Integrable Systems and Geometry Venue: Pondicherry University Dates: August 12-17, 2010 IMU Section(s): 12	K. M. Tamizhmani tamizh@yahoo.com
14	Recent Trends in Graph Theory and Combinatorics Venue: CUSAT, Cochin Dates: August 12-15, 2010 IMU Section(s): 14	A. Vijayakumar vijay@cusat.ac.in
15	Mathematical Logic and Set Theory Venue: IMSc., Chennai Dates: August 13-15, 2010 IMU Section(s): 1	R. Ramanujam jam@imsc.res.in
16	Automorphic Forms and Number Theory Venue: International Centre, Goa Dates: August 13-17, 2010 IMU Section(s): 3	D. Prasad dprasad@math.tifr.res.in E.Ghate eghate@math.tifr.res.in
17	PDE and Related Topics Venue: TIFR-CAM, Bangalore Dates: August 13-17, 2010 IMU Section(s): 11	M. Vanninathan vanni@math.tifrbng.res.in
18	Probability and Stochastic Processes Venue: ISI, Bangalore Dates: August 13-17, 2010 IMU Section(s): 13	Abhay Bhatt abhay@isid.ac.in Siva Athreya athreya@isibang.ac.in
19	Quantum Probability and Related Topics Venue: JNCASR, Bangalore Dates: August 14-17, 2010 IMU Section(s): 9,12,13	K. B. Sinha Tirthankar Bhattacharyya B. V. Rajarama Bhat qpconference2010@gmail.com
20	Quantum Systems Venue: IMSc., Chennai Dates: August 14-18, 2010 IMU Section(s): 12	A. Mohari anilesh@imsc.res.in M. Krishna krishna@imsc.res.in
21	Application of Control Theory and Optimization in Biochemical Pathways Venue: CCMB, Hyderabad Dates: August 15-17, 2010 IMU Section(s): 17	M. Vidyasagar Somdatta Sinha somdattasinha@gmail.com
22	Mathematics in Science and Technology Venue:India Habitat Centre, N. Delhi Dates: August 15-17, 2010 IMU Section(s): 18	A. H. Siddiqi Siddiqi.abulhasan@gmail.com H.P. Dikshit
23	Algebraic and Probabilistic Aspects of Combinatorics and Computing Venue: Bangalore Dates: Aug. 29-Sept. 3, 2010 IMU Section(s): 14,15	C. R. Subramanian crs@imsc.res.in

24 Analytic and Combinatorial Number Theory
Venue: IMSc., Chennai
Dates: Aug. 29-Sept. 3, 2010
IMU Section(s): 3,14
A. Mukhopadhyay
K. Srinivas
icmzeta@imsc.res.in
adhyay@gmail.com

25 Buildings, Finite Geometries and Groups
Venue: ISI, Bangalore
Dates: August 29-31, 2010
IMU Section(s): 2,14
N. S. Narasimha Sastry
nsastry@isibang.ac.in

26 Various Aspects of Dynamical Systems
Venue: MS University, Vadodara
Dates: Aug. 29-Sept. 1, 2010
IMU Section(s): 10
V. Kannan
Tarun Das
tarunkd@yahoo.com

27 Workshop on Recent Advances in Computational Fluid Dynamics
Venue: IIT Guwahati
Dates: Aug. 30-Sept. 2, 2010
IMU Section(s): 2
Durga Charan Dalal
Rajen Kumar Sinha
Siddhartha P. Chakrabarty
racfd@iitg.ernet.in

28 Rings and Near Rings
Venue: NEHU, Shillong
Dates: Aug. 30-Sept. 11, 2010
IMU Section(s): 2
M.B. Rege
mb29rege@yahoo.co.in

29 Probability and Statistics
Venue: Sambalpur University
Dates: September 1-3, 2010
IMU Section(s): 13
S. K. Acharya
acharya_sarat@yahoo.co.in

30 Harmonic Analysis
Venue: NISER, Bhubaneswar
Dates: Aug. 29 - Sept. 2, 2010
IMU Section(s): 8
V. Muruganandam
vmuruganandam@gmail.com

31 International Conference of Women Mathematicians, (ICWM) 2010
Venue: University of Hyderabad
Dates: August 17-18, 2010
Shobha Madan
madan.icwm2010@gmail.com

O. Committees

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Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Lexington, Kentucky

University of Kentucky

March 27–28, 2010

Saturday – Sunday

Meeting #1057

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January 2010
Program first available on AMS website: February 11, 2010
Program issue of electronic *Notices*: March 2010
Issue of *Abstracts*: Volume 31, 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

Percy A. Deift, Courant Institute–New York University, *Open problems in integrable systems and random matrix theory*.

Irina Mitrea, Worcester Polytechnic Institute, *Recent progress in the area of elliptic boundary value problems on rough domains*.

Bruce Reznick, University of Illinois at Urbana Champaign, *The secret life of polynomial identities* (AMS-MAA Invited Address).

Bernd Ulrich, Purdue University, *Multiplicities, integral dependence, and equisingularity*.

Doron Zeilberger, Rutgers University, $3x + 1$ (Erdős Memorial Lecture).

Special Sessions

Advances in Algebraic Coding Theory, **Heide Gluesing-Luerssen**, University of Kentucky, and **Jon-Lark Kim**, University of Louisville.

Advances in Algebraic Statistics, **Sonja Petrović**, University of Illinois, Chicago, and **Ruriko Yoshida**, University of Kentucky.

Advances in Algebraic and Geometric Combinatorics, **Richard Ehrenborg** and **Margaret A. Readdy**, University of Kentucky.

Analysis and Control of Dispersive Partial Differential Equations, **Michael J. Goldberg** and **Bingyu Zhang**, University of Cincinnati.

Combinatorial Algebra, **Juan C. Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Commutative Algebra, **Alberto Corso**, University of Kentucky, **Claudia Polini**, University of Notre Dame, and **Bernd Ulrich**, Purdue University.

Complex Analysis and Potential Theory, **James E. Brennan** and **Vladimir Eiderman**, University of Kentucky.

Financial Mathematics and Statistics, **Kiseop Lee**, University of Louisville, and **Jose Figueroa-Lopez**, Department of Statistics, Purdue University.

Function Theory, Harmonic Analysis, and Partial Differential Equations, **Joel Kilty**, Centre College, **Irina**

Mitrea, Worcester Polytechnic Institute, and **Katharine Ott**, University of Kentucky.

Geometric Function Theory and Analysis on Metric Spaces, **John L. Lewis**, University of Kentucky, and **Nageswari Shanmugalingam**, University of Cincinnati.

Homotopy Theory and Geometric Aspects of Algebraic Topology, **Serge Ochanine**, University of Kentucky, and **Marian F. Anton**, Centre College.

Interactions between Logic, Topology, and Complex Analysis, **Matt Insall**, Missouri University of Science and Technology, and **Malgorzata Marciniak**, University of Toledo.

Inverse Problems, Riemann-Hilbert Problems, and Nonlinear Dispersive Equations, **Peter A. Perry**, University of Kentucky, and **Peter Topalov**, Northeastern University.

Large Scale Matrix Computation, **Qiang Ye**, University of Kentucky, and **Lothar Reichel**, Kent State University.

Mathematical Economics, **Adib Bagh** and **Robert E. Molzon**, University of Kentucky.

Mathematical Problems in Mechanics and Materials Science, **Michel E. Jabbour** and **Chi-Sing Man**, University of Kentucky, and **Kazumi Tanuma**, Gunma University.

Mathematical String Theory, **Al Shapere**, Department of Physics and Astronomy, University of Kentucky, **Eric Sharpe**, Physics Department, Virginia Polytechnic Institute and State University, and **Mark A. Stern**, Duke University.

Mathematics Outreach, **Carl W. Lee** and **David C. Royster**, University of Kentucky.

Matroid Theory, **Jakayla Robbins**, University of Kentucky, and **Xiangqian Zhou**, Wright State University.

Multivariate and Banach Space Polynomials, **Richard A. Aron**, Kent State University, and **Lawrence A. Harris**, University of Kentucky.

Noncommutative Algebraic Geometry, **Dennis S. Keeler** and **Kimberly Retert**, Miami University.

Partial Differential Equations in Geometry and Variational Problems, **Luca Capogna**, University of Arkansas, and **Changyou Wang**, University of Kentucky.

Recent Progress in Numerical Methods for Partial Differential Equations, **Alan Demlow**, University of Kentucky, and **Xiaobing H. Feng**, University of Tennessee at Knoxville.

Relative Homological Algebra, **Edgar E. Enochs**, University of Kentucky, and **Alina C. Iacob**, Georgia Southern University.

Sharp Spectral Estimates in Analysis, Geometry, and Probability, **Richard S. Laugesen** and **Bartlomiej Siudeja**, University of Illinois.

Spectral and Transport Properties of Schrödinger Operators, **Peter D. Hislop**, University of Kentucky, and **Jeffrey H. Schenker**, Michigan State University.

St. Paul, Minnesota

Macalester College

April 10–11, 2010

Saturday – Sunday

Meeting #1058

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2010
Program first available on AMS website: February 25, 2010
Program issue of electronic *Notices*: April 2010
Issue of *Abstracts*: Volume 31, 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

Charles Doering, University of Michigan, *Title to be announced.*

Matthew James Emerton, Northwestern University, *Title to be announced.*

Vladimir Touraev, Indiana University, *Title to be announced.*

Peter Webb, University of Minnesota, *Title to be announced.*

Special Sessions

Applications of a Geometric Approach to Chaotic Dynamics, **Evelyn Sander**, George Mason University, **Judy Kennedy**, Lamar University, and **James Yorke**, University of Maryland.

Cohomology and Representation Theory of Algebraic Groups and Related Structures, **Christopher Bendel**, University of Wisconsin-Stout, **Bobbe Cooper**, University of Minnesota, and **Terrell Hodge**, Western Michigan University.

Combinatorial Representation Theory, **Tom Halverson**, Macalester College, and **Victor Reiner**, University of Minnesota.

Commutative Ring Theory, **Michael Axtell**, University of St. Thomas, and **Joe Stickles**, Millikin University.

Differential Equations and Applications, **Nicolai Tarfulea**, Purdue University Calumet, and **Catalin Turc**, Case Western Reserve University.

Fractals, Convolution Measures, and Frames, **Keri Kornelson**, University of Oklahoma, and **Karen Shuman**, Grinnell College.

Geometric Flows, Moving Frames and Integrable Systems, **Gloria Mari-Beffa**, University of Wisconsin-Madison, and **Peter Olver**, University of Minnesota.

Hecke Algebras and Deformations in Geometry and Topology, **Matthew Douglass** and **Anne Shepler**, University of North Texas.

Mathematical Developments in Cell and Systems Biology, **Anastasios Matzavinos**, Iowa State University, and **Nicoleta Eugenia Tarfulea**, Purdue University Calumet.

Matrices and Graphs, **Luz M. DeAlba**, Drake University, **Adam Berliner**, St. Olaf College, **Leslie Hogben**, Iowa State University, and **In-Jae Kim**, Minnesota State University.

Partition Theory and the Combinatorics of Symmetric Functions, **Eric S. Egge**, Carleton College, and **Kristina Garrett**, St. Olaf College.

Pattern Formation in Biological Systems, **Magdalena Skolarska**, University of St. Thomas, and **Chad Topaz**, Macalester College.

Physical Knotting and Linking and its Applications, **Eric Rawden**, University of St. Thomas, **Yuanan Diao**, University of North Carolina at Charlotte, and **Claus Ernst**, Western Kentucky University.

Probabilistic and Extremal Combinatorics, **Ryan Martin** and **Maria Axenovich**, Iowa State University.

Quantum Invariants of 3-manifolds and Modular Categories, **Thang Le**, Georgia Institute of Technology, **Eric Rowell**, Texas A&M University, and **Vladimir Touraev**, Indiana University.

Universal Algebra and Order, **Jeffrey Olson**, Norwich University, **Jeremy Alm**, Illinois College, **Kristi Meyer**, Wisconsin Lutheran College, and **Japheth Wood**, Bard College.

Albuquerque, New Mexico

University of New Mexico

April 17–18, 2010

Saturday – Sunday

Meeting #1059

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2010
Program first available on AMS website: March 4, 2010
Program issue of electronic *Notices*: April 2010
Issue of *Abstracts*: Volume 31, Issue 3

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

Kenneth Bromberg, University of Utah, *Title to be announced*.

Ioana Dumitriu, University of Washington, *Title to be announced*.

Steffen Rohde, University of Washington, *Title to be announced*.

Special Sessions

Dyadic and Non-Dyadic Harmonic Analysis, **M. Cristina Pereyra**, University of New Mexico, and **Stephanie A. Salomone**, University of Portland.

Financial Mathematics: The Mathematics of Financial Markets and Structures, **Maria Cristina Mariani**, University of Texas at El Paso, **Ionut Florescu**, Stevens Institute of Technology, and **Maria P. Beccar-Varela**, University of Texas at El Paso.

Function Spaces, PDEs and Nonlinear Analysis, **Osvaldo Mendez**, **Behzad Rouhani**, and **Mohamed Amine Khamsi**, University of Texas at El Paso.

Geometric Combinatorics, **Art M. Duval**, University of Texas at El Paso, and **Jeremy Martin**, University of Kansas.

Geometric Function Theory, **Lukas Geyer**, Montana State University, and **Donald Marshall** and **Steffen Rohde**, University of Washington.

Geometric Structures and PDEs, **Charles Boyer** and **Dimiter Vassilev**, University of New Mexico.

Harmonic Analysis and Partial Differential Equations, **Matthew Blair**, University of New Mexico, and **Hart Smith**, University of Washington.

Kleinian Groups and Teichmüller Theory, **Kasra Rafi**, University of Oklahoma, **Hossein Namaze**, University of Texas, and **Kenneth Bromberg**, University of Utah.

Positivity in Noncommutative Settings, **Roger Roybal**, California State University Channel Islands, and **Terry Loring**, University of New Mexico.

Random Matrix Theory and Applications, **Ioana Dumitriu**, University of Washington, and **Raj Rao**, University of Michigan.

Selected Topics in Analysis and Numerics for PDEs, **Thomas Hagstrom**, Southern Methodist University, and **Stephen Lau** and **Jens Lorenz**, University of New Mexico.

Strongly-nonlinear Phenomena: Theory and Applications to Nonlinear Optics, Hydrodynamics, Bose–Einstein Condensation and Biology, **Alejandro Aceves**, Southern Methodist University, and **Alexander Korotkevich** and **Pavel Lushnikov**, University of New Mexico.

Subjects in between Pure and Applied Mathematics, **Hanna Makaruk** and **Robert Owczarek**, Los Alamos National Laboratory.

Topics in Geometric Group Theory, **Matthew Day**, California Institute of Technology, **Daniel Peter Groves**, University of Illinois at Chicago, **Jason Manning**, SUNY at Buffalo, and **Henry Wilton**, California Institute of Technology.

Trends in Commutative Algebra, **Louiza Fouli**, New Mexico State University, and **Janet Vassilev**, University New Mexico.

Newark, New Jersey

New Jersey Institute of Technology

May 22–23, 2010

Saturday – Sunday

Meeting #1060

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: March 2020
Program first available on AMS website: April 8, 2010
Program issue of electronic *Notices*: May 2020
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: March 30, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Simon Brendle, Stanford University, *Hamilton's Ricci flow and the sphere theorem in geometry*.

Konstantin M. Mischaikow, Rutgers University, *Computational topology applied to the global dynamics of nonlinear systems*.

Ricardo H. Nochetto, University of Maryland, *Curvature driven flows in deformable domains*.

Richard E. Schwartz, Brown University, *Polygonal outer billiards*.

Special Sessions

Automorphic Forms, L-functions, and Applications (Code: SS 6A), **Ameya Pitale**, American Institute of Mathematics, and **Anantharam Raghuram**, Oklahoma State University.

Biomembranes: Modeling, Analysis, and Computation (Code: SS 16A), **Ricardo H. Nochetto** and **Dionisios Margetis**, University of Maryland.

Elliptic and Parabolic Problems in Geometry (Code: SS 12A), **Simon Brendle**, Stanford University, and **Mu-Tao Wang**, Columbia University.

Expandable Computations, Algorithms, Methodologies and Experiments for Engineering Interpretation (Code: SS 1A), **Mustapha S. Fofana**, Worcester Polytechnic Institute, **Marie D. Dahleh**, Harvard School of Engineering and Applied Sciences, Harvard University, and **Kenji Kawashima**, Precision and Intelligence Laboratory, Tokyo Institute of Technology.

Financial Mathematics (Code: SS 9A), **Tim S.T. Leung**, Johns Hopkins University.

Graph Theory (Code: SS 10A), **Nathan W. Kahl**, Seton Hall University, **Michael J. Ferrara**, University of Colorado at Denver, and **Arthur H. Busch**, University of Dayton.

Groups, Computations, and Applications (Code: SS 2A), **Delaram Kahrobaei**, City University of New York.

Homology Theories for Knots and Skein Modules (Code: SS 3A), **Mikhail Khovanov**, Columbia University, and **Jozef H. Przytycki** and **Radmila Sazdanovic**, George Washington University.

Invariants of Knots, Links, and 3-Manifolds (Code: SS 4A), **Abhijit Champanerkar** and **Ilya S. Kofman**, College of Staten Island, CUNY, and **Philip J. P. Ording**, Medgar Evers College, CUNY.

Lie Algebras and Representation Theory (Code: SS 8A), **Gautam Chinta**, City College, City University of New York, **Andrew Douglas**, New York City College of Technology, City University of New York, and **Bart Van Steirteghem**, Medgar Evers College, City University of New York.

Logic and Groups (Code: SS 17A), **Peggy Dean**, **Claire Wladis**, and **Marcos Zyman**, Borough of Manhattan Community College, City University of New York.

Mathematical Neuroscience: Modeling, Analysis, and Simulations (Code: SS 14A), **Horacio G. Rotstein**, New Jersey Institute of Technology.

Mathematics and Computations of Fluid Dynamics (Code: SS 15A), **Yuan N. Young**, New Jersey Institute of Technology.

Mathematics of Optics and Matter Waves (Code: SS 13A), **Roy Goodman**, New Jersey Institute of Technology.

Nonlinear Waves (Code: SS 19A), **A. David Trubatch**, Montclair State University.

Recent Trends in Cayley Graphs to Model Interconnection Networks (Code: SS 18A), **Daniela Ferrero**, Texas State University, and **Beth Novick**, Clemson University.

Teichmüller Theory, Hyperbolic Geometry, and Complex Dynamics (Code: SS 5A), **Zheng Huang**, College of Staten Island, CUNY, and **Ren Guo**, University of Minnesota.

Topological and Computational Dynamics (Code: SS 7A), **Jean-Philippe Lessard**, Institute for Advanced Study and Rutgers University, and **Konstantin M. Mischaikow**, Rutgers University.

Vortex Dynamics: Theory and Applications (Code: SS 11A), **Denis Blackmore**, New Jersey Institute of Technology, **Morten Brøns**, Technical University of Denmark, and **Chjan Lim**, Rochester Polytechnic Institute.

Berkeley, California

University of California Berkeley

June 2–4, 2010

Wednesday – Friday

Meeting #1061

Eighth Joint International Meeting of the AMS and the Sociedad Matemática Mexicana.
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: April 2010
Program first available on AMS website: April 22, 2010
Program issue of electronic *Notices*: June 2010
Issue of *Abstracts*: Volume 31, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: April 13, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses

Alejandro Adem, University of British Columbia and PIMS, *Homotopy theory and spaces of representations*.

Peter W.-K. Li, University of California Irvine, *What do we know about open manifolds?*.

Ernesto Lupercio, CINVESTAV, *Title to be announced*.

Victor Perez Abreu, CIMAT, *On convolutions and infinite divisibility of probability measures*.

Alberto Verjovsky, IM-UNAM, *Title to be announced*.

Maciej Zworski, University of California Berkeley, *Random perturbations in discrete quantization*.

Special Sessions

Algebraic Topology and Related Topics (Code: SS 3A), **Alejandro Adem**, University of British Columbia, **Gunnar E. Carlsson** and **Ralph L. Cohen**, Stanford University, and **Ernesto Lupercio**, CINVESTAV.

Analytic Aspects of Differential Geometry (Code: SS 2A), **Nelia Charalambous**, ITAM, **Lizhen Ji**, University of Michigan, and **Jiaping Wang**, University of Minnesota.

Commutative Algebra and Representation Theory (Code: SS 7A), **David Eisenbud** and **Daniel M. Erman**, University of California, Berkeley, **Jose Antonio de la Pena**, UNAM, and **Rafael Villareal**, Cinvestav-IPN.

Complex Analysis and Operator Theory (Code: SS 10A), **Maribel Loaiza**, **Enrique Ramirez de Arellano**, and **Nikolai Vasilevski**, CINVESTAV, **Ilya M. Spitkovsky**, College of William & Mary, and **Kehe Zhu**, State University of New York at Albany.

Dynamical Systems (Code: SS 4A), **Alberto Verjovsky**, IM-UNAM, and **Rodrigo Perez**, Indiana University-Purdue University, Indianapolis.

Graph Theory and Combinatorics with Emphasis on Geometric and Topological Aspects (Code: SS 9A), **Gelasio Salazar**, Instituto de Fisica, Universidad Autonoma de San Luis Potosi, and **Dan S. Archdeacon**, University of Vermont.

Harmonic Analysis, Microlocal Analysis, and Partial Differential Equations (Code: SS 1A), **Gunther Uhlmann**, University of Washington, and **Salvador Perez Esteva**, UNAM.

Low-Dimensional Topology (Code: SS 8A), **Kenneth L. Baker**, University of Miami, and **Enrique Ramirez Losada**, CIMAT.

Singularity Theory and Algebraic Geometry (Code: SS 6A), **David Eisenbud**, University of California, Berkeley, **Anatoly S. Libgober**, University of Illinois at Chicago, **Jose Seade**, UNAM, and **Xavier Gomez-Mont**, CIMAT.

Töplitz Operators and Discrete Quantum Models (Code: SS 5A), **Alejandro Uribe**, University of Michigan, and **Maciej Zworski**, University of California, Berkeley.

Hotel Accommodations

Participants should make their own arrangements directly with the hotel listed below. The AMS is not responsible for room inventory, rate changes, or for the quality of the accommodations in this hotel.

Hotel Shattuck, 2086 Allston Way, Berkeley, CA 94704; 510-845-7300 or 866-466-9199 (toll free in the U.S.); 510-845-7320 (fax). Rates include complimentary Internet access (wireless or wired). Rates do not include the state and local tax of 12%. There is a lounge and restaurant in the hotel, and many restaurants/food outlets within easy walking distance. See http://www.hotelshattuckplaza.com/. This is a nonsmoking hotel. It is about a 15-minute walk to the meeting location on campus. The hotel has a 24-hour cancellation policy.

The Hotel Shattuck is offering a 17% discount off its regular rates to participants of this meeting. For reference, regular rates in June will be US$139 for a single room with a double bed and US$149 for a single room with a king bed or a double room with two beds. This offer is valid as long as rooms are available. To make reservations, a) call 510-845-7300 or 866-466-9199 and ask for the "AMS-SMM Meeting" rate, or b) book online by going to http://www.hotelshattuckplaza.com, entering the dates, clicking "Book Now", clicking "Corporate Rates" and entering the code "amssmm10".

Residence Hall Accommodations

Arrangements have been made to house participants in the Foothill Suites Residence Hall at the University of California, Berkeley (UCB). The AMS is not responsible for the quality of the accommodations in this residence hall.

To reserve a room, please submit a completed registration/housing form located at https://www.ams.org/meetreg?meetnum=1061. A minimum 50% deposit is due when the reservation is made with the remaining balance due by **May 14, 2010**. The only accepted form of payment is by credit card. If you cannot pay by credit card, please contact the Mathematics Meetings Service Bureau (MMSB) at 800-321-4267 ext. 4144 or ext. 4137, to arrange a different form of payment. The deadline for reserving a room in the residence hall is **May 14, 2010**. Payments cannot be accepted onsite. For additional questions about reservations for the residence hall, contact the MMSB at mmsb@ams.org.

Foothill Suites Residence Hall, 2700 Hearst Avenue, Berkeley, CA 94720. All participants who choose to stay here will be housed in suites of varying sizes that include shared bathroom facilities/private showers. There will be a common area on each floor that has couches, tables, and chairs. Each sleeping room has one or two desks and one or two twin beds which will be made prior to arrival with a pillow, pillow case, sheets, blanket, and a bedspread. Two towels, a face cloth, a bar of soap will be provided at check-in. Each room will have a small lamp (for each occupant) and a phone (local and on campus calls free of charge).

Windows do not open in the rooms and rooms are not air conditioned; however, fans can be requested at the front desk, if needed. Towels can be exchanged daily at the front desk. There is no maid service for the bedrooms; however, the common areas such as lounges and bathrooms will be cleaned daily. Participants will have access to a laundry room equipped with coin-operated machines.

Participants housed in Foothill Suites will also have access to a lounge equipped with a large screen television and a DVD player, and a recreation center with fitness equipment. There will be a self-service print and email station located in the Stern Library. These services will be available daily from 7:00 a.m. to 11:00 p.m., free of charge to participants. Complimentary Wi-Fi will be offered throughout the residence hall. A username and password will be provided to participants at check-in to access it.

Rooms are available on a **per package basis** only, which includes a three-night stay (June 2, 3, and 4) and a full hot breakfast each morning (June 3, 4, and 5). The cost per person is US$242.63/single occupancy and US$164.63/double occupancy. **The full package is mandatory**. Reservations for individual nights will not be accepted. No refunds will be issued for early check-outs or missed meals.

Cancellation Policy: Any reservations cancelled by **May 7, 2010**, will be issued a 100% refund. A 10% penalty will be applied to any reservations cancelled after **May 7, 2010**. The fee for any lost room keys will be US$75.

Roommates: Participants will be solely responsible for finding their roommates. The MMSB cannot assign roommates. The deadline for all roommate assignments will be **May 14, 2010**. The single rate and appropriate additional charges will be applied to any double room that does not have both roommates assigned after this date. For your convenience, a roommate search board is provided at `http://boards2go.com/boards/board.cgi?user=webgoddess1`.

Food Service

A list of restaurants and food outlets convenient to the meeting location(s), hotel, and dormitory accommodations will be distributed on-site.

Local Information

The following websites provide useful information about the local area: `http://visitberkeley.com/`, `http://berkeley.edu/visit/`.

Other Activities

Book Sales: Examine the newest titles from the AMS! Many of the AMS books will be available at a special 50% discount available only at the meeting. Complimentary coffee will be served courtesy of AMS Membership Services. The AMS Exhibit and Book Sale will operate during the same hours as registration and will be held on the 10th floor Evans Hall, exact location TBD.

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 located on the 10th floor Evans Hall, exact location TBD.

Registration and Meeting Information

The meeting will take place at the University of California, Berkeley, with sessions in Evans Hall and other locations to be announced. Invited Addresses and sessions will take place on Thursday and Friday, June 3--4, with an Opening Ceremony/Welcome Reception held during the evening of Wednesday, June 2. Watch the AMS website for details.

Registration will take place in Evans Hall, room TBD, on the 10th floor on Wednesday (6/2) from 2:00 p.m. to 6:00 p.m.; Thursday (6/3), from 7:30 a.m. to 4:00 p.m., and Friday (6/4), from 8:00 a.m. to noon. Registration fees are US$70 for regular participants and US$35 for students, payable in advance by credit card or onsite by cash, check, or credit card. To register in advance, please submit a completed registration/housing form located at `https://www.ams.org/meetreg?meetnum=1061`. The only accepted form of payment is by credit card. If you cannot pay by credit card, please contact the Mathematics Meetings Service Bureau (MMSB) at 800-321-4267 ext. 4144 or ext. 4137, to arrange a different form of payment. The deadline for registering in advance is **May 14, 2010**. For additional questions about registration, contact the MMSB at `mmsb@ams.org`.

Cancellation Policy: Any registrations cancelled by **May 7, 2010**, will be issued a 100% refund. A 10% penalty will be applied to any registrations cancelled after **May 7, 2010**.

A campus map showing all the buildings where sessions and registration will take place can be found at `http://berkeley.edu/map/maps/campusmap.pdf`.

Parking

It is inadvisable to drive a car to campus as parking is very limited. There is no parking convenient to the meeting location(s). If you need a handicap parking permit, please contact Donna Salter at the AMS, `dls@ams.org`. University visitor parking information is listed at `http://pt.berkeley.edu/park/public` and `http://visitors.berkeley.edu/documents/parking.pdf`. The City of Berkeley Telegraph/Channing Garage at 2450 Durant Avenue is located two blocks from the campus and has entrances on Durant Avenue and Channing Way, but there is no overnight parking. The rates are listed at `http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=8264`. There is also a small underground public parking garage at 2558 Bancroft Way and another at 2308 Bowditch Street.

The Upper Hearst Parking Structure will be available to people staying at the Foothill Residence Hall. It is located on the corner of La Loma Avenue and Hearst Avenue. Parking permits cost US$14 per day and can be purchased on-site at the university check-in desk. The Foothill Parking Lot located on Cyclotron Road is available for parking. Parking passes can be purchased from a dispensing machine on the lot. For more details, see the websites listed above. Public parking is available at both the Upper Hearst parking structure and the Foothill Lot on weekends.

Travel

By air: The nearest major commercial airports are the Oakland International Airport (OAK), which is 15 miles away, and the San Francisco International Airport (SFO), which is 25 miles away.

Taxis: The cost to take a taxicab from the Oakland Airport to the Berkeley area is approximately US$40. The cost to take a taxicab from the San Francisco International Airport to the Berkeley area is approximately US$70.

Airport Shuttle: BayPorter Express, 510-864-4000. Toll free number (within the SF Bay Area only): 877-467-1800. The BayPorter Express operates between 4:30 a.m. and 10:00 p.m. daily to both the Hotel Shattuck and the Foothill Suites Residence Hall. Please call after you pick up your luggage. The shuttle will arrive approximately 30 minutes after you call. The cost is US$25 for the first person and US$15 for each additional person in the party from OAK and US$32 for the first person and US$15 for any additional person in the party from SFO.

By car: Driving directions to the UCB campus can be found at http://visitors.berkeley.edu/gethere/traveling.shtml or to the Hotel Shatttuck at http://www.hotelshattuckplaza.com.

From San Francisco, the San Francisco airport, and points south on northbound Highway 101 to the Berkeley campus:

Follow U.S. 101 north and then switch to I-80 East, and take it across the San Francisco/Oakland Bay Bridge. Stay left as you get off the Bay Bridge and take I-80 East heading to Berkeley and Sacramento. Exit I-80 onto University Avenue. Continue east on University Avenue for approximately 1.5 miles until you get to Oxford Street at the western edge of the campus. To get to the Upper Hearst Parking Structure and the Foothill Lot, turn left onto Oxford Street. Turn right onto Hearst Avenue. The Upper Hearst Parking Structure is at the corner of Hearst and La Loma Avenue. The entrance is on La Loma. To get to the Foothill Lot, continue on Hearst Avenue for another block. Hearst Avenue becomes Cyclotron Road.

From Oakland, the Oakland airport, Hayward, or San Jose on northbound I-880:

Stay in left center lanes on I-880 when you reach downtown Oakland. Take Exit I-80 East to Berkeley and Sacramento. Exit I-80 at University Avenue and continue using the directions listed above.

From the East Bay on northbound Highway 13:

Highway 13 ends and becomes Tunnel Road. Continue on Tunnel Road, which will become Ashby Avenue near the Claremont Hotel. Continue on Ashby and turn right at Telegraph Avenue. Continue on Telegraph. Telegraph Avenue ends at the south side of the campus on Bancroft Way. Turn left at Bancroft Way. Turn right at Fulton Street. Continue on to Oxford Street (Fulton becomes Oxford). Turn right onto Hearst Avenue. Continue using the directions listed above.

From the East Bay on westbound Highway 24:

From Highway 24 exit at Telegraph Avenue and take a right on Telegraph. Continue on Telegraph until the street ends at Bancroft Way. Turn left at Bancroft Way. Turn right at Fulton Street. Continue on to Oxford Street. Turn right onto Hearst Avenue. Continue using the directions listed above.

Car Rental: Avis is the official car rental company for AMS-SMM meeting. All rates include unlimited free mileage. 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. For the best available rate and to make a reservation please call Avis at 800-331-1600 or go online at http://www.avis.com. Please use the AMS **meeting Avis Discount Number J098887**.

Bay Area Rapid Transit (BART): The BART system provides fast, convenient, and economical transportation from the airports to the campus and hotel. Oakland Airport has a shuttle called AirBart, which transports people between the airport and the Coliseum/Oakland Airport BART station. The fare is US$3. The San Francisco Airport has a BART station. The station nearest the UCB campus and the Shattuck Hotel is Downtown Berkeley, which is located near the intersection of Shattuck Avenue and Allston Way, about half a block from the Hotel Shattuck. The fare on BART from Coliseum/Oakland Airport to Downtown Berkeley is US$2.35, and the trip takes about 20 minutes. The fare from the San Francisco Airport Station is US$8.65 and takes approximately 50 minutes. Please visit http://www.bart.gov for more details.

UCB Bear Transit (Campus Bus Service): UCB has excellent shuttle bus service. The Bear Transit Service lines loop through campus, generally at 20 to 30 minute intervals, Monday to Friday. Most shuttles cost US$1 per trip. For actual maps and schedules please visit: http://pt.berkeley.edu/around/transit/routes. To take Bear Transit from the Downtown Berkeley BART station, depart the BART station heading towards Addison Street, and walk across the street to the area immediately in front of the Bank of America, where you can catch the UCB "P", "C", or "R" bus to the Hearst Mining Circle on campus, which is the closest stop to Evans Hall and to the Foothill Suites Residence Hall. The "R" bus also stops at East Gate Gayley Road University Drive, which is even closer to the residence hall. Unfortunately, Bear Transit does not run on Saturday during the day. A cab from the Foothill Residence Suites to the BART station would cost approximately US$5 to US$8. The walk (about 1 mile) is all downhill.

Weather

June is very pleasant in the Bay Area of California. Expect daytime temperatures of about 70 degrees, falling to around 55 degrees in the evenings. The incidence of precipitation in June is very 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.

Syracuse, New York

Syracuse University

October 2–3, 2010

Saturday – Sunday

Meeting #1062

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2011
Program first available on AMS website: August 19, 2010
Program issue of electronic *Notices*: October
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: June 15, 2010
For abstracts: August 10, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Alan Frieze, Carnegie-Mellon University, *Title to be announced*.

Yan Guo, Brown University, *Title to be announced*.

William Minicozzi, Johns Hopkins University, *Title to be announced*.

Andrei Zelevinsky, Northeastern University, *Title to be announced*.

Special Sessions

Analysis, Probability and Mathematical Physics on Fractals (Code: SS 9A), **Luke Rogers**, University of Connecticut, **Robert Strichartz**, Cornell University, and **Alexander Teplyaev**, University of Connecticut.

Commutative Algebra and Algebraic Geometry (Code: SS 8A), **Anthony Geramita**, Queen's University, **Graham Leuschke** and **Claudia Miller**, Syracuse University, and **Michael Stillman**, Cornell University.

Difference Equations and Applications (Code: SS 2A), **Michael Radin**, Rochester Institute of Technology.

Graphs Embedded in Surfaces, and Their Symmetries (Code: SS 4A), **Jack E. Graver** and **Mark E. Watkins**, Syracuse University.

Harmonic Analysis (Code: SS 10A), **Dmitriy Bilyk**, University of South Carolina, and **Svitlana Mayboroda**, Purdue University.

Mathematical Image Processing (Code: SS 5A), **Lixin Shen** and **Yuesheng Xu**, Syracuse University.

Nonlinear Analysis and Geometry (Code: SS 1A), **Tadeusz Iwaniec**, **Leonid V. Kovalev**, and **Jani Onninen**, Syracuse University.

Quasiconformal Mappings, Riemann Surfaces, and Teichmüller Spaces (in honor of Clifford J. Earle) (Code: SS 7A), **Yunping Jiang**, Queens College and The Graduate Center, City University of New York, and **Sudeb Mitra**, Queens College, City University of New York.

Representations of Algebras (Code: SS 6A), **Ed Green**, Virginia Polytechnic Institute, **Mark Kleiner** and **Dan Zacharia**, Syracuse University, and **Andrei Zelevinsky**, Northeastern University.

Several Complex Variables (Code: SS 3A), **Dan F. Coman** and **Evgeny A. Poletsky**, Syracuse University.

Los Angeles, California

University of California Los Angeles

October 9–10, 2010

Saturday – Sunday

Meeting #1063

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2010
Program first available on AMS website: August 26, 2010
Program issue of electronic *Notices*: October 2010
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: June 22, 2010
For abstracts: August 17, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Greg Kuperberg, University of California Davis, *Title to be announced*.

Cris Moore, University of New Mexico, *Title to be announced*.

Stanley Osher, University of California Los Angeles, *Title to be announced*.

Terence Tao, University of California Los Angeles, *Title to be announced* (Einstein Public Lecture in Mathematics).

Melanie Wood, Princeton University, *Title to be announced*.

Special Sessions

Algebraic Structures in Knot Theory (Code: SS 8A), **Sam Nelson**, Claremont McKenna College, and **Carmen Caprau**, California State University Fresno.

Applications of Nonlinear PDE (Code: SS 5A), **Susan J. Friedlander** and **Igor Kukavica**, University of Southern California.

Combinatorics and Probability on Groups (Code: SS 3A), **Jason Fulman** and **Robert Guralnick**, University of Southern California, and **Igor Pak**, University of California Los Angeles.

Extremal and Probabilistic Combinatorics (Code: SS 4A), **Benny Sudakov**, University of California Los Angeles, and **Jacques Verstraete**, University of California San Diego.

Harmonic Analysis (Code: SS 9A), **Christoph Thiele**, University of California Los Angeles, and **Ignacio Uriarte-Tuero** and **Alexander Volberg**, Michigan State University.

Large Cardinals and the Continuum (Code: SS 2A), **Matthew Foreman**, University of California Irvine, **Alekos Kechris**, California Institute for Technology, **Itay Neeman**, University of California Los Angeles, and **Martin Zeman**, University of California Irvine.

Mathematical Models of Random Phenomena (Code: SS 7A), **Mark Burgin**, University of California Los Angeles, and **Alan C. Krinik**, California State Polytechnic University Pomona.

Recent Trends in Probability and Related Fields (Code: SS 6A), **Marek Biskup**, University of California Los Angeles, **Yuval Peres**, Microsoft Research, and **Sebastien Roch**, University of California Los Angeles.

Topology and Symplectic Geometry (Code: SS 1A), **Robert Brown** and **Ciprian Manolescu**, University of California Los Angeles, and **Stefano Vidussi**, University of California Riverside.

Notre Dame, Indiana

Notre Dame University

November 5–7, 2010

Friday – Sunday

Meeting #1064

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: September 2010
Program first available on AMS website: September 23, 2010
Program issue of electronic *Notices*: November 2010
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: April 2, 2010
For consideration of contributed papers in Special Sessions: July 27, 2010
For abstracts: September 14, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Laura DeMarco, University of Illinois at Chicago, *Title to be announced*.

Jordan Ellenberg, University of Wisconsin, *Title to be announced*.

David Fisher, Indiana University, *Title to be announced*.

Jared Wunsch, Northwestern University, *Title to be announced*.

Special Sessions

Algebraic and Topological Combinatorics (Code: SS 9A), **John Shareshian**, Washington University, and **Bridget Tenner**, DePaul University.

Commutative Algebra and Its Interactions with Algebraic Geometry (Code: SS 2A), **Claudia Polini**, University of Notre Dame, **Alberto Corso**, University of Kentucky, and **Bernd Ulrich**, Purdue University.

Computability and Its Applications (Code: SS 11A), **Peter Cholak**, **Peter Gerdes**, and **Karen Lange**, University of Notre Dame.

Geometry and Lie Theory (Code: SS 10A), **John Caine** and **Samuel Evens**, University of Notre Dame.

Groups, Representations, and Characters (Code: SS 4A), **James P. Cossey**, University of Akron, and **Mark Lewis**, Kent State University.

Hilbert Functions in Commutative Algebra and Algebraic Combinatorics (Code: SS 3A), **Fabrizio Zanello**, Michigan Technological University, **Juan Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Interdisciplinary Session on Deterministic and Stochastic Partial Differential Equations (Code: SS 5A), **Nathan Glatt-Holtz**, Indiana University, and **Vlad Vicol**, University of Southern California.

Nonlinear Evolution Equations (Code: SS 7A), **Alex Himonas** and **Gerard Misiolek**, University of Notre Dame.

Number Theory and Physics (Code: SS 8A), **Adrian Clingher**, University of Missouri St. Louis, **Charles Doran**, University of Alberta, **Shabnam N. Kadir**, Wilhelm Leibniz Universitat, and **Rolf Schimmrigk**, Indiana University.

Quasigroups, Loops, and Nonassociative Division Algebras (Code: SS 6A), **Clifton E. Ealy**, Western Michigan University, **Stephen Gagola**, University of Arizona, **Julia Knight**, University of Notre Dame, **J. D. Phillips**, Northern Michigan University, and **Petr Vojtechovsky**, University of Denver.

Singularities in Algebraic Geometry (Code: SS 1A), **Nero Budur**, University of Notre Dame, and **Lawrence Ein**, University of Illinois at Chicago.

Undergraduate Mathematics Education: A Vision for the 21st Century (Code: SS 12A), **Steven Broad**, St. Mary's College, **Nahid Erfan** and **Alex Himonas**, University of Notre Dame, and **Morteza Shafii-Mousavi**, Indiana University South Bend.

Richmond, Virginia

University of Richmond

November 6–7, 2010

Saturday – Sunday

Meeting #1065

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: September 2010
Program first available on AMS website: September 23, 2010
Program issue of electronic *Notices*: November 2010
Issue of *Abstracts*: Volume 31, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: July 27, 2010
For abstracts: September 14, 2010

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Matthew H. Baker, Georgia Institute of Technology, *Title to be announced.*

Michael J. Field, University of Houston, *Title to be announced.*

Sharon R. Lubkin, North Carolina State University, *Title to be announced.*

Stefan Richter, University of Tennessee, Knoxville, *Title to be announced.*

Special Sessions

Applications of Non-Archimedean Geometry (Code: SS 6A), **Matthew H. Baker**, Georgia Institute of Technology.

Kac-Moody Algebras, Vertex (Operator) Algebras, and Applications (Code: SS 7A), **William J. Cook**, Appalachian State University, and **Kailash C. Misra**, North Carolina State University.

Mathematics and the Arts (Code: SS 5A), **Michael J. Field**, University of Houston, **Gary R. Greenfield**, University of Richmond, and **Reza Sarhangi**, Towson University.

Minimum Rank Problems (Code: SS 3A), **Lon H. Mitchell**, Virginia Commonwealth University, and **Sivaram K. Narayan**, Central Michigan University.

Operator Theory (Code: SS 2A), **Stefan Richter**, University of Tennessee, and **William T. Ross**, University of Richmond.

Statistical Properties of Dynamical Systems (Code: SS 4A), **Michael J. Field** and **Matthew J. Nicol**, University of Houston.

Topics in Graph Theory (Code: SS 1A), **Daniel W. Cranston**, Virginia Commonwealth University, and **Gexin Yu**, College of William & Mary.

Pucon, Chile

December 15–18, 2010

Wednesday – Saturday

Meeting #1066

First Joint International Meeting between the AMS and the Sociedad de Matematica de Chile.
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2010
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 15, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

AMS Invited Addresses

Ricardo Baeza, Universidad de Talca, Chile, *Title to be announced*.

Igor Dolgachev, University of Michigan, *Title to be announced*.

Andres Navas, Universidad de Santiago de Chile, *Title to be announced*.

Rodolfo Rodriguez, Universidad de Concepcion, *Title to be announced*.

Gunther Uhlmann, University of Washington, *Title to be announced*.

S. R. Srinivasa Varadhan, New York University, *Title to be announced*.

AMS Special Sessions

Arithmetic of Quadratic Forms and Integral Lattices (Code: SS 6A), **Maria Ines Icaza**, Universidad de Talca, Chile, **Wai Kiu Chan**, Wesleyan University, and **Ricardo Baeza**, Universidad de Talca, Chile.

Automorphic Forms and Dirichlet Series (Code: SS 5A), **Yves Martin**, Universidad de Chile, Chile, and **Solomon Friedberg**, Boston College.

Complex Algebraic Geometry (Code: SS 1A), **Giancarlo Urzua** and **Eduardo Cattani**, University of Massachusetts.

Foliations and Dynamics (Code: SS 4A), **Andrés Navas**, Universidad de Santiago de Chile, and **Steve Hurder**, University of Illinois at Chicago.

Group Actions: Probability and Dynamics (Code: SS 3A), **Andres Navas**, Universidad de Santiago de Chile, and **Rostislav Grigorchuk**, University of Texas.

Inverse Problems and PDE Control (Code: SS 8A), **Matias Courdurier**, Pontificia Universidad Católica de Chile, **Axel Osses**, Universidad de Chile, and **Gunther Uhlmann**, University of Washington.

Non-Associative Algebras (Code: SS 2A), **Alicia Labra**, Universidad de Chile, and **Kevin McCrimmon**, University of Virginia.

Probability and Mathematical Physics (Code: SS 7A), **Hui-Hsiung Kuo**, Louisiana State University, and **Rolando Rebolledo**, Pontificia Universidad Catolica de Chile.

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011

Wednesday – Saturday

Meeting #1067

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: Steven H. Weintraub
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

Statesboro, Georgia

Georgia Southern University

March 12–13, 2011

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 12, 2010
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

Harmonic Analysis and Partial Differential Equations (Code: SS 1A), **Paul A. Hagelstein**, Baylor University, **Alexander Stokolos**, Georgia Southern University, **Xiaoyi Zhang**, IAS Princeton and University of Iowa, and **Shijun Zheng**, Georgia Southern University.

Iowa City, Iowa

University of Iowa

March 18–20, 2011

Friday – Sunday

Central Section
Associate secretary: Georgia Benkart
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: July 16, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Worcester, Massachusetts

College of the Holy Cross

April 9–10, 2011

Saturday – Sunday
Eastern Section
Associate secretary: Steven H. Weintraub
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 9, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Las Vegas, Nevada

University of Nevada

April 30 – May 1, 2011

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Special Sessions

Advances in Modeling, Numerical Analysis and Computations of Fluid Flow Problems (Code: SS 2A), **Monika Neda**, University of Nevada Las Vegas.

Geometric PDEs (Code: SS 1A), **Matthew Gursky**, Notre Dame University, and **Emmanuel Hebey**, Université de Cergy-Pontoise.

Lincoln, Nebraska

University of Nebraska-Lincoln

October 14–16, 2011

Friday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2011
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2011
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Salt Lake City, Utah

University of Utah

October 22–23, 2011

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Port Elizabeth, Republic of South Africa

Nelson Mandela Metropolitan University

November 29 – December 3, 2011

Tuesday – Saturday
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced

Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

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

Lawrence, Kansas

University of Kansas

March 30 – April 1, 2012

Friday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center 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: Georgia Benkart
Announcement issue of *Notices*: October 2012
Program first available on AMS website: November 1, 2012
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 34, Issue 1

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, Baltimore Hilton, and Marriott Inner Harbor

January 15–18, 2014

Wednesday – Saturday
Joint Mathematics Meetings, including the 120th Annual 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*: October 2013
Program first available on AMS website: November 1, 2013
Program issue of electronic *Notices*: January 2013
Issue of *Abstracts*: Volume 35, Issue 1

Deadlines

For organizers: April 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015

Saturday – Tuesday

Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th 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 of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: October 2014
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2015
Issue of *Abstracts*: Volume 36, Issue 1

Deadlines

For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seattle, Washington

Washington State Convention & Trade Center and the Sheraton Seattle Hotel

January 6–9, 2016

Wednesday – Saturday

Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th 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 of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2016
Issue of *Abstracts*: Volume 37, Issue 1

Deadlines

For organizers: April 1, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday – Saturday

Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th 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 of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2017
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: Georgia Benkart, University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

Eastern Section: Steven H. Weintraub, Department of Mathematics, Lehigh University, Bethlehem, PA 18105-3174; e-mail: steve.weintraub@lehigh.edu; telephone: 610-758-3717.

Southeastern Section: Matthew Miller, Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001, e-mail: miller@math.sc.edu; telephone: 803-777-3690.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at** www.ams.org/meetings/.

Meetings:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 92 in the January 2010 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

Co-sponsored conferences:

May 24-29, 2010: From Carthage to the World, the Isoperimetric Problem of Queen Dido and its Mathematics Ramifications, Carthage, Tunisia (for more information please see http://math.arizona.edu/~dido/welcome.html).

June 17-19, 2010: Coimbra Meeting on 0-1 Matrix Theory and Related Topics, University of Coimbra, Portugal (for more information please see http://www.mat.uc.pt/~cmf/01MatrixTheory).

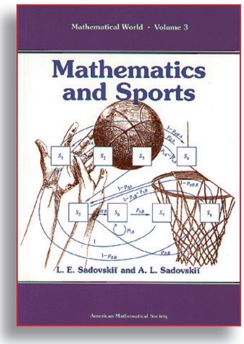
American Mathematical Society

April is Mathematics Awareness Month

Find out more about mathematics and sports at **www.mathaware.org**

The theme for 2010 is:

Mathematics and Sports



Mathematics and Sports

L. E. Sadovskiĭ, *Institute of Railroad Transportation Engineering, Moscow, Russia*, and **A. L. Sadovskiĭ**, *Texas A & I University, Kingsville, TX*

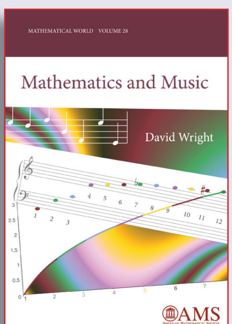
Some of the … mathematical applications—particularly in areas related to operations research—are more intriguing. The authors have made a good effort to draw illustrations from many different sports … They also demonstrate a wide variety of mathematical techniques with relatively simple examples … a student might find something here to spark an interest in further investigation.

—Journal of the American Statistical Association

This unique book presents simple mathematical models of various aspects of sports with applications to sports training and competitions. Requiring only a background in precalculus, it would be suitable as a textbook for courses in mathematical modeling and operations research at the high school or college level. Coaches and those who participate in sports will find it interesting as well. The lively writing style and wide range of topics make this book especially appealing.

Mathematical World, Volume 3; 1993; 152 pages; Softcover; ISBN: 978-0-8218-9500-9; List US$22; AMS members US$18; Order code MAWRLD/3

Other books of interest:



Mathematics and Music

David Wright, *Washington University, St. Louis, MO*

Mathematical World, Volume 28; 2009; 161 pages; Softcover; ISBN: 978-0-8218-4873-9; List US$35; AMS members US$28; Order code MAWRLD/28

Famous Puzzles of Great Mathematicians

Miodrag S. Petković, *University of Nis, Serbia*

2009; 325 pages; Softcover; ISBN: 978-0-8218-4814-2; List US$36; AMS members US$29; Order code MBK/63

Not Always Buried Deep

A Second Course in Elementary Number Theory

Paul Pollack, *University of Illinois, Urbana-Champaign, IL*

2009; 303 pages; Hardcover; ISBN: 978-0-8218-4880-7; List US$62; AMS members US$50; Order code MBK/68

TEXTBOOKS FROM THE AMS

AMS BOOKSTORE

www.ams.org/bookstore

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