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Notices

of the American Mathematical Society

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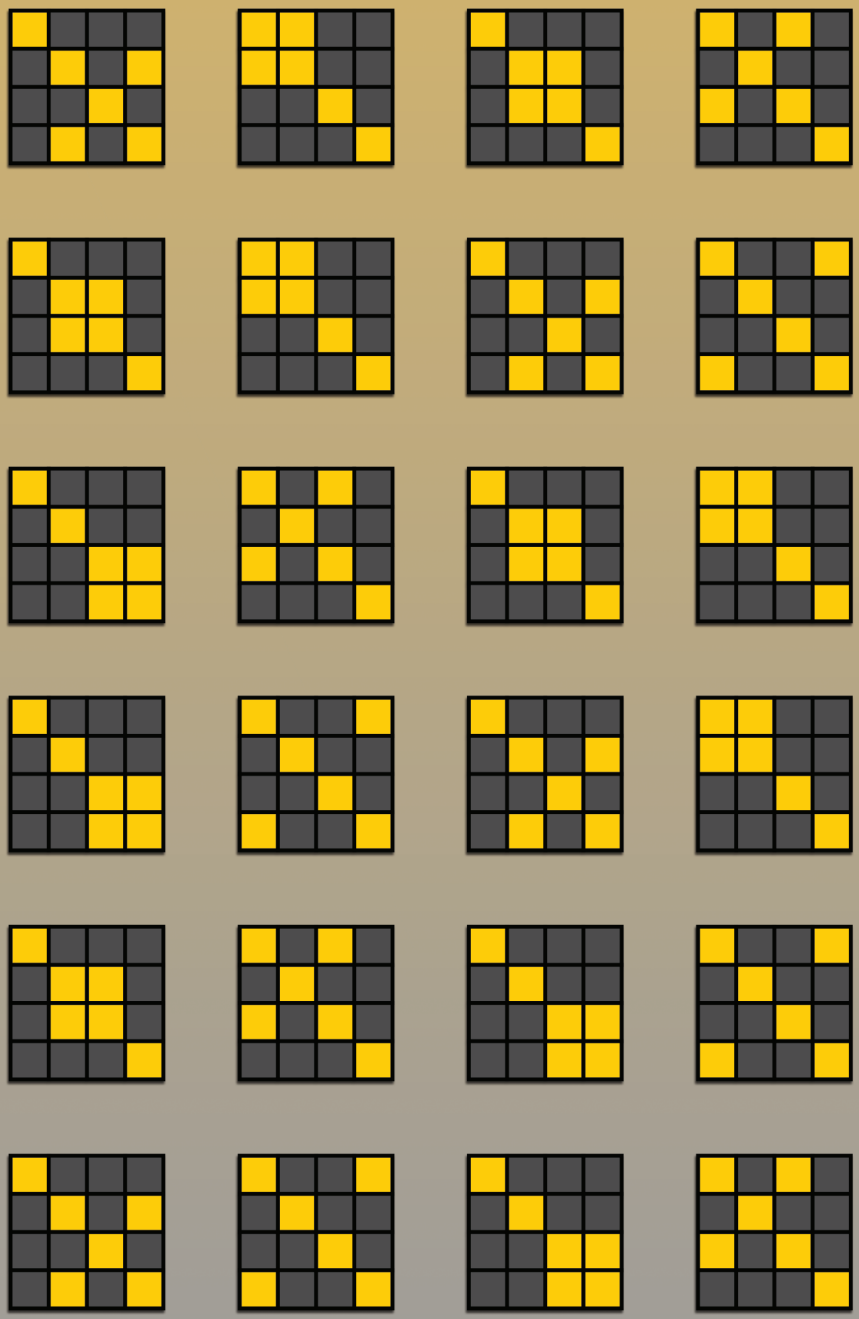

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About the cover: Twenty-four views of $\square$. *(see page 38)*

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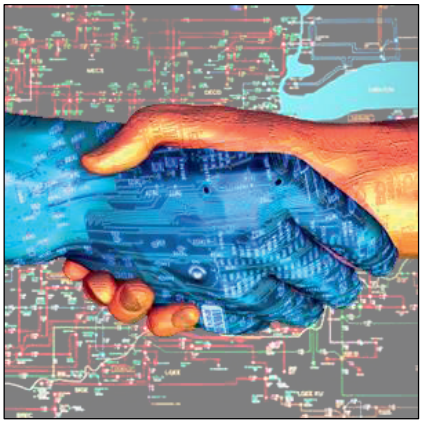

Graduate Summer School:

Games and Contracts for Cyber-Physical Security

July 7-23, 2015

Organizing Committee

Saurabh Amin (MIT) and **Galina Schwartz** (UC Berkeley)

Scientific Overview

This summer school will provide an advanced introduction on how the mathematical tools of game theory can be applied to improve the resilience (security and reliability) of cyber physical systems (CPS) that control critical national infrastructures, such as our electricity, water, and transportation networks. The operations of such CPS are driven by actions of many human decision makers who need to make decisions based on limited information. In addition, these humans frequently have conflicting objectives, which make them reluctant to share even partial information with others. Game-theoretic tools allow analyzing strategic behavior of the entities upon whose choices the CPS operations depend.

The first two weeks will provide an overview of the relevant mathematical tools of game and contract theory, and an outline of the incentive theory framework. The third week will give applications of game theory tools to improving CPS security in various infrastructure domains.

Participation

The summer school will provide a rare opportunity for researchers in mathematics, computer science, engineering, and related sciences to learn about recent research directions and future challenges in this area. Funding is available to support graduate students and postdoctoral researchers in the early stages of their career, as well as more senior researchers interested in undertaking new research in this area. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission, and we welcome their applications. The application is available online, and is due March 31, 2015.

www.ipam.ucla.edu/gss2015

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January 2015

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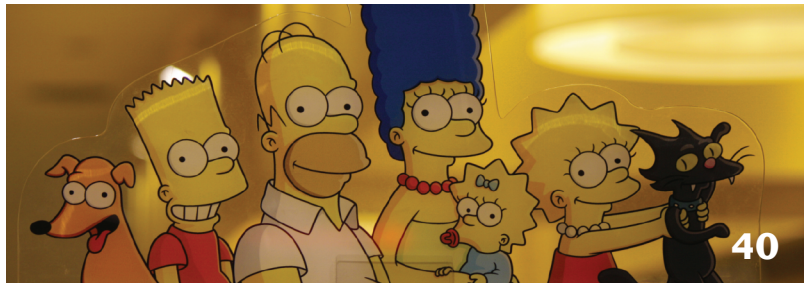

The January issue features two fascinating articles about the Fields Medal. One considers whether the Fields Medal is actually the Nobel Prize of mathematics, and the other discusses whether the Fields Medal is a career-breaker for mathematical research. We also have an historical article about David Rittenhouse and a memorial article for distinguished analyst Joram Lindenstrauss. There is an article about the experience of being a Congressional Fellow in the United States Senate, and a *Doceamus* about writing a compelling teaching statement. Finally, there is a fascinating collection of Letters to the Editor that discuss whether or not diversity trumps ability. —*Steven G. Krantz, Editor*

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Notices

of the American Mathematical Society

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AMERICAN MATHEMATICAL SOCIETY

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My Year in the United States Senate

This past year I served as one of thirty-four Congressional Fellows as part of the Science & Technology Policy Fellowship program run by the American Association for the Advancement of Science (AAAS) and funded by the AMS. In addition to the Congressional Fellows, there are about 200 AAAS Fellows placed in the Executive Branch each year. While the AAAS funds the Executive Branch Fellows, professional associations typically fund Congressional Fellows. Other scientific associations—ranging from the American Society of Mechanical Engineers to the American Veterinary Medical Association to the American Psychological Association—support PhD scientists as fellows in the same way that the AMS does. Recently, most fellows have come from academic settings, but some come from the private sector. Most have recently completed their PhD or postdoc, but some are more advanced in their careers. The fellows form a tight social group and work together on projects outside of the day job; for example, I worked with other fellows to run the first ever DC Mini Maker Faire, which served as a warm up for some of the participants who would attend the first ever White House Maker Faire the next week.

The fellowship starts at the beginning of September, with a two-week orientation that is exhilarating and extremely informative. Next, the Congressional Fellows begin the interview and placement process, looking for a good match for the year. Many considerations go into the match—majority v. minority, geographic connections, Democratic v. Republican, member's legislative priorities and committee assignments, etc. I chose to work for my home state, for Senator Franken. I worked on education issues, with focus on higher education and STEM (science, technology, engineering, and mathematics) education. This assignment suited me, as I have worked in higher ed in Minnesota for over twenty years and know the education landscape well. Also, Senator Franken serves on committees I care about. I supported the Senator in his work on the Senate HELP (Health, Education, Labor and Pensions) Committee and on the Senate Indian Affairs Committee. The policy areas covered by the 2013–2014 fellows included food safety, transportation, agriculture, energy, and climate science. It was a big year for health policy and energy, as the Affordable Care Act was being rolled out during our fellowship year and as Congress increased its attention to "fracking." In my portfolio the topics of high visibility included student loan reform and college access and completion.

In the Senate, the pace of work and the interactions with colleagues are quite different from academia. A typical day included preparing background material and questions for HELP Committee hearings that the Senator attended, preparing video remarks for the Senator to deliver, writing legislation, and vetting proposed legislation from other Senators to consider whether or not to ask my boss to cosponsor. Every Monday began with a meeting of the full legislative team, followed by a meeting with the Senator and the full office staff to lay out the week ahead. Each week I also participated in a meeting of education policy advisors for the Democratic HELP Committee Senators. We also had weekly check-ins with our education staffers back in Minnesota.

The scientific experience of the fellows helped us engage in "science for policy"; for example, our scientific background was helpful as lawmakers considered poultry immunizations while developing legislation regulating the poultry industry. The lawmakers we worked for were eager to hear our input, and our expertise was valued. There are very few scientists in Congress and only one mathematician: Representative Jerry McNerney of California. After participating in the Joint Meetings in 2014, he gave a House floor speech about the twin prime conjecture. The purpose of the speech was to interest the public in STEM fields broadly and also to emphasize that basic research is a valuable investment even when it does not generate immediate impact.

While fellows provide "science for policy," we also engage in "policy for science", which includes for example efforts to ensure that the National Science Foundation (NSF) is well-funded and that basic research remains a budgetary priority. "Policy for science" is critical in appropriations discussions, during which priorities are set for the small portion of the federal budget that goes to discretionary non-defense items such as the NSF. Some of us also worked with our offices on other "policies for science," including funding for research universities, promoting STEM education and participation in STEM fields by women and other underrepresented groups, patent legislation that might affect scientists and universities, and so on.

Policymaking is hard. It is a subtle craft involving many stakeholders. I worked with a great office, with supportive constituents, and with conscientious Senators who are good people, trying to do good things. It is easy to be cynical about Capitol Hill these days, and I wondered if the fellowship experience might exacerbate my own cynicism. For the most part, the experience reduced it.

The fellowship was a terrific and life-changing experience and I am grateful to the AMS for making it possible and for working to keep mathematics visible in the policymaking arena. If you are interested in pursuing the fellowship, feel free to contact me.

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Letters to the Editor

A Plea for Civility and Collegiality

I applaud the editorial commitment stated in the March, 2014 "Letters to the Editor" section of *Notices* not to have its articles "aggravate already existing schisms and wounds." For that reason, I was surprised that *Notices* chose to publish Abigail Thompson's article "Does diversity trump ability?" [4], heavily criticizing arguments by Lu Hong and Scott Page in [2] and [3], without insisting that the author omit the article's belittling and uncollegial language characterizing work in an area in which "strongly held beliefs are in play," as she herself states in the article. It is particularly important for highly respected, award-winning mathematicians such as Professor Thompson to help foster a civil discussion in realms in which there are, indeed, strongly held opinions and people just waiting for permission to rip into others with their own.

No mention is made in the article of the reactions of Hong and Page to these claims of fundamental mathematical errors in their work. Given that, it would have also seemed natural during the editorial process to have checked whether the concerns had been discussed with them. According to Page, he knew nothing about the imminent appearance of the *Notices* article until its author sent him a pro forma note that it was about to be published. I am certain that Page, whose bachelor's and master's degrees in mathematics are from Michigan and Wisconsin prior to his PhD in managerial economics and decision sciences from the Kellogg School at Northwestern, and who is director of the Center for Study of Complex Systems at Michigan, would have enjoyed the opportunity to have had a conversation ahead of time regarding Thompson's concerns about the mathematics.

Quote-checking during the review process could also have helped. This one from Page's book [3] is displayed on the first page of the article and sets the stage for what is to follow: "…the veracity of the diversity trumps ability claim is not a matter of dispute. It's true, just as 1+1=2 is true." This appears to invite the reader to believe that Page claims to have in hand a mathematical result that can be fearlessly applied in social science settings to groups of people, and a remark in the same paragraph of the *Notices* article that the quote refers to work "ostensibly proving that a group picked on the basis of 'diversity' criteria outperforms one picked on the basis of 'ability'" seems to confirm that interpretation. Had Page's quote been checked for context, I am certain that there would have been insistence that the sentence following the excerpt also be included in the quote: "However, the claim applies to mathematical objects and not to people directly." Page's claims for the applicability of his "diversity trumps ability" assertion are actually highly qualified throughout his book. For example, right up front in his introduction (p. xxiii) Page states that, "My claims that diversity produces benefits rest on conditions. These conditions require, among other things, that diversity is relevant—we cannot expect that adding a poet to a medical research team would enable them to find a cure for the common cold." This is far from the flat, unqualified endorsement of diversity over ability the reader might infer from the truncated quote.

If someone believes there is an error in a published argument, then of course there is nothing wrong (and everything right) with working with the people originally making the argument to get the word out if corrections need to be made. But the tone and language of the *Notices* article, however much the author's intent might be that it be aimed only at her perception of mathematical content, will likely provide ammunition for doubters who would like to believe that the very value and importance of diversity have somehow been called into question. With or without the mathematical arguments under fire in the *Notices* article, Page's book contains ample arguments and evidence that this is not so. My final thought would be addressed to such a doubter, and was said well in a different context by anthropologist Clifford Geertz in a conversation with colleagues reported in [1], if we just substitute "theorems" for "studies": In a discussion of a topic "of some significance,"

… [one of the colleagues] interjected, "Well, we really don't know whether that's right, because we have no studies on that." To which Geertz retorted, "Well, you live in the society and have eyes, don't you?"

References

[1] M. Dunkelman, *What data can't convey*, Chronicle of Higher Education, August 19, 2014, available online at `chronicle.com/blogs/conversation/2014/08/19/what-data-cant-convey/`.

[2] L. Hong and S. Page, Groups of diverse problem solvers can outperform groups of high-ability problem solvers, *Proc. Nat. Acad of Sciences* 101, no. 46 (2004), 16385–16389.

[3] S. Page, *The Difference*, Princeton University Press, 2007.

[4] A. Thompson, Does diversity trump ability?, *Notices of the AMS* 61, no. 9 (2014), 1024–1030.

—Robert Megginson
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(Received October 16, 2014)

Diversity Trumps Ability and The Proper Use of Mathematics

In my book *Difference*, I present a framework for modeling problem-solving groups. In it, I demonstrate the value of diverse problem representations and heuristics. One of the book's claims, proven jointly with Lu Hong, provides sufficient conditions for a collection of randomly chosen problem solvers to almost always outperform a group of the best problem solvers.

The article "Does diversity trump ability?" (*Notices*, October 2014) characterized that claim as false. That characterization was based on an erroneous counterexample that violates my theorem's **Condition 3**, (specified in my book): *for any nonglobal optimum, some positive proportion of the problem solvers can locate a solution of higher value.*

The counterexample would apply to an alternative set of conditions Lu Hong and I published in *PNAS*, if one

assumes that distinct solutions can take identical values—a possibility that by convention we had ruled out. Note that even with identical values, Condition 3 invalidates the counter-example.

Second, and more troubling, the note accuses me of misusing mathematics, claiming that I imply that the mathematical results are somehow *fact* in the world of people. The accusation is baseless. In my book, I caution readers to apply mathematical models carefully, highlighting the subtleties of moving from the starkness of mathematical logic to the richness of human interactions.

Not everyone understands the role of mathematical claims in the social sciences. Some nonmathematicians have stated that Lu and I "proved mathematically that diverse groups of people always outperform groups of the best." Obviously, such a proof would be impossible. Instead, Lu and I have used mathematics to identify sufficient conditions for a result to hold, a technique widely used by social scientists. Implicit in our derivation is that there also exist conditions under which diversity won't trump ability. The practice of social science often involves carving up the space of possibilities in this way. Doing so helps us to understand when intuitions hold and when they don't.

The *diversity trumps ability result* is just one of many findings described in my book. The contribution of that claim or any other is best understood in the context of the entire ensemble of claims. The purpose of writing the book was to provide formal frameworks within which one can analyze the contributions of cognitive diversity in solving problems and making predictions. By bringing logic to bear on a set of questions that are all too often approached ideologically, my efforts are not a misuse of mathematics, but a valuable and important use.

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(Received October 16, 2014)

Response to Page and Megginson

I thank Professors Page and Megginson for their responses to my article.

Professor Page contests the validity of my counter-example to the main theorem of his 2004 article with Hong. He says that it "violates my theorem's Condition 3, (specified in my book)". But the book appeared in 2007. The 2004 article in the *Proceedings of the National Academy of Sciences* contained the complete statement of the theorem with the proof. This article and its arguments were the subject of my paper. The counter-example is correct.

I regret that Professor Megginson found some of the language uncollegial. My intention was only to comment on the merits of arguments that were made in a published research article. Professor Megginson argues that it is simply obvious that diversity is a good thing, regardless of the mathematical content of the Hong-Page article ("Well, you live in the society and have eyes, don't you?"). I did not address the question of the value of diversity in my article. The question I considered was simply whether or not a mathematical case for diversity is made in the Hong-Page paper. It is not.

As for their other remarks, I stand by the points in my paper.

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(Received October 27, 2014)

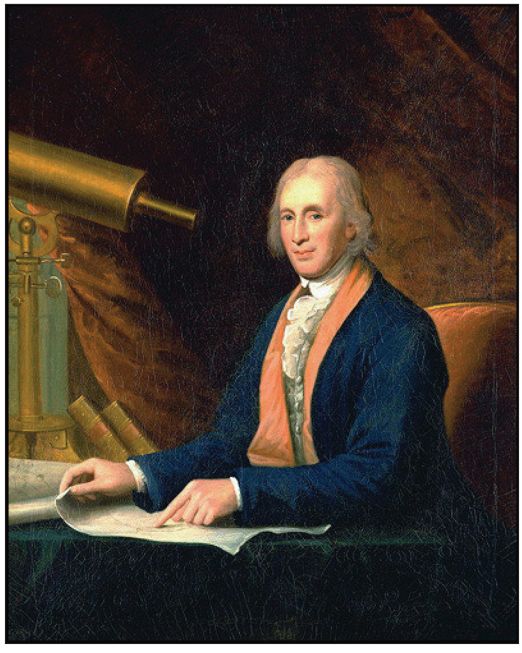
David Rittenhouse: Modern Mathematician

David E. Zitarelli

On the surface it seems implausible that a colonial scientist could be characterized as a mathematician by today's standards. Yet the single aim of this note is to provide evidence that two of David Rittenhouse's papers from 220 years ago qualify him as a modern analyst.

Rittenhouse (1732–1796) had no formal education and never earned a degree. Except for a brief appointment as professor of astronomy at the University of Pennsylvania, he never held an academic position. Yet he became one of America's leading colonial scientists.

Rittenhouse can be regarded as a modern mathematician in three ways. For one, his research on the transit of Venus of 1769 was financed by a governmental agency (the Colony of Pennsylvania) for the first time in American history, setting an early precedent for NSF grants. For another, much like Oswald Veblen in World War I, he aided a war effort by refining the ballistics of rifles and cannons as well as locating forts to maximize defenses for General Washington. But the main reason is because of two papers he read at scientific meetings and subsequently published in that society's *Transactions*. A close reading of these papers would label him an analyst—even, perhaps, a numerical analyst—today.



"David Rittenhouse" by Charles Wilson Peale—Smithsonian National Portrait Gallery—public domain.

David Rittenhouse

Analyst

Rittenhouse read the paper "A method of finding the sum of the several powers of the sines" at a monthly meeting of the American Philosophical Society (APS) in May 1792, a month after turning sixty. Its introduction reveals the source of the project he was investigating: to determine the times of vibration of a pendulum. However, he stated a philosophy embraced by many mathematicians today: "I was induced to attempt the means of doing this solely by its usefulness, but in prosecuting the enquiry I found much of that pleasing regularity, the discovery of which the geometrician often thinks a sufficient reward for his labours" [2, p. 155]. The "pleasing regularity" can be seen in the bottom half of Figure 1. The first two cases reveal formulas for the sums of sin and $\sin^2$ in the first quadrant. Here the old English way of writing the letter "s" is suggestive because the first letter

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resembles an integral sign. Thus by "the sum of the sines" Rittenhouse was appealing to areas under their curves which, in modern terms, become the two formulas

$$\int_0^{\pi/2} \sin x\, dx = 1 \tag{1}$$

and

$$\int_0^{\pi/2} \sin^2 x\, dx = \frac{\pi}{4}. \tag{2}$$

Throughout this section I restrict the radius of the circle to be $r = 1$; it is a simple exercise to extend these formulas to Rittenhouse's expression, with some care. For instance, in all even-numbered cases "the arch of 90°" means the circumference of the first quadrant of a circle, so $\int_0^{\pi/2} \sin^2 x\, dx = \frac{1}{2} \times \frac{\pi}{2}$.

Rittenhouse indicated his methods on the right side of Figure 1. Thus he proved the first two cases "By Demonstration," meaning he was in possession of proofs by synthetic geometry. Without saying so, he left the proofs as an exercise for the reader.

Similarly, Rittenhouse stated that he obtained formulas for the next four cases "By Infinite Series." It is therefore impressive that he was able to evaluate $\int_0^{\pi/2} \sin^n x\, dx$ for $n = 3, 4, 5, 6$ by this method, but it is equally tantalizing because, once again, he provided no proofs. Moreover, Rittenhouse was a taciturn, introverted individual who corresponded infrequently and left few notes behind, so we have nary a hint as to how he proved, for example, that

$$\int_0^{\pi/2} \sin^6 x\, dx = \frac{5\pi}{32}.$$

Neither his file in the APS archives nor correspondence with Thomas Jefferson reveals any evidence.

If we are left feeling empty for lack of proofs, Rittenhouse felt equally frustrated, though for a different reason. He wrote, "I have not been able strictly to demonstrate any more than the first two cases." This statement places him squarely in the eighteenth century, a time when proofs by Euclidean geometry set the standard.

Rittenhouse obtained the two cases $n = 7$, $n = 8$ "By the Law of Continuation," called induction today. Table 1 summarizes the eight cases. It is not particularly straightforward to see how to induce the results for $n = 7$ and $n = 8$ from the first six cases. (Spoiler alert: I am about to state the rule. Inquisitive readers are encouraged to attempt this problem independently.) Rittenhouse wrote: "The law is this, make a fraction whose denominator is the index of the given power, and its numerator the same index, diminished by unit…; by this fraction multiply the sum of the next but one lower power, and we have the form of the given power."

Table 1.

N	Sum
1	1
2	$\pi/2$
3	$2/3$
4	$3\pi/16$
5	$8/15$
6	$5\pi/32$
7	$16/35$
8	$35\pi/256$

Based on today's methods for evaluating $\int \sin^n x\, dx$ by trigonometric identities, we know that these cases must be taken in pairs, because those identities differ according to the parity of n. In symbols, for the sum of $\sin^n$ the index is n, so the multiplier is $\frac{n-1}{n}$. By interpreting "the next but one lower power" as $n - 2$, we arrive at the formula

$$\int_0^{\pi/2} \sin^n x\, dx = \frac{n-1}{n} \int_0^{\pi/2} \sin^{n-2} x\, dx.$$

Rittenhouse, it seems, had discovered this recursion formula unaware that "Wallis's formulas" were discovered by the English mathematician John Wallis around 1655.

The title of the printed version of the paper Rittenhouse delivered begins "Dr. Rittenhouse to Mr. Patterson." Rittenhouse concluded by beseeching University of Pennsylvania mathematician Robert Patterson, "Should your leisure permit you to give any attention to this subject I shall be glad to see you furnish a demonstration for the 3^d, or any subsequent case abovementioned [*sic*]."

The discovery of this recursion formula shows that Rittenhouse was a modern mathematician in practice as well as in spirit. His only other paper devoted strictly to pure mathematics looks to contain little more than brute-force arithmetic computations, but a closer examination reveals a much deeper algorithm.

Numerical Analyst

David Rittenhouse was sufficiently inspired by his progress to investigate other mathematical problems for their own sake. In August 1795, after succeeding Benjamin Franklin as president of the APS, he read the paper "Method of raising [evaluating] the common logarithm of any number immediately" at an APS meeting. It was published posthumously in 1799 [3].

The late Jesuit priest Frederick A. Homann (1929–2011) described this paper in [1], illustrating the Rittenhouse algorithm by evaluating $\log N$ for $N = 20$. A cursory glance at the massive columns of calculations in Rittenhouse's paper suggests why Homann chose $N = 20$—it simplifies

the ultimate ratio which the ſum of the given power of the ſines bears to a known power of the radius.

Having proceeded ſo far as the 6th power the law of continuation became evident; ſo that, ſhould any problem in mathematical philoſophy require it, we may proceed as far as we pleaſe in ſumming the powers of the ſines. The law is this,

Make a fraction whoſe denominator is the index of the given power, and its numerator the ſame index, diminiſhed by unity, and multiplied by the ſquare of the radius; by this fraction multiply the ſum ot the next but one lower power, and we have the ſum of the given power.

Thus 1ſt, the ſum of the 1ſt power of the ſines is = rr, or the ſquare of the radius — By Demonſtration.

2d, ſum of the 2d, power or ſquares is = $\frac{1}{2}$rr × by the arch of 90°. — By Demonſtration.

3d, ſum of the 3d, power or cubes is $\frac{2}{3}$rr of the 1ſt, or = $\frac{2}{3}$r³. — By Infinite Series.

4th. ſum of 4th powers is = $\frac{3}{4}$rr of the 2d or = $\frac{3}{8}$r⁴ × by the arch of 90°. — By Infinite Series.

5th, ſum of 5th. powers is = $\frac{4}{5}$rr of the 3d, or = $\frac{8}{15}$r⁵. — By Infinite Series.

6th, ſum of 6th. powers is = $\frac{5}{6}$rr of the 4th or = $\frac{5}{16}$r⁶ × by arch of 90°. — By Infinite Series.

7th, ſum of 7th. powers is = $\frac{6}{7}$rr of the 5th, or = $\frac{16}{35}$r⁷. — By the Law of Continuation.

8th, ſum of 8th. powers is = $\frac{7}{8}$rr of the 6th, or = $\frac{35}{128}$r⁸ × by the arch of 90°. — By the Law of Continuation.

&c. &c.

Should your leiſure permit you to give any attention to this ſubject I ſhall be glad to ſee you furniſh a demonſtration for the 3d, or any ſubſequent caſe abovementioned.

I am, Sir,

Your moſt obedient humble ſervant,

DAVID RITTENHOUSE.

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Figure 1

calculations enormously. Yet this simplification belies Rittenhouse's numerical dexterity, so I will adapt Homann's approach to approximate $\log 99$, the case Rittenhouse exhibited in his paper.

Rittenhouse began by calculating the characteristic of $\log N$, which, by definition, is the largest integer C for which $\frac{N}{10^C} \geq 1$. For $N = 99$ it is immediate that $C = 1$. The mantissa of $\log N$ is then the continued fraction $[n_0, n_1, n_2, \dots]$, where

$$Q_{-1} = 10, Q_0 = \frac{N}{10^C}, Q_{k+1} = \frac{Q_{k-1}}{Q_k^{n_k}} \text{ for } k = 0, 1, 2, \dots$$

and n_k is the largest integer for which $Q_{k+1} \geq 1$. By definition

$$Q_1 = \frac{Q_{-1}}{Q_0^{n_0}} = \frac{10}{9.9^{n_0}}.$$

Clearly $n_0 = 1$ is the largest integer for which $Q_1 \geq 1$. Therefore

$$Q_1 = \frac{10}{9.9}.$$

Now the calculations become tedious, because the next step is to find the largest integer n_1 for which $Q_2 \geq 1$, where

$$Q_2 = \frac{Q_0}{Q_1^{n_1}} = \frac{9.9}{\left(\frac{10}{9.9}\right)^{n_1}}.$$

This was easy for n_0, as we saw. But it turns out that $n_1 = 228$.

How did Rittenhouse conclude that $n_1 = 228$? His computations show a master numerical analyst at work. First, he set $a = \frac{10}{9.9}$. The approach was to calculate powers of the denominator a^n of Q_2 for $n = 2, 4, 8, 16, \ldots$ by successive squaring until a^n exceeded the numerator 9.9. He halted the process at $a^{128} = 3.619887649$ because the next term would be $a^{256} = (a^{128})^2 > 3.6^2 > 9.9$. Consequently, $128 \leq n_1 \leq 256$. At that point Rittenhouse examined prior powers of a^n to determine which of their products remained below 9.9. He concluded that $n_1 = 228 = 128 + 64 + 32 + 4$ because $a^{128} \cdot a^{64} \cdot a^{32} \cdot a^4 = a^{228} = 9.889521 < 9.9$.

It is especially impressive that all of these calculations were carried out by hand. Yet we wonder, how did he not become discouraged after the first several iterations of a^n? We will never know the answer because this paper, like his first, contains only the finished product, not the underlying scaffolding.

Subsequently Rittenhouse carried out similar calculations to obtain $n_2 = 9$, $n_3 = 2$, and $n_4 = 75$, producing the continued fraction approximation $[1, 228, 9, 2, 75]$. This means that the fifth Rittenhouse approximation for the mantissa of $\log 99$ is

$$R_5 = \cfrac{1}{1 + \cfrac{1}{228 + \cfrac{1}{9 + \cfrac{1}{2 + \cfrac{1}{75}}}}} = \frac{327103}{328537} = 0.995\,635\,194.$$

Thus, correct to nine decimal places,

$$\log 99 = 1.995\,635\,194.$$

Rittenhouse's closing statement, "3 [is] too much in the tenth [place]" reflects the style of modern numerical analysts to obtain bounds on approximations. These rather nasty computations, even when evaluated with modern software, give pause to the word "immediately" in the title of his paper.

Rittenhouse's method also suggests an easy generalization to evaluating $\log_B N$ for any base B. In this case the characteristic becomes the largest integer C for which $\frac{N}{B^C} \geq 1$. Then the mantissa is the continued fraction $[n_0, n_1, n_2, \ldots]$, where $Q_{-1} = B$, $Q_0 = \frac{N}{B^C}$, and subsequent pairs (Q_k, n_k) are defined in an identical way.

David Rittenhouse did not supply the reason why he desired logarithms to such accuracy, but undoubtedly it was due to the fact that logarithms were of great use in colonial surveying and astronomy, two areas he pursued in earnest. Although he knew much of the mathematics carried out in England in the eighteenth century, he was apparently unaware that his algorithm had already appeared in a 1717 article by Brook Taylor in the *Philosophical Transactions* of the Royal Society of London [5]. As Rittenhouse's papers on the sums of powers of sines showed, he had a masterful command of series, and thus it is surprising that he missed Taylor's work.

Ironically, in 1954 the numerical analyst Daniel Shanks (1917–1996) discovered the algorithm independently and published it in *Mathematical Tables and Aids to Computation* (*Mathematics of Computation* since 1960) without knowledge of either predecessor. That paper begins, "The method of calculating logarithms given in this paper is quite unlike anything previously known to the author and seems worth recording because of its mathematical beauty and its adaptability to high speed computing machines…[T]his algorithm is based directly upon…arithmetic continued fractions." Shanks illustrated the algorithm by computing $\log 2$.

The colonial scientist David Rittenhouse would surely have been very happy to know of this independent discovery almost one hundred fifty years after his death.

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The Myth and the Medal

Michael J. Barany

The weekend before the start of the 2014 International Congress of Mathemati- cians, I contributed an op-ed to the *New York Times* about the history of the Fields Medal. The article treated two topics that are familiar to many mathematicians, if not necessarily to the general public. I suggested that a previously unrecognized connection between these two stories, discovered in the course of my research, helped illuminate the relationship between politics and modern mathematics.

The first relatively well-known story involved the lack of a Nobel Prize in mathematics and the creation of the Fields Medal some three decades later. While the criteria, compensation, and other aspects of these awards have always been quite different, many have seen the Fields Medal's origin as a response to the lack of a corresponding Nobel Prize (e.g., [18, p. 167], [9, p. 62]). Especially for public audiences, the Fields Medal is often called the Nobel Prize of Mathematics. Even the organizers of the 2014 ICM used the comparison on their official website.

The second story was the public controversy surrounding Stephen Smale's 1966 Fields Medal and his opposition to the Vietnam War. I became interested in Smale's tale while studying the published and private documents that circulated in the international mathematical community after World War II. Before 1966, with one exception, no source I encountered made what today is an almost reflexive comparison between the Fields Medal and the more famous Nobel Prize. After 1966 the comparison quickly became common. Looking closer, I found that the seemingly perennial speculation about the lack of a Nobel Prize in mathematics and its relation to the origins of the Fields Medal also dated to after 1966, at least when it came to what mathematicians and historians put in writing.

The reason for this sudden shift was the so-called Smale Affair. Here, I offer a full account of this finding, along with what I think it means for the history and discipline of mathematics. The stories mathematicians and historians tell about famous awards like the Fields Medal are not simply interesting trivia. They shape how the broader public views the discipline and how mathematicians see themselves. The true story of the Fields Medal and its link to the Nobel Prize, I contend, can challenge mathematicians and nonmathematicians alike to reconsider the relationship between the discipline and the societies that sustain it.

Photo of the obverse of the Fields Medal. Public Domain.

Myths and Their Motivations

According to myth, there is no Nobel Prize in mathematics because of the personal antagonism between Alfred Nobel, who endowed the prizes on his death in 1896, and Swedish mathematician Gösta Mittag-Leffler. Perhaps, the story goes, Mittag-Leffler had an affair with Nobel's wife or perhaps they were just rivals in the Royal Swedish Academy of Science. Then, the story often continues, Canadian mathematician John Charles Fields saw an opportunity to rectify Nobel's unfortunate and spiteful omission. And so, shortly after Fields's death in 1932, the international mathematics community created an award in his name that would serve as the Nobel Prize of mathematics.

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Lars Gårding and Lars Hörmander tackled the first part of this myth in 1985 [7]. The speculation about Nobel's wife was easily refuted on existential grounds: Nobel was a confirmed bachelor. Regarding Swedish academic politics, Gårding and Hörmander could find no evidence that Nobel and Mittag-Leffler had much interaction in their lives, much less a history-altering antagonism. Instead, the authors concluded that there was no Nobel Prize in mathematics for the simple reason that mathematics just was not that important to Nobel. Neither, for that matter, was economics, whose prize was endowed separately in 1968 and first awarded in 1969.

The question of why there was no Nobel Prize in mathematics was motivated by an assumption, pointed out and refuted by Gårding and Hörmander, that mathematics was especially salient for Nobel. The myth that the Fields Medal was created as a substitute rests on the converse (and also mistaken) assumption that the Nobel Prize was especially salient for mathematicians. In fact, while mathematicians took a general interest in the honors bestowed on their scientific colleagues, they did not seem preoccupied with the lack of a Nobel Prize for themselves. If mathematicians harbored private questions, these were rarely set to paper. It was only after a public controversy forced mathematicians to articulate what the Fields Medal was in terms that were meaningful to a much broader and more skeptical audience that the comparison between the awards took hold.

Once established, however, the comparison came to matter for both mathematicians and their public. It raised the stature of certain mathematicians and certain areas of mathematics by associating Fields Medals with a much better-known award. Among mathematicians, the comparison sparked new conversations about the history of the Fields Medal and its relationship to the Nobel Prize. J. L. Synge, who had been instrumental in creating the Fields Medal itself, began to speculate anew about whether Fields could have been motivated by Nobel's omission, and his musings influenced an important early history of the medal (see [18]). Others asked the kinds of questions that led to Gårding and Hörmander's article. These conversations may have helped to spur the creation of new awards, like the Wolf and Abel Prizes, closer in spirit and compensation to the Nobel Prizes.

Myths form and take root for many reasons. In 1966 the myth tying the Fields Medal and Nobel Prize arose in response to an unpopular war and the grandstanding US House of Representatives Committee on Un-American Activities. Since then, the myth has shaped not just images of mathematics but the discipline's funding, public role, and collective memory.

An Obscure and Confusing Distinction

Medals have long been a part of the formal trappings of powerful institutions and their imitators. Governments, militaries, and scientific societies alike have furnished them to mark the merit of their most distinguished subjects and members. It was in this tradition that Nobel endowed his eponymous prizes, and, independent of Nobel, it was this tradition that propelled the International Congresses of Mathematicians to establish the Fields Medal.

Fields's proposal for a medal came at a dark and difficult time for the international mathematics community. On the heels of the Great War, mathematicians were among the many scholarly communities to try to rebuild international alliances while excluding those from the former Central Powers, whom many blamed for the conflict. While mathematicians did sometimes cooperate across borders in this period, the war's geopolitical aftermath helped national rivalries flare, and suspicion and score-settling were rarely far below the surface rhetoric of common enterprise. The fractious national bodies of mathematicians that adhered to the first International Mathematical Union (founded in 1920 and formally dissolved in 1936) had good reason to worry about a discipline in disarray (see [9, pp. 23–71], [12], [13]).

Scientific communities of many shapes and sizes had, from the late nineteenth century, espoused an ideal of scientific internationalism that tended by far to outstrip its realization in practice. These communities created and promoted prizes like Nobel's as a token of outward unity to complement the variety of inward-looking medals with which national scientific organizations proclaimed their distinctiveness. Fields was not the only one to propose a medal for mathematicians. Mittag-Leffler himself hoped to endow a gold medal for outstanding discoveries in mathematics, although instead of a monetary award the medal was to be accompanied by a set of his journal *Acta Mathematica*. The 1908 International Congress of Mathematicians presented the Medaglia Guccia in honor of the founder of the Circolo Matematico di Palermo to Francesco Severi, but later congresses did not continue the award.[1] The Fields Medals were ultimately established at the closing session of the

[1] *Full bibliographic information for proceedings and for newspaper and magazine articles to which I refer in this essay can be found at* `mbarany.com/Fields.html`.

1932 International Congress of Mathematicians in Zürich. The same session featured a resolution to study the prospects for international organization in view of an International Mathematical Union that was all but dead.

The first Fields Medals were awarded at the 1936 Congress in Oslo to Lars Ahlfors and Jesse Douglas, though the latter's fatigue kept him from the ceremony and the medal was accepted on his behalf by his MIT colleague Norbert Wiener. The Second World War delayed the next pair of medals until 1950, when they were presented in Cambridge, Massachusetts, to Laurent Schwartz and Atle Selberg. Neither recipient professed to have heard of the medal before having been notified by the selection committee of his achievement [14, p. 311], [15].

The October 24, 1950, edition of *L'Est Républicain*, a regional newspaper based in Nancy, France, where Schwartz taught at the time, touted the young mathematician's "médaille Field." The brief report contains the earliest statement I have found in any published document or private letter comparing the medal to the Nobel Prize.[2] The article reads: "The Field [*sic*] gold medal is considered as having the importance of a Nobel prize," and it makes no claims about the medal's origins or founder. The so-called "collaborators of Bourbaki" in this period, including Schwartz and his Nancy colleague Jean Dieudonné, to whom Schwartz later credited the article's orchestration, had a notorious sense of humor (see [4]). So it is entirely possible that the comparison in the article came tongue-in-cheek. In any case, *L'Est Républicain* was a small newspaper, scarcely read outside its region, much less abroad, and the claim seems to have rested there.

Indeed, for some it was the lack of any equivalent to a Nobel Prize that made mathematics distinctive. Not long before Schwartz won his medal, his compatriot André Weil declared:

> Let others besiege the offices of the mighty in the hope of getting the expensive apparatus, without which no Nobel prize comes within reach. Pencil and paper is all the mathematician needs; he can even sometimes get along without these. Neither are there Nobel prizes to tempt him away from slowly maturing work, towards a brilliant but ephemeral result. [19]

The secretary of the American Mathematical Society made no mention of Nobel in a detailed response to a 1951 query about the Fields Medal's background [8]. A Curriculum Vitae for Ahlfors from that period shows that the medal's purpose could not be assumed as common knowledge [1]. His entry for the Fields Medal explained that it was awarded at the International Congress of Mathematicians to those "distinguished by particularly remarkable works." Even in October 1966, shortly after the events described below that would tie the prize and the medal together for many, a mathematician could propose that the Ford Foundation sponsor a Nobel Prize in mathematics on the premise that no equivalent then existed [6].

At the same time, the Fields Medal itself was not widely known beyond the international mathematics community. It rarely received coverage in the mass media or even in general scientific publications. Where it did appear, typically as a brief notice, the coverage betrayed the award's obscurity. The *Hattiesburg American* reported in 1936, for instance, that Douglas's medal was "for the best mathematical work of the year" and that Fields "was the first president of the congress [of mathematicians,…] elected in 1924." When the *New York Times* reported on the 1954 accolades of Jean-Pierre Serre and Kunihiko Kodaira, it joined the many periodicals to omit the "s" from Fields's name and clarified for its readers that the medal "is one of the highest honors in mathematics." This orthographic confusion can be found even from members of the Fields Medal selection committee: 1950 committee member Marston Morse referred to the award in a 1951 article as "Field's medals and prizes" and again as "Field's prize and medal" [11, p. 35].

Nor could those closely tied to the Fields Medal jury as late as 1966 be assured of having a clear idea about the prize's rules and organization. Alonzo Church, who would give the official Fields laudation for Paul Cohen at the 1966 Congress, suggested to the Fields committee that the medal be shared by Cohen and Kurt Gödel for their respective contributions to a solution of the continuum problem before being informed that Gödel was ineligible at the time due to age [5].

In fact, the strict age limit of forty was only codified at the 1966 Congress, although an informal criterion of youth preceded it. Fields's remark that is often interpreted as favoring young medalists, that the prize should be "in recognition of work already done" but was "at the same time intended to be an encouragement for further achievement," is associated with no claim about the age or career status of the recipient. Rather, the stipulation that the award should be given "not alone because of the outstanding character of the achievement but also with a view to encouraging further development along these lines," was Fields's suggestion for how "to avoid invidious comparisons" from partisans

[2] *I am grateful to Laurent Rollet for locating a copy of the article.*

dissecting candidates' existing work [18, pp. 173–174]. What started with a worry about rivalrous national factions became an excuse to narrow the pool of candidates and eventually turned into a restrictive cutoff. It is yet another myth that Fields intended the medal only for the young.

Vietnam, Berkeley, Moscow

Mathematicians had no need of the Nobel Prize comparison for themselves. From its start in 1966, and even in its fleeting appearance in 1950, it was a way for mathematicians to explain and justify themselves to the general public. In the two decades following World War II, mathematicians in the United States had been quite successful winning support from those who mattered most—which is to say those in the government, military, and other organizations who held the purse strings and amply funded their activities [2], [16]. These entities also supported mathematicians beyond the US both directly and indirectly and helped establish the dominant place of US institutions in postwar international mathematics even as major non-US sponsors eventually emerged. Thus, while the Smale Affair hinged largely on American politics, its implications reached far beyond US borders.

The basic story of the Smale Affair has been told in detail (e.g. [3, Chs. 6–8]), including by Smale himself [17], and was covered extensively in this very journal as it unfolded. My purpose in this section is to reexamine the story in order to pinpoint how, when, and why the Fields Medal became linked to the Nobel Prize.

As a member of the mathematics faculty at the University of California at Berkeley, Smale was active on the campus's Vietnam Day Committee, which had organized efforts to block troop transports and otherwise to protest the war. The worst of the loyalty oaths and blacklists that shook many in the academic community seemed to have passed, but Cold War politics continued to stir controversy, and universities were centers for such provocation and confrontation.

On August 5, 1966, the *San Francisco Examiner* reported that Smale had been subpoenaed to appear before the House Un-American Activities Committee for his antiwar activism. The article insinuated that rather than face the committee, Smale had fled to Moscow. The acting chairman of Smale's department, Leon Henkin, rushed to notify the media that Smale was on his way to Moscow not to avoid HUAC but rather to attend that summer's International Congress of Mathematicians.[3] In fact, on the same day Smale was intended to testify he was due to receive what would appear under an Associated Press byline in news outlets nationwide the next day as "the Field [*sic*] Medal, one of mathematics' highest awards." We know from the report in the *San Francisco Chronicle* (the *Examiner*'s main competitor) that Henkin suggested something further. Its article reported that "Dr. Smale will be given the Field [*sic*] Medal, the highest honor in mathematics and comparable to the Nobel Prize." The next day, the *New York Times* quoted a university announcement that called Smale's medal "mathematics' closest award to the Nobel Prize."

Comparing an award to a Nobel Prize is a political claim. It is a way of saying that the weight of the disinterested judgment of the world's experts has found the award's recipient particularly meritorious. Nobel Prizes and their laureates have been, from relatively early in their history (but by no means uniformly from the start), covetously tallied by powerful nations and their elite centers of research. To win the equivalent of a Nobel Prize is to be wanted, valued, and respected in the widely recognized and purportedly neutral idiom of scientific fame. On its surface, Henkin's press statement was simply a matter of setting the record straight on behalf of a colleague facing insidious allegations. Deep down, whether intentionally or not, Henkin was defending his discipline.

For the most part, the comparison worked. When all four winners that year were announced, on the same day as the HUAC hearing, journalists praised the mathematical prestige of the Moscow Congress without supposing its medal to be suspiciously Soviet. Page 10 of the August 16 *Oakland Tribune* featured, in the left column, an account of the "uproar" that ensued when Smale's fellow Vietnam activists faced the House committee. In the right column it praised the "Two brilliant Bay Area mathematics professors [Smale and Cohen] whose work in the realm of pure math is dazzling in its originality," who that day claimed their medals. The second article made no mention of Smale's connection to the other story. Here, local interest extended Smale's spotlight as far as Cohen but did not reach as far as Michael Atiyah or Alexander Grothendieck from across the Atlantic—a pattern shared across US coverage of the medals that year. The next day, side-by-side, the *Tribune* again reported on the Vietnam Day Committee and included an AP dispatch from Moscow tying Smale's award to the raucous HUAC hearing.

Such was the intrigue of a Vietnam-protesting and HUAC-subpoenaed mathematician receiving a medal in Moscow that the *New York Times* secured its own special dispatch on the topic a week later. The article reported on an effort by US, French, and North Vietnamese mathematicians to circulate

[3] *Serge Lang, visiting Berkeley at the time, was also involved in communications with the press. See* [17, p. 23].

a resolution at the Moscow Congress condemning HUAC and the US incursion in Vietnam. The same reporter followed his story five days later with a sensational account of Smale's "informal news conference" on the steps of Moscow University. There, Smale criticized the US military's role in Vietnam (along with political repression in the Soviet Union) before being whisked away for a special sitting with the Soviet press.

The general scientific press proved most susceptible to the Nobel Prize comparison. *Science News* reported on Smale and Cohen (but not HUAC) and described the Fields Medal as "considered to be as prestigious as the Nobel Prize by mathematicians." An essay in *Science* on Smale and HUAC (but not Cohen) implied that the comparison had a still broader reach, with the Fields Medal "a prize frequently called the 'Nobel Prize' of mathematics." Such evasive journalistic formulations, by not crediting the comparison to particular sources, gave the impression that it was a long-standing and widely shared consensus. A recent suggestion, promulgated far and wide by the Associated Press and then churned through the scientific and general media, became a ready truism.

This identification resurfaced a year later for Smale's defenders after the US National Science Foundation rejected his grant request for $150,000 over the next two years. The incidents of August 1966 had sparked the ire of some House of Representatives members, and Smale and his defenders were quick to suggest that the rejection was for his politics alone. Reporting on the new controversy, the *New York Times* described his medal of the prior year as "considered by some as 'the Nobel Prize of mathematics'." This posture (and the accompanying uproar among other professors) proved effective, at least in part. The *Los Angeles Times* reported that the bulk of the grant would be approved after all, noting that Smale held "the equivalent of the Nobel Prize in mathematics." The same article attributed his broader recognition in the public eye to his twinned headlines the year before. Even an opponent who decried "this peacenik mathematician" who continued to "ride this gravy train" of government funding acknowledged in his *Newsday* column the Nobel-like prestige of Smale's award.

From Myth to Politics

Prizes are what people make of them. In important respects, such as its public stature, the Fields Medal has indeed become more like the Nobel Prize by virtue of the comparison. Born as a defensive analogy, insulating Smale from political criticism at a key juncture, the link has become common currency in the international scientific and mathematical communities and in some parts of the wider public.

So it is worth considering how common views of mathematics and its history might be different without the Fields-Nobel myth. What if, instead of an obvious correction to an erroneous oversight, one saw the Fields Medal as a troubled compromise among disagreeing national mathematical communities? What if, instead of assuming mathematics has always held pride of place among the international sciences, one stresses the struggles mathematicians have sometimes faced in winning legitimacy and prestige for their discipline?

The true origin story of the Fields Medal is a reminder of the messy underside of international mathematics and the muddied idealism of its interwar participants—mathematicians who spoke loftily of a free and open discipline but whose institutions often belied those same ideals. The international discipline that emerged in the postwar period continues to bear the marks of these conflicts and compromises, and the population of Fields Medalists has reflected this.

Put bluntly, with few exceptions, the Fields Medal (along with the Wolf and Abel Prizes) has been an award for white European and American men. Their educations and careers, with few exceptions, traverse a small collection of elite institutions disproportionately located in the United States and France. Not coincidentally, these institutions were home to some of the most active and well-resourced shapers of international mathematics in the mid-twentieth century. The 2014 medalists represented a litany of "firsts" for the award: each was the first medalist from her or his country of origin, Artur Avila was the first from his continent, Maryam Mirzakhani was the first of her gender. The selection committee too had its first female chair, also the first female president of the International Mathematical Union, Ingrid Daubechies.

Their stories show how the international mathematics community has changed in many ways but continues to inherit its interwar and early postwar legacies. The upper echelons of modern mathematics may in principle be open to anyone, but mathematicians live and work in societies and educational systems rife with sexism, racism, privilege, and inequality, often in forms that are hard to recognize. Exceptional talent seems a prerequisite for a Fields Medal, but so does being the right kind of person in the right place at the right time.

It does not diminish the impressive feats of individual past medalists to acknowledge that, as a group, they represent the products of societies and institutions in which mathematicians have not been mere bystanders. Mathematicians have been leading advocates for academic freedom and

international peace but also crucial participants in wars and in programs of secrecy and control. Mathematical organizations have done important work to recognize bias and promote opportunities for aspiring mathematicians, but they have not been without blind spots and shortcomings.

Seeing the medal in this way, as a compromise rather than a culmination, can also help one to appreciate what has been left out of the compromise. To claim, as one prominent mathematician has, that "an ϵ-grid over the works of the Fields medalists covers a significant portion of the achievements of modern mathematics" [10, p. 4] is to espouse an impoverished view of who mathematicians are and what they do. No group numbering in the dozens, however distinguished, can possibly represent the range of so broad and variegated a discipline. Yet the synecdoche of medalists for the community of mathematicians from which they are drawn has grown with the award's Nobelian prestige in the last half century.

Presentations, discussions, and mythologies of medals offer special opportunities to promote and debate what mathematicians value. The Fields Medal is an important way of celebrating some of the best that mathematicians can offer. Perhaps a fuller view of its history can help mathematicians celebrate that they have more to offer the world than just profound new theorems. It may also help underscore that the history of mathematics is not without ambivalence, moral choices, and social responsibilities.

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Is There a Curse of the Fields Medal?

János Kollár

How worried should you be that getting a Fields medal might destroy your research career? The question seems preposterous, but a recent paper [BD14] by two economists, George Borjas and Kirk Doran, suggests that this is a question that we, the mathematical and scientific community, should consider. Happily, readers over the age of forty do not need to worry, but perhaps young researchers should take this problem seriously. Of course there are so few Fields Medals that the likelihood of being hit by one seems to be virtually zero. Nevertheless, they do not strike randomly. With one exception, only people with a PhD in mathematics have received Fields Medals. Young readers of the *Notices of the AMS* have a roughly 1:8000 chance of getting one, much higher than being in an airplane crash (about 1:11,000,000),[1] a danger many people worry about, but much lower than being considered a nerd (nearly 1:1.1 for mathematicians). Surprisingly, even in the very comprehensive and otherwise excellent encyclopedic volume [Gow08], in Section VIII.6 titled "Advice to a young mathematician," Atiyah, Connes, and Gowers give not even a hint on what to do should you get a Fields Medal.

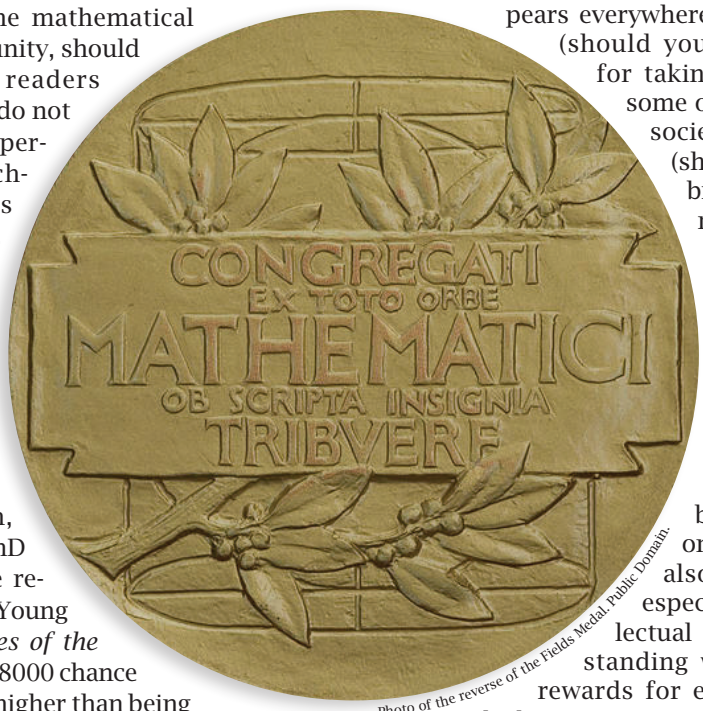

Photo of the reverse of the Fields Medal. Public Domain.

The paper by Borjas and Doran, while not offering any practical advice, is the first to call attention to this issue.

All joking aside, [BD14] is a serious paper about a serious question. The need to understand the right choice of rewards and incentives appears everywhere, from the mundane (should you pay your teenager for taking out the trash?) to some of the basic questions society is wrestling with (should bankers be paid billions?). Labor economists have long tried to understand the optimal level of reward for work done. For a company or organization, but also for society as a whole, it is important to know which rewards encourage better work and which ones do not. There has also been an interest—especially among the intellectual 1 percent—in understanding whether exceptional rewards for exceptional work are the best way to encourage achievement, a question studied by Tournament Theory.[2]

The Fields Medals occupy a unique place among the prizes offered for exceptional achievement. Nobel Prizes—perhaps contrary to the original intent—are frequently awarded near the end of a career, at an average age of fifty-nine.[3] Thus, in practice, a Nobel Prizes rewards a lifetime of work. In the economic analysis, its main value is that people who aspire to it work hard before getting it, thereby adding to our store of knowledge. There is no requirement of further scientific work, though many recipients continue to perform exceptionally, occasionally leading to a second Nobel Prize (Bardeen, Curie, Pauling, and Sanger).

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[1] www.pbs.org/wgbh/nova/space/how-risky-is-flying.html.

DOI: http://dx.doi.org/10.1090/noti1192

[2] en.wikipedia.org/wiki/Wiki/Tournament_theory.

[3] www.nobelprize.org/nobel_prizes/facts.

Many fields of study have prizes aimed at young researchers, but these are all viewed as stepping-stones toward greater rewards. The Fields Medal is the only prize that is viewed as the highest honor in a discipline and yet is awarded in the middle of a career. Its founding document states that the Fields Medal is "intended to be an encouragement for further achievement on the part of the recipients." The question that Borjas and Doran ask is, is the Fields Medal good at encouraging "further achievement"?

Receiving a Fields Medal is likely to have immediate financial benefits for the recipient. While the award itself comes with a modest sum (US$15,000), it is likely to lead to substantial salary increases. (Though I believe that the example [BD14] mentions, without name, attributing a salary increase of US$120,000 to the medal, is not typical.) There is also no doubt a rather strong feeling of happiness and pride of achievement associated with receiving the honor. What happens afterwards?

Borjas and Doran are not mathematicians, and they did not read the papers of the Fields Medalists. They make no attempt to judge directly whether papers written after receiving the medal are better or worse than those written before. Instead, they draw inferences from the data available on MathSciNet. Since the year 2000 MathSciNet has recorded the citations in each paper reviewed. By now the available data constitute a large collection amenable to statistical analysis. [BD14] focuses on the number of publications, the number of citations, and the distribution of the papers among the subfields of mathematics.

It is not clear that the number of papers or the number of citations is the best way to judge scientific worth. These numbers seem objective, but, as shown by the informative paper [AF11], they can be—and have been—manipulated. There is, however, no reason to believe that the raw data analyzed by [BD14] have been affected by any such manipulation.

There are many oddities to be gleaned from the author profiles on MathSciNet. For instance, going by the highest number of citations, Atiyah's main work is in commutative algebra [AM69] and Grothendieck's is in functional analysis [Gro55], but for the several other Fields Medalists I checked, the result correctly identified the author's main research area. I am willing to believe that the data on MathSciNet provide good snapshots about the work of most mathematicians.

[BD14] finds that getting a Fields Medal has a strong negative effect on the recipient's productivity. Fields Medalists write 25 percent fewer papers per year after receiving the medal, and the postmedal papers get fewer citations. (The authors control for the fact that older papers tend to have more citations.)

This is interesting, but it could be unrelated to the Fields Medal. It could be just the usual regression to the mean or simply an indication that strength and productivity fall with age. How can further analysis filter out these two general causes?

Comparing the productivity of Fields Medalists with that of an average mathematician is not illuminating. A control group of "contenders" who are comparable to the medalists is needed. Assembling such a group is not an easy task. The minutes of the deliberations of the Fields Medal committees are sealed for seventy-five years, so it is not possible to get a list of the actual contenders who were seriously considered but eventually lost out. Asking around in the mathematical community would be problematic as well. Hindsight is deceiving. It is hard to remember when some results became known, and the importance of many papers emerges only years after the publication. Borjas and Doran turned to lists that were established contemporaneously: they looked at recipients of the Cole Prize, the Bôcher Prize, the Veblen Prize, or the Salem Prize who were still eligible for the Fields Medal when they received one of these other prizes. This is a quite reasonable choice for the group of "contenders," though tilted towards mathematicians working in the US.

They added to this the recipients of the Abel and Wolf Prizes. It is quite likely that these two prizes, awarded typically to people well over forty, take very much into account research conducted after age forty. Thus someone whose productivity did not decline is more likely to receive one of these. The study could have been cleaner without these additions. All contenders along with the Fields Medalists are listed in [BD14, Appendix].[4] (A small quibble with the list: it would have been better to exclude those who were still eligible for the Fields Medal in 2014. For example, Artur Avila is included as a contender, not as a medalist.)

The surprising comparison is given in [BD14, Figure 1].

Borjas and Doran also considered three controls. First, they selected from the group of contenders those who have been most productive during their years of Fields Medal eligibility, resulting in a group of "top contenders." Second, they considered those mathematicians who have been

[4] *I am neither a medalist nor a contender.*

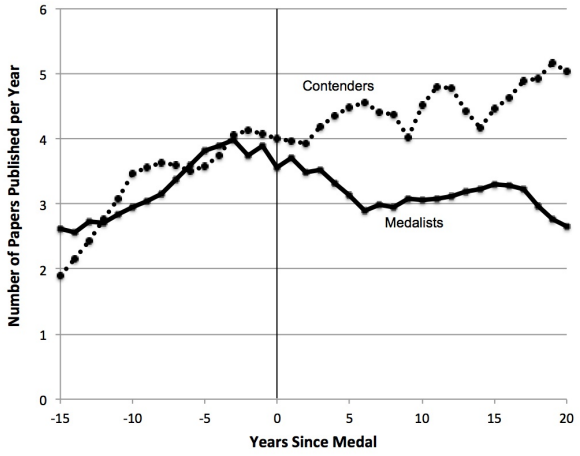

Figure 1. Publication rate of medalists and contenders.

plenary speakers at an ICM while still eligible for the Fields Medal. Third, they ran their numbers with everyone normalized to have the same total number of papers. Their analysis for all of these leads to very similar comparisons.

What explains this drop of productivity as measured by papers and citations? The authors considered several possible causes. First, we can imagine that Fields Medalists become more popular advisors and take on more postdocs, thus contributing more to science through teaching. This is, however, not the case. They actually have slightly fewer students and postdocs after the medal. Another possibility is that other contributions to science and society (directorships, prize committees, popular lectures) take up more of their time. Several medalists, for instance, Villani, are keenly aware of both the worth and the magnitude of such nonresearch activities.

A third explanation is that the recipients feel the "weight of expectations" and so publish only papers that they consider "worthy of a Fields Medalist," resulting in fewer but better papers. There are anecdotes that indeed several prize recipients experienced this effect. This guess, however, does not bear up well under further scrutiny of the data. Such an effect would explain the fewer papers but not the fewer citations per paper. The decline in the number of citations is especially surprising since, presumably, others would go out of their way to refer to connections between their work and the work of a Fields Medalist.

Borjas and Doran call a paper a "home run" if it gets more citations on MathSciNet than 99.5 percent of the papers published in the same year. (The cutoff shows quite a lot of variation from year to year. Between 1965 and 2000 it ranges between 63.5 and 112 [Dor14]. Considering that in mathematics it is common to have a lag of several years between the appearance of the preprint and publication, a more smoothed-out cutoff could have been better.) For Fields Medalists, the number of "home runs" decreases by 15 percent. (The authors also count the number of "strike outs," these are papers that were never cited. I do not consider this a relevant number. For instance, among Atiyah's papers ordered by the number of citations, the last item is an obituary of J. A. Todd [Ati98]; the paucity of references to it is hardly a comment on Atiyah's mathematical work. I was surprised, however, by the number of papers with only one citation in all the author profiles I looked at on MathSciNet.)[5]

A very interesting fourth explanation is, in the terminology of economics, an increased "consumption of leisure." This means not only more time devoted to playing golf or collecting stamps but also an "increased freedom" to follow one's interests, leading to "cognitive mobility" in work. I would expect that this "increased freedom" is more relevant in experimental fields where young researchers have to work on the experiments of senior professors, biding their time until they can establish their own labs and direct their own students. Even then, the constant need to secure funding may well steer them away from unconventional topics. By contrast, young mathematicians are quite free to work on their own problems or topics. However, there is no doubt a pressure, especially before tenure, to play it safe and establish a solid reputation as an expert in *one* field by producing a steady stream of papers. Some of this pressure goes away with tenure, but changing fields drastically is viewed as risky for a young researcher and maybe even for an older one.

According to [BD14, Figure 2] Fields Medalists are 2.5 times more likely to start working on "brand-new" directions than contenders. Mumford's leaving algebraic geometry for work on vision and pattern theory in artificial intelligence is a well-known example, but this is more than matched by Simons, a contender, leaving academia to start the hedge fund Renaissance Technologies. Borjas and Doran estimate that about half of the decline in productivity is due to this sort of shift in research topic. Learning a new trade takes time and produces fewer papers, at least initially.

It would be interesting to get a better understanding of how well these changes work out. We assume that exceptional scientists would do first-rate work in a new field as well, but of course they would have continued to do first-rate work in

[5] *Dear reader, please refer to this article. I hope not to have a strike-out.*

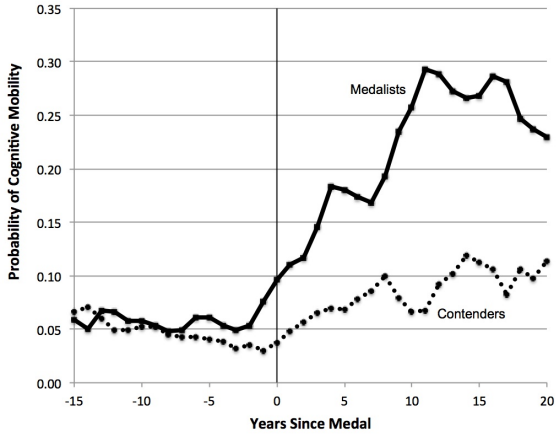

Figure 2. Cognitive mobility of medalists and contenders.

their original field without losing time to become expert in a new subject. From society's point of view, the change is worthwhile if the investigators bring something original and unexpected from their old research area to the new field. The article does not investigate this issue.

A question [BD14] had to address in this connection is, what constitutes a brand-new direction? Again MathSciNet guides the answer. For each pair of the 73 Mathematics Subject Classification numbers, the authors worked out the likelihood that a paper in one area is referred to by a paper in another area. Thus, for instance, they see that 35 (Partial Differential Equations) is closest to 58 (Global Analysis) and 76 (Fluid Mechanics) but furthest from 08 (General Algebraic Systems) and 19 (K-theory). Borjas and Doran deem a topic brand-new if it is not among the fifteen closest to the researcher's original area. This is a conservative choice and probably underestimates the cognitive mobility.

I talked to several people who felt that the conclusions of this study do not describe the Fields Medalists they know and that a few early medalists must be skewing the numbers. We can all cite many examples of medalists who continue to have long and exceptionally productive careers. On the other hand, these are exactly the examples that would come to mind, and one role of statistics is to find unexpected correlations. Having read the article I feel that there may well be a connection between getting an exceptional award and a decline, permanent or temporary, in the recipient's productivity, though much of it is apparently explained by a significant broadening of the medalist's research interests.

Assuming that the numbers and claims of [BD14] are correct, what, if anything, should be done by the mathematical community?

One could raise the age of eligibility for the Fields Medal to fifty or even sixty. This could ensure that more mathematicians continue to work very hard ten or twenty years longer. One could also remove any age limit, but by now mathematics has the Abel Prize, with no age limit, just like the Nobel Prize.

Despite the findings of this paper, I see several arguments for keeping the age limit at forty. First, it is a tradition. A transitional period would be hard to manage, and every other age limit would be equally arbitrary. One should also note that a benefit of an early age limit is increased peace of mind for contenders who can stop worrying about the prize. I am sure that each October many writers, physicists, chemists, and biologists experience a complicated mix of hope and dread, getting particularly annoying early-morning calls from telemarketers and fretting about literary or scientific politics instead of their work. Maybe "contenders" do better after forty because they can focus more of their energy on mathematics instead of worrying about impressing some committee. Finally, by keeping the age limit at forty, we give a recurring opportunity for economists to study the effects of getting a top prize at a young age.

The limits of statistics are illustrated by the numbers contained in the penultimate line of [BD14, Table 1]. (It is not commented on in the paper.) While most of the Fields Medalists and contenders are happily alive, Figure 3 shows a disturbing pattern about those who have passed away.

Fields Medalists	Top Contenders	All Contenders
74.0	60.5	66.3

Figure 3. Average age at death of medalists and contenders.

Thus, if you got a Fields Medal, you can expect to enjoy your extra US$120,000 per year for almost eight more years. However, if you were a contender who lost out, the future is bleak. Your life expectancy is down by eight years. There is only small consolation in knowing that you can get six of these years back by slacking off. Slowing down saves lives, but in this case it is not clear why.

A psychological explanation could be related to the observation that Olympic silver medalists are less happy than bronze medalists.[6] A biological one could relate to the Heartbeat Hypothesis, which asserts that all creatures have about the same number of heartbeats during their lifespan.[7] Fans

[6] blogs.scientificamerican.com/thoughtful-animal/2012/08/09/why-bronze-medalists-are-happier-than-silver-winners

[7] en.wikipedia.org/wiki/Wiki/Heartbeat_hypothesis

of mythology might call the mathematical version of the latter the Arachne Hypothesis: Athena supports science but strikes down those who weave too-large a mathematical tapestry.

The averages of Figure 3 are based on small samples; no doubt some graduate students continuing these studies are eagerly scouring the obituaries daily for additional data points.

Acknowledgments

I thank G. J. Borjas and K. B. Doran for making available the JPG files for Figures 1 and 2 and answering many questions, and J. M. Johnson for numerous suggestions.

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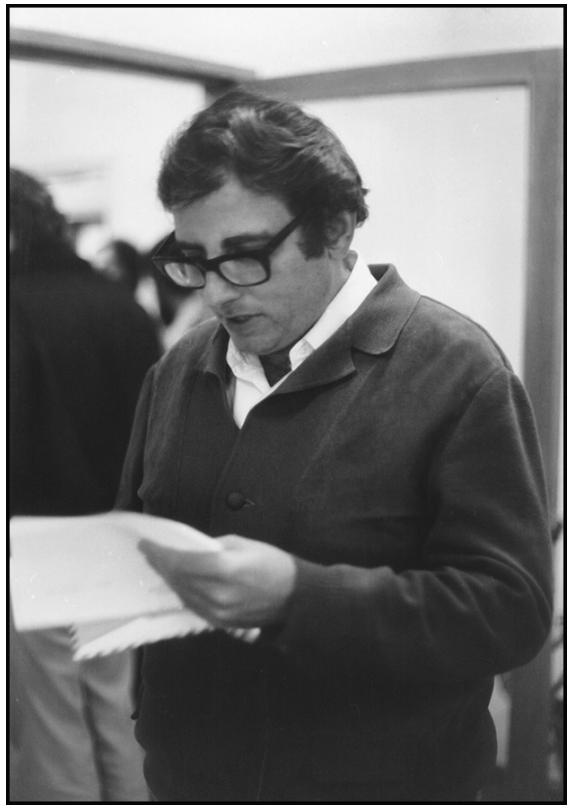
Joram Lindenstrauss, in Memoriam

Compiled by William B. Johnson and Gideon Schechtman

Joram Lindenstrauss was born on October 28, 1936, in Tel Aviv. He was the only child of parents who were both lawyers. Joram began his studies in mathematics at The Hebrew University of Jerusalem in 1954 and completed his PhD in 1962 under A. Dvoretzky and B. Grunbaum. After postdocs at Yale University and the University of Washington, he returned to the Hebrew University, where he remained until retiring in 2005. He passed away on April 29, 2012.

Joram met his wife, Naomi, during his studies at the Hebrew University. Naomi holds a PhD degree in computer science from Texas A&M University. They have four children, all of whom have PhDs: Ayelet and Elon are mathematicians at Indiana University and The Hebrew University of Jerusalem, respectively; Kinneret Keren is a biophysicist at The Technion, and Gallia is a researcher at the Institute for National Security Studies at Tel Aviv University.

Joram's PhD dealt with extensions of linear operators between Banach spaces, leading also to the study of preduals of L_1 spaces. Some of his other groundbreaking research results include a study with A. Pełczyński of Grothendieck's work in Banach space theory and applications thereof, which also led to the introduction of $\mathcal{L}_p$ spaces and their study, a topic which he continued to pursue with H. P. Rosenthal. Lindenstrauss and Pełczyński promoted in their paper the "local theory of Banach spaces," which involves the study of numerical parameters associated with finite-dimensional subspaces of a Banach space and the asymptotics of the parameters as the dimensions of the subspaces tend to infinity. With L. Tzafriri he solved the "complemented subspace problem," showing that, isomorphically, the only Banach spaces all of whose subspaces are complemented are Hilbert spaces. The proof uses Dvoretzky's theorem on Euclidean sections of convex bodies, a topic Joram returned to in an influential paper with T. Figiel and V. Milman and a related one with J. Bourgain and Milman.



Archives of the Mathematisches Forschungsinstitut Oberwolfach.

Joram, 1975.

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Personal and family photos of J. Lindenstrauss provided courtesy of the Lindenstrauss Family Album. Used with permission.

DOI: http://dx.doi.org/10.1090/noti1205

Early in his career, in a paper on nonlinear projections in Banach spaces, Joram introduced the study of nonlinear Lipschitz and uniform equivalences between Banach spaces. Surprisingly, it turns out that often nonlinear bi-Lipschitz or even biuniformly continuous nonlinear maps preserve the linear structure to some degree. This topic appears on and off during his career, and his last publication, a research book with D. Preiss and J. Tišer, deals with Lipschitz functions on Banach spaces. The two of us were also attracted to this topic and had the good fortune to cooperate with Joram on it (sometimes together with others, notably Preiss).

In a paper of Johnson and Lindenstrauss there is a relatively simple lemma which is widely used, mostly in connection with theoretical computer science, and which is by far the most quoted result of Joram. It states that n points in Euclidean space can be mapped into an approximately $\log n$ dimensional Euclidean space while approximately preserving the pairwise distances. Curiously, but not coincidentally, the paper does not appear in the list of selected publications that Joram prepared in his last year.

Joram Lindenstrauss wrote several very influential books. His two-volume book with Tzafriri, *Classical Banach Spaces*, as well as his book with Y. Benyamini, *Geometric Nonlinear Functional Analysis*, is a must read for anybody interested in the linear (respectively, nonlinear) theory of Banach spaces. With Johnson, Joram edited the two-volume *Handbook of the Geometry of Banach Spaces*.

Joram had twelve official PhD students. All but two of them hold/held respectable academic positions, most in Israel.

Joram's many honors include the Israel Prize for Mathematics and the Banach Medal. He was a member of the Israel Academy of Sciences and was a Foreign Member of the Austrian Academy of Sciences.

Yoav Benyamini

In 1965 Joram Lindenstrauss joined the Hebrew University as a new faculty, and I was a third-year undergraduate student sitting in his Banach Spaces course. This first encounter set the course of my life.

The Banach space group in Jerusalem began with Dvoretzky, who was joined by his former student Grünbaum and their students. A phase transition occurred with the arrival of Joram, who joined Dvoretzky in the supervision of the doctoral theses of Lazar and Zippin, and Joram's influence dominated their work. Soon Gordon started to work with him on his PhD; I started to work with him on a master's thesis in 1966. Joram gave excellent basic and advanced courses, and within a few years the list of his students grew very fast, with Aharoni, Arazy, Schechtman, and Sternfeld. New faculty Perles, Tzafriri, and Zippin joined the department. We had a very active weekly seminar, many visitors, and intensive informal discussions. Soon Joram and Tzafriri wrote their Springer Lecture Notes and then the two-volume "*Classical Banach Spaces*". By reading proofs of the lecture notes and books, students knew in real time what was happening throughout Banach space theory.

Joram's supervision style was very "open." We did not have orderly weekly meetings, and he never gave me a problem for the thesis. The exposure to the different directions and problems came through his comments and criticism in the seminar and other discussions. This is also how I learned how to judge what is "important," "interesting," what is worthwhile to read, and what is publishable. His approach and views were so dominant that he was "heard" even when he was not present.

Joram was very systematic and methodical. His answers to questions sounded like he had prepared a lecture on the subject. He did not like to discuss speculations: he would send me to write up my ideas and, of course, in most cases the speculation led nowhere. But when I did hand him something in writing, he was a wonderful reader. It would come back the next day with detailed feedback. He was also a wonderful writer, and his papers, books, and lecture notes (in Hebrew) are written in his typical systematic, clear, and concise style.

It was a pleasure to work on our book *Geometric Nonlinear Functional Analysis* and to benefit from his excellent judgment, his clear view of the big picture, together with his care for details, and his clear and careful writing. Joram was quite disappointed when I was not very enthusiastic about writing the planned second volume. The two main subjects were supposed to be the theory of finite metric spaces and differentiabililty of Lipschitz functions on Banach spaces. I thought that they were not ripe yet for a book. Joram did the right thing and cooperated with two experts, Preiss and Tišer, to write their major research monograph *Differentiability of Lipschitz Functions and Porous Sets in Banach Spaces*, which will be the basis for any future study of the difficult and important topic of Fréchet differentiability. Our last conversation was when I called to congratulate him on Elon's Fields Medal, and he told me proudly that the manuscript of the book was just sent to the publisher.

Most of Joram's students remained in academia, mostly in Israel. Israeli mathematics was very

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important to him. He stopped taking new students because Israel is a small country that could not absorb more Banach space experts. As editor of *Israel Journal of Mathematics* his commitment to high standards was also influenced, as he told me several times, by the high quality we have to preserve of anything that carries the brand name of Israel. He was an active representative, on behalf of the Israeli Academy of Sciences, in the IMU and talked seriously about applying for the organization of the International Congress in Jerusalem before the murder of Prime Minister Rabin and the increased terrorist attacks put an end to this dream.

Joram set my professional career, and I tried to follow the values he installed in me. I was also very lucky to be a student of his devoted wife, Naomi. She was an exemplary TA in the real analysis course that I took in the same year, 1965—and over the years she also taught my nephew and two of my children!

Jean Bourgain

My early memories of Joram go back to the late seventies and very early eighties with functional analysis meetings in Crete and Ohio and a workshop at the Hebrew University. He was of course an authority in the field, while I was a beginning researcher at the Belgian Science Foundation. From our first encounters, I felt very much at ease and happy to chat with him whenever I got a chance. He was a good person to talk to. Such things are difficult to rationalize, but it was probably the combination of his encouragement, an unmistakable sharpness of mind, also in mathematics outside his direct expertise or interests, and, above all, the perception of a human warmth that evolved into true friendship and affection in later years.

As a matter of fact, even at that time, Joram as a mathematician was no stranger to me. Starting from the mid-seventies, my advisor, F. Delbaen at the Free University of Brussels, had introduced me to Joram's many contributions to Banach space theory and some of the problems left open by his work: they were the background and motivation of my early research. These were questions related to extreme points, a subject that has been consistently close to Joram's heart. Also the global implications of certain local structural properties as studied in Joram's own thesis about extension of compact operators. So I was most excited to meet the man in person and get some feedback. Joram expressed some praise, although not quite as much as I had hoped for. He was indeed in the middle of

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Joram and Aleksander Pełczyński, 1973.

preparing the second volume of *Classical Banach Spaces*, together with his long-time collaborator Lior Tzafriri, which was mostly devoted to other aspects of the theory. This reminds me of a little anecdote at the Heraklion meeting in 1978, when Joram made it clear that "stable Banach spaces," a concept then freshly introduced (and conceptualizing some striking results of D. Aldous), was the most important thing of the moment and should definitely be part of the book in writing. He showed great unhappiness that neither J-L. Krivine nor B. Maurey, who developed that concept, were present at this gathering.

Joram was focused and liked to pursue matters in depth. In the very early eighties, he came to visit in Belgium for a few days. We went sightseeing in the medieval town of Brugge, where we spent the afternoon viewing the paintings of the great Flemish and Dutch masters. His taste in this matter was different from mine, though, and I tried in vein to convince him that the scenes pictured by Hieronymus Bosch are fascinating. Towards the evening he told me he had a favor to ask. The favor was simply to check P. Enflo's recent solution of the invariant subspace problem. With that I guided him back to the train station, with only a vague promise.

Over the years, especially in the eighties and early nineties during my almost yearly trips to Jerusalem, Joram was invariably a marvelous host, and I truly enjoyed these visits. Our interaction and collaboration centered around questions in high-dimensional convexity, a topic that had been revolutionized by methods from the so-called Local Theory of Banach Spaces and in particular Joram's joint work with T. Figiel and V. Milman on large-dimensional Hilbertian sections, which is one of the most seminal contributions in the field. We worked on problems of low-dimensional embeddings (an issue that became increasingly important in theoretical computer science), fast

symmetrization, approximations, and also on very classical themes such as the regularity of the Gauss map and optimal distribution of points on spheres. Coming back to low-dimensional embeddings, perhaps one of his most influential results (jointly with W. Johnson) is the principle of dimensional reduction in Hilbert space, which is central in modern data processing. Then, by the mid-nineties we had drifted somewhat apart as we got to work on different things. Joram had gotten back to the love of his youth, which is infinite-dimensional theory, and started a fruitful collaboration with D. Preiss and J. Tišer on Fréchet differentiability of Lipschitz maps.

Through a significant part of his professional career, especially in the later years, Joram had to struggle with severe health problems. His answer to them was a motivation and determination in his work that is exemplary to all of us.

These are some personal reminiscences and comments, but many of them are surely shared by my colleagues. Of course, we all miss him.

Nassif Ghoussoub

I knew that Joram had been seriously ill for some time, but the cryptic email announcing his passing brought more than its share of extreme sadness. Both my professional and my personal lives have been deeply touched by Joram and his family. I worked with him on several projects, and hearing that he, as well, was gone only a few short months after another friend and coauthor, William J. Davis, passed away feels like a bad dream.

But Joram was much more than a coauthor to me. I was a twenty-two-year-old "kid" when I first met him. It was in Columbus, Ohio. He was already a leader in functional analysis, my field of research at that time. It is fair to say that he was a feared leader, with extremely high scientific standards. He was tough and never minced his words, but I never felt intimidated by him, though I was well aware that many other, often smarter, mathematicians around me were. He was quite demanding of his students: he wanted them to excel, and they did.

I often wondered whether others understood this man the way that I did—this man who seemed so tough on the outside was so gentle, even soft, on the inside. A sabra! Confirmation came several years later when I got to know his children. He was as demanding as an old-fashioned patriarch could be, but they knew …

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I was "fresh off the boat" on the American continent for a postdoctoral position. Joram Lindenstrauss was already a pillar of Israeli mathematics. He was the first Israeli I ever met. The encounter was one that would mark my life. His parents had left Germany for Jerusalem as soon as the Nazis came to power. He was born in the holiest of places, lived there all his life, and endeavored to make its Hebrew University one of the best, and not only in Israel. We quarreled about politics of course, yet there was always this feeling, which may seem naive nowadays, that all would end up well one day. It was there and then that I first learned—and, yes, relatively late in life—that "what we have in common is much greater and more powerful than what divides us."

All this was before I met his incredibly kind wife, Naomi, and his amazing, then-teenaged children. Watching the Lindenstrauss family together amounted to seeing humanity at its glorious best. That's how I wanted my own family to be. I've wondered lately how incredulous he, a recipient of the Israel Prize with a Fields Medalist for a son, would have been upon watching *Footnote* the movie. His children lived up to every expectation. He must have been so happy as he passed.

Joram's mathematical contributions are numerous and varied. His defining role, with Alexander Pełczyński, in uncovering the true impact and depth of Grothendick's "Résumé" is well documented. The Figiel-Lindenstrauss-Milman paper on "the dimension of almost spherical sections of convex bodies" is a classic. The Johnson-Lindenstrauss Lemma about nearly isometric embeddings of finite point sets in lower-dimensional spaces is one for the ages. The depth of his latest work on geometric nonlinear functional analysis with David Preiss and others defied the trends and defined a new age for the field. Joram was a mathematical trendsetter because he never cared whether his mathematics followed the trodden path.

Joram—colleague, mentor, friend. My life has been deeply enriched by his presence.

William B. Johnson

I met Joram in 1972 when he asked me to speak at a conference. He and Olek Pełczczyński were the acknowledged leaders of the resurgence of Banach space theory, while I was a beginning researcher, yet within fifteen minutes the great Lindenstrauss asked me a math question! Although the question was right up my alley, I had to work most of the night in order to have something for Joram the next day. This was the beginning of a friendship and collaboration that spanned five decades, and I take pride in the fact that I have more collaborations

than anyone else (fifteen according to MR) with Joram.

In the 1970s Joram's family spent several summers in Columbus (I was at Ohio State then), and my family spent one year in Jerusalem. In 1981–82 both families were in College Station, where Joram and I took our sabbaticals and Joram's wife, Naomi, worked on her PhD in computer science. Our wives became close friends and our children grew up together. Once when we went for Shabbat dinner at the Lindenstrauss home, Joram, with some help from Ayelet and Elon, built a Lego city in their living room. Our son was always happy to return to "Joram's toy store." Later I was a coach of a soccer team on which my son and Joram's daughter played, and I played basketball with Kinneret and some of her boy friends. Kinneret, now well known in the biophysics community, was the best player on the court and had a successful second career as a professional basketball player. Shabbat dinners at the Lindenstrauss home after our children were grown were particularly enjoyable when some of their children were present. It was great to get to know the adult Gallia, the youngest and most widely read of the Lindenstrauss clan (Google her to find out why), who was often present helping Naomi with the preparations.

Joram's and my mathematical collaborations ranged from nonseparable Banach spaces to the geometry of finite metric spaces. To Joram these were not very different. He viewed his migrations from topic to topic as natural. Our early research was in the linear world, although even in the 1970s Joram tried to interest me in the nonlinear geometry of Banach spaces. I knew well his landmark 1964 paper, in which he laid out a blueprint for what nonlinear Banach space theory should be, but I thought I had no intuition for the topic. That changed in 1981 during our sabbaticals. Marcus and Pisier, as a consequence of their work on stochastic processes, proved a seemingly unrelated result on the extension of Lipschitz mappings from finite subsets of L_p, $1 < p < 2$, into a Hilbert space. Their theorem suggested a general result, where L_p is replaced by a general Banach space, but because of the nature of their proof, they did not get a result even for the Banach space L_1. Joram and I realized that we could solve the problem if we could prove a dimension reduction lemma in Hilbert space. After formulating the lemma (now called the Johnson-Lindenstrauss Lemma) we proved it in fifteen minutes. Still, we knew it was a neat result because it not only allowed us to solve the problem of Marcus and Pisier but also eliminated the "curse of dimensionality" in certain high-dimensional pattern recognition problems. Of course, we had no idea that this lemma would become the most quoted result of either of us, having 1,000+ references according to Google Scholar, more than three times the references for all of our other research articles combined, and getting 134,000 hits when Googling "Johnson-Lindenstrauss lemma." Joram's appreciation of the J-L Lemma is revealed by looking at the list of his selected publications that Joram drew up in the year before his death when he knew that the end was near; that is, the paper containing the lemma is not among the twenty-six articles he selected! Actually, I was not surprised by that; Joram put a premium on difficulty and was not very comfortable with the attention the J-L Lemma received.

Joram, Gideon Schechtman, and I spent a lot more time on the geometry of finite metric spaces in the 1970s and wrote three articles on the topic, but even after averaging these with the J-L Lemma paper, our results per hour of work on the topic were pretty low. At the end of the decade I thought my initial desire to stay away from the nonlinear world was correct. Then in the 1990s I explained to Joram how results in the linear theory could combine with an argument of Bourgain to show that certain Banach spaces (specifically ℓ_p for $1 < p < 2$) are determined by their uniform structure (a Banach space is determined by its uniform structure if whenever it is uniformly homeomorphic to a Banach space Y, it must be linearly homeomorphic to Y). This excited Joram and led to a series of papers, all joint with Schechtman and all but one joint with David Preiss, on nonlinear Banach space theory in an infinite-dimensional setting. It's a good thing that I let Joram drag me into the project, as the only three of our joint papers that appear on his selected publications list are from this period. (As you can see, even after all these years I long for Joram's approval.) After these collaborations, David and Joram continued in the nonlinear world and did deep research on the differentiation of Lipschitz functions, culminating in their book with J. Tišer. Joram was very happy with this work and was looking forward to doing more on differentiation theory, but, alas, that was the last mathematical contribution he was to make.

Ayelet Lindenstrauss

My father loved being a mathematician. The boy who grew up in Israel and left it for the first time after completing his PhD never ceased to marvel at being a member of the international fellowship of mathematics. To us, his children, it was also a wonderful thing. Some of my father's earliest and

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Joram holding Ayelet; parents Ilse and Bruno.

best mathematical contacts were in Poland. We knew of many people who were separated from friends by the Iron Curtain, but my father was the only person that we knew who had made friends across it. By communicating through colleagues in Western Europe, he was able to maintain these friendships as relations between Poland and Israel worsened and resume them when the Iron Curtain fell. My father had a Syrian friend and a Lebanese; none of my friends' parents knew anyone from these countries. Mathematicians my parents talked about, from faraway places, would then show up in our house.

Often my father took us along on his mathematical trips, especially when there were beautiful places to be seen. When we were young and he went on trips without us, he would hide chocolates in various cabinets around the house for us to find: easy ones in the kitchen cabinets for the first days, and hard ones in upper cabinets we rarely used for the later days. When he got back, there were always lots of presents. Once a customs agent, inspecting my father's suitcase, suspected him of being a toy salesman. When I was twelve and decided I wanted to embroider on evenweave fabric, my father returned from Switzerland with a full meter of the most glorious handwoven linen. I used it very sparingly and worked every last bit of it. Afterwards, when I needed kinds of thread which were not available in Israel, I would tell him what I wanted, and during his next trip he would go to a thread store and pick out colors. Apparently his repeated visits caused some of the salespeople to wonder what he did with the threads, but he always brought me very useful color ranges.

My father did not talk much about his work at home, and when I got to my second year as an undergraduate, he chose not to teach what had become his signature second-year analysis course because I would be taking it. (Many of my classmates were quite unhappy about this.) My main mathematical interaction with him was writing, from his outline, most of the second volume of his (Hebrew) textbook for this analysis course. It is a sampler of topics in analysis, each pursued long enough to prove a great theorem or two. My father had very high standards for mathematical writing, particularly for getting to the heart of the matter as quickly as possible and for not writing anything in a more complicated way than was absolutely necessary. I certainly learned a lot from the experience.

I do a very different kind of mathematics than my father did. He was frustrated by the distance, but maybe it is not so far fundamentally: my starting point is also geometry. When I prepare a class or write out a calculation, I often hear him preferring one approach over another.

In the last thirteen years, my father thoroughly enjoyed his new role as a grandfather. My family and I miss him very much.

Elon Lindenstrauss

My father influenced me in many ways—some that I am aware of, some that I am not. Mathematics has been tangibly present in my parents' house since I can remember. Many dinnertime conversations would be about academics; from time to time, particularly when a collaborator of my father would come for an extended visit, a mathematician would join the family for an informal dinner. Sometimes there would be more formal dinners where we kids stayed in our rooms and helped (or at least tried not to hinder) my mother's preparations. One of my mother's favorite stories is that when Erdős came to a party at my parents' house while on sabbatical in the US, he immediately wanted to see us, the Epsilons, who were upstairs in a part of the house that we (which probably mostly means my mother) had not had time to tidy up.

While academic life was frequently mentioned in our house, my father did not talk much about his mathematical work. He never pressured us in any way to become mathematicians, though both my big sister Ayelet and later I decided to go in this direction. Indeed he seemed initially ambivalent about mathematics as a career choice, even though he clearly enjoyed being a mathematician. He was certainly extremely pleased to follow our progress.

As a child I played board games with my father. Risk and Othello (aka Reversi) were among our favorite board games, and as in all endeavors, he was very systematic and thorough, developing strategies that he shared with me. When I got older and started getting interested in mathematics, he would suggest books from his large and carefully selected mathematical library. Only once have I been directly taught by him—in a course for

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mathematically inclined youth, where he would present problems and we would try to solve them. In retrospect I am very happy for this experience.

My father was very honest, had high standards both for himself and for others, and always said exactly what he thought, regardless of whether what he thought was pleasant or unpleasant to hear. From the time I was a graduate student to the last talks of mine which he attended when I was already a well-established researcher, I was always especially nervous and tried to be very well prepared when giving a talk when he was in the audience, as I was sure I would be told afterwards exactly what he thought of the talk.

Until very close to his death, even as his health was deteriorating, I have relied on his advice, both on mathematical and nonmathematical matters. He was a source of pride and strength to our family and will be dearly missed.

Vitali Milman

It was the ICM-1966 in Moscow. A lot of mathematicians arrived from the West, but my highest expectation was to meet Dvoretzky and Lindenstrauss. I knew well one of the first papers by Joram about duality for the moduli of convexity and smoothness and also read all of his work that I could find in our (poor) libraries. However, Dvoretzky indeed arrived, but Lindenstrauss did not. Dvoretzky told me that "they" (Russian authorities) wrote to Joram that there is no room in hotels (?!) and they cannot let him in. So, the first time I met Joram was in Israel in 1973 after my emigration. It was a very difficult time, after the Yom Kippur war. My family stayed in a dormitory for new emigrants in Tel Aviv. Once someone knocked on our door. I opened and saw a young, extremely nice-looking person who looked at me and said, "Joram Lindenstrauss." I remember this moment well after forty years. I lost my voice, and I hardly remember the continuation of our first meeting. Despite hundreds of days we spent together later, and despite the passing of forty years, that first image of Joram stays in my mind, comes to my mind when he is mentioned, and is not shadowed by later changes.

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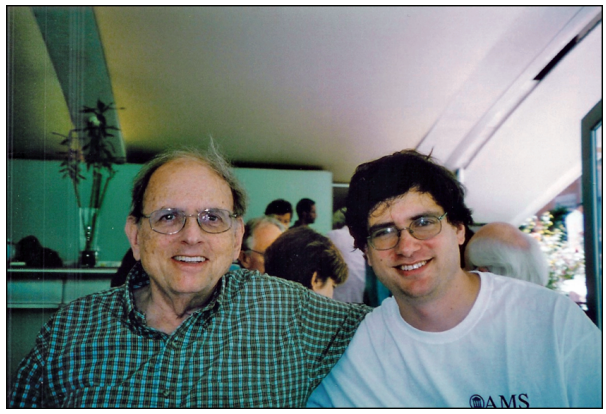

Joram and Elon at IMU, 2006.

Our serious scientific cooperation started two years later (I needed this time to learn Hebrew and English, at least to understand a little bit of both) and resulted in joint papers with Figiel (Figiel-Lindenstrauss-Milman) in 1976 (*Bulletin AMS*) and 1977 (*Acta Math.*). I heard opinions that these were the most significant results in geometric functional analysis in the 1970s. I learned a lot from working on this paper with Joram, learning from his broad knowledge and his taste. I felt that I became a different mathematician at the end of this period. Unfortunately, this cooperation stopped and returned only ten years later. We actually prepared some directions and ideas for working together, and I even wrote a few pages of notes. But one young mathematician heard the discussion on these results, quickly wrote a paper on them, and submitted it. Joram was very angry, for the "cornerstone" for a new direction we wanted to build was taken out from under us, and our cooperation was stopped for a long decade.

Our second period of research cooperation, from the mid-1980s, was joint with Jean Bourgain. It also, I think, was very successful. That time I turned to the direction of convexity, but "asymptotic" convexity, not the classical one, and "pushed" Joram to discuss this subject during our summer stays at IHES. I hope he liked the outcome as much as I liked it.

Our joint activities and cooperation were not reduced to joint research. From the start of the 1980s we organized a seminar (mostly in Tel Aviv) on geometric aspects of functional analysis, which soon became very famous and world known under the nickname GAFA seminar. For many years it met regularly, generally twice monthly on Fridays, and attracted a lot of people from all over Israel (and many foreign guests). Six books of proceedings of this GAFA seminar were published during that time, mostly by Springer, jointly edited by the two of us. Later, the health of Joram did not allow him

to come regularly, and the seminar changed its appearance.

In his work and his activity, Joram always emphasized nontriviality and difficulties, but also quickly caught new ideas and had good taste. He did not allow "easy" works to come through his hands. This harsh approach of his kept the high level of research in geometric functional analysis and also had a great influence on the *Israel Journal of Mathematics* during the period he was a leading editor.

The loss of Joram is a great loss to all of us—his colleagues, friends, and mathematics in whole.

Assaf Naor

Being the last doctoral student that Joram advised before retiring, I have known him for a shorter period than the other contributors to this memorial article. For this reason I will not describe a personal story about Joram, but rather mention aspects of his impact on mathematics and mathematicians.

Joram's influence was multifaceted. I and many others who interacted with Joram associate his name with uncompromising professional standards, be it integrity, good taste in choosing research projects, or reserving praise only for results that contain truly outstanding and important new ideas. This approach inevitably made Joram an exceptionally sharp critic, perhaps somewhat intimidating at times, and always an inspiring role model.

Joram's mathematical contributions were exemplified by deep and original insights combined with remarkable feats of technical strength. This resulted in his solution of some of the oldest and most important questions on the geometry of Banach spaces. In addition, Joram had transformative impacts on mathematics by putting forth new research paradigms that shifted the focus of subsequent work, and after decades of efforts by Joram and others, his deep insights have led to rich new theories of central importance. An example of Joram's forward-looking introduction of a powerful research agenda is his work on the nonlinear geometry of Banach spaces, motivated by rigidity phenomena (some of which were his own discovery) that indicated that there should be a "dictionary" that translates insights from the geometry of Banach spaces to the setting of general metric spaces. Almost fifty years after his initial contributions along these lines, one can safely say that this approach has led to many unexpected results in metric geometry, spreading the influence of ideas that originate in Banach space theory to areas such as computer science and group theory. These cross-cutting links between mathematical disciplines were far from obvious when Joram initially formulated his questions, requiring (in hindsight) coping with new phenomena and the introduction of new tools that go far beyond what was previously understood in the linear theory. As an example, one can point out Joram's remarkable intuition, formulated jointly with W. B. Johnson, that there should be a nonlinear analog of Maurey's extension theorem (a phenomenon that was eventually verified due to ideas of K. Ball). This was put forth in his work on extension of Lipschitz functions, a paper that included, as a tool, a dimensionality reduction lemma which has had an extremely important and central impact on various aspects of computer science (exemplifying Joram being a sharp critic, he believed that this lemma, despite being his most cited work, was too simple to be considered an actual result).

Joram's death is a huge professional and personal loss to many people. It is certain that his insights and profound impact on mathematics will perpetually endure and even increase over time as more progress is made on his long-term research programs and the ideas and methods that he introduced are used in new contexts.

Gilles Pisier

Reminiscing about Joram, the first thing that comes to mind is how incredibly nice and supportive he was to me early on. So much so that the initial awe that I had of him quickly evaporated, even though we never exchanged too many words. In fact, although this cannot be entirely true, I remember having only "serious" conversations with him, meaning all revolving around math, in sharp contrast with the discussions I had with his friend and colleague Lior (Tzafriri), which covered the whole spectrum and could be at times very funny or quite intimate. Joram always remained (mostly in my imagination) a rather tough father figure always in demand for deeper and harder theorems.

I met Joram for the first time in Oberwolfach in October 1973. He and A. Pełczyński emerged there as the two main leaders of the new field to be labeled "geometry of Banach spaces." I was only twenty-two and he still thirty-six for a few more weeks. This was also the first time I met most of my future friends and colleagues in that field, including Tadek Figiel, with whom conversations led to a theorem that to our surprise (because it looked to us as a mere combination of known results) Joram pushed us to publish together. This was

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an isomorphic characterization of Hilbert spaces as those Banach spaces E admitting an equivalent norm with (essentially) best possible modulus of convexity δ_E and one (possibly different) with best possible modulus of smoothness ρ_E. Joram had long been interested in questions related to these notions and had proved a famous duality formula between δ_E and ρ_{E^*}.

We met again in Durham in summer 1974 when I presented a more substantial theorem on renorming of uniformly convex spaces using martingales. I don't remember any comment from him, but he and Lior immediately invited me to visit them in Jerusalem, which I did for two months in December 1974. While in Durham, Joram heard that I was preparing a paper with Per Enflo on what we called the 3-space problem: If a given Banach space X has a closed subspace $Y \subset X$ such that both Y and X/Y are isomorphic to Hilbert space, is it also true for X? This was a famous question attributed to Palais (but this was never confirmed). Enflo and I could not solve it but showed that in terms of type, cotype, uniform convexity and smoothness, the space X was very close to being Hilbertian. For instance, in the n-dimensional version of the problem we concluded that X was C_n-isomorphic to ℓ_2^n with $C_n = O((\log n)^\alpha)$ for some $\alpha > 0$. Joram told me he had an approach to that problem and, to my terror, insisted that I give him a private briefing to describe our results, at the end of which he made no comment, but I remember being puzzled that he seemed happy. Perhaps it made him feel he was on the right track. Later on that same year but in Jerusalem, Joram showed me his counterexample to the Palais problem, and to my surprise (and actually against my will!) he contacted Enflo to stop the publication of our paper (on which printer composition had started) in order to make sure that he could join us as a coauthor. In Joram's ingenious counterexample, the distance to Euclidean n-space was larger than $c\sqrt{\log n}$. Thus it showed that the positive results were essentially best possible, and so the final joint paper gave a quite complete solution of the Palais problem. This took me by surprise and to this day I remember feeling embarrassed to have become, at his insistence, a coauthor of such a major breakthrough. Kalton and Peck later gave a different example (usually denoted by Z_2), which is very closely related to complex interpolation theory for the pair (ℓ_1, ℓ_∞). Kalton also gave an example where the above $\sqrt{\log n}$ is replaced by $\log n$, which is sharp.

From the 1973 meeting I remember with emotion Bob James's lectures on his nonoctahedral nonreflexive outstanding example, solving a long-standing problem. In a famous *Annals* paper from the 1960's he had proved that any nonreflexive space must be square. A space is called octahedral (resp. square) if it contains for any $\varepsilon > 0$ a $(1+\varepsilon)$-isomorphic copy of ℓ_1^3 (resp. ℓ_1^2). James went on for hours in his own strange style of "hands-on" mathematics, seemingly allergic to the more commonly formalized statements others were used to, and everybody seemed lost save for Joram. James had made premature claims in the past decade, so there was some skepticism in the audience. To us junior auditors he looked like he had hit too many a wall and all he kept doing was explaining how to cleverly add "bumps," but this time he was right! Joram listened patiently till the end, and the next year he produced with James an improved and much more digestible version of James's landmark example. Moreover, with Davis and Johnson he developed a penetrating analysis of the degrees of reflexivity of a Banach space. A sample result is that while James's example shows that nonreflexivity of a space X fails to imply that X is octahedral, the nonreflexivity of $R(X) = X^{**}/X$ does. This somewhat explains why the James examples were found among spaces of codimension 1 in their bidual (i.e. $\dim(R(X)) = 1$), just like the space J for which James had become famous in the 1950's. More precisely, letting $R^2(X) = R(R(X))$ and $R^k(X) = R(R^{k-1}(X))$, they showed that if $R^k(X) \neq 0$ (i.e. $R^{k-1}(X)$ is not reflexive), then for any $\varepsilon > 0$, the space X contains a $(1+\varepsilon)$-isomorphic copy of ℓ_1^{k+1}.

This reminds me of a very dear souvenir of the Lindenstrauss family, a sort of personal treasure. In the type/cotype language, the above examples showed that type $p > 1$ did not imply super-reflexivity (or reflexivity). Thus it was natural to wonder what happened in the extreme case $p = 2$. Joram knew that I was obstinately trying to prove that type 2 implied reflexivity while in Jerusalem back in early 1975, and one day he called to say that he thought he had a proof using the iterated logarithm law (this later collapsed), but since his

Joram receives the Israel Prize, 1981.

son, Elon, was sick and his wife, Naomi, had to go teach, he had to stay at home, so would I agree to come to his place to talk while babysitting with him. Of course I was delighted, so he picked me up and we worked for a couple of hours at his home until Naomi's return. How could I have imagined then that the charming little toddler who was jumping around under our table was a future 2010 Fields Medalist!

To complete the James saga, shortly after Oberwolfach, Joram and Bill Davis showed the existence among the James zoo of nonreflexive spaces of type p for any $p < 2$, and finally James himself showed (while we were all back in Jerusalem for a special year in 1976/77) that even type 2 does not imply reflexivity. Eventually, a few years later, Xu and I managed to exhibit (by a different method, using real interpolation), for all $1 \le p \le 2 \le q < \infty$, nonreflexive examples with type p and cotype q, except for the obvious exception $p = q = 2$ characterizing Hilbert space.

David Preiss

I feel as if I have known Joram all my life, even if for the first forty years I lived in a country whose relations with Israel were not on a level that would allow us to work together, and even our one brief meeting at a conference was not to be mentioned too loudly. My mathematics, however, has always been deeply influenced by Joram's work, as documented by a referee calling me "a mathematician of Lindenstrauss's school" long before the political situation allowed us to meet and work together. Towards the end of the eighties Nassif Ghoussoub considered inviting me for a visit and asked Joram about me. Joram responded that we had never met (and then he said something positive about my mathematics). When I later told him that we actually had met, he said, "So I was wrong" (specifying quickly "but only in one point"). I remember this because of my admiration for his "so I was wrong": it was very rare, because he was usually right; but when he wasn't, he would not waste time arguing. Just these four words, and we would start discussing new ideas.

I recall a number of nonmathematical events, such as playing basketball on a team opposing him (he was very good), going to concerts, his daughter Gallia's pictures of Jerusalem, walks in Jerusalem, exhibitions, and of course his welcoming family and the huge amount of help we were given by his wife, Naomi. Surprisingly, I cannot recall when we started talking serious mathematics. Most probably, we began by discussing the Lipschitz isomorphism problem and its possible solution using derivatives. This still-open problem asks whether, say, reflexive, separable Banach spaces E and F are linearly isomorphic provided they are Lipschitz isomorphic. A natural candidate for the linear isomorphism is the derivative of the Lipschitz isomorphism at a suitable point. In special situations the use of Gâteaux derivatives, which are known to exist but need not be surjective, combined with results from the geometry of Banach spaces gives a positive answer. Fréchet derivatives have the property that the derivative of a Lipschitz isomorphism is a linear isomorphism, but even Lipschitz self-maps of Hilbert spaces can fail to be Fréchet differentiable at any point. Nevertheless, the Gâteaux derivative of a Lipschitz isomorphism of E to F at a point x is a linear isomorphism provided that its compositions with elements of the dual of F are Fréchet differentiable at x. Whether such a point x exists (when E, F are reflexive, say) is open. This problem is naturally divided into two parts: firstly, whether any countable collection of real-valued Lipschitz functions on a reflexive space has a common point of Fréchet differentiability, and secondly, whether such a point can be a point of Gâteaux differentiability of a vector-valued function.

Much of what we did with Joram was related to the above problems. Our first paper, written mostly during my first longer-term visit to Jerusalem, was motivated by the observation that a weakening of Fréchet differentiability, called almost Fréchet differentiability, suffices to answer the Lipschitz isomorphism problem. We constructed such points for any finite number of real-valued Lipschitz functions on superreflexive spaces. We spent some time discussing whether the method, a variant of density points, could lead to stronger results, but eventually agreed that there are serious obstacles to it. In the end, in a paper with Johnson and Schechtman, we gave a much simpler proof of this result from which the main obstacle to extending it to countably many functions is clearly seen.

When we began our investigation of differentiability problems, it was known only that real-valued Lipschitz functions on spaces with separable dual have points of Fréchet differentiability. It was not even clear whether there is a single infinite-dimensional Banach space in which any two such functions have a common point of Fréchet differentiability. The key problem in trying to find such a point seems to be that the (weaker) Gâteaux differentiability requires a measure-theoretic concept of smallness, while the Fréchet requirement is closer to the use of Baire category. Mixing measure and category smallness are fraught with the danger of proving excellent results for elements of the empty set. Nevertheless, we noticed that while

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measure theoretical smallness is required in the space, smallness in the sense of category may be needed only in a suitable space of measures. Thus we defined a new class of negligible sets, which we called Γ-null sets, as those sets that are null for typical (in the sense of category) measures in a naturally chosen space of measures. In some Banach spaces, including c_0 and Tsirelson's space, we showed that real-valued Lipschitz functions are Fréchet differentiable Γ-almost everywhere, and for these spaces we therefore know that every countable collection of such functions has a common point of Fréchet differentiability. However, we also proved that with the space of measures that we have used or with similar spaces this program fails in Hilbert spaces.

An important point was our recognition that Fréchet differentiability problems are sharply divided into two categories depending on whether one requires validity of mean value estimates or not. The validity of mean value estimates means that the closed convex hull of the set of Fréchet derivatives and of Gâteaux derivatives coincide. In an "on and off" (as Joram called it) investigation lasting about ten years, joined also by Jaroslav Tišer from Prague, we found reasonably satisfactory answers in the first case. Perhaps the easiest of our results to state is that $\mathbb{R}^2$-valued functions on Hilbert spaces have so many points of Fréchet differentiability that the mean value estimates hold, but $\mathbb{R}^3$-valued Lipschitz functions may have so small a number of them that the mean value estimate fails, and analogous results hold for n functions on ℓ_n. Our rather involved proofs appeared in the research monograph *Fréchet Differentiability of Lipschitz Functions and Porous Sets in Banach Spaces*, published in February 2012. We did not consider this as the end of our joint work, but corresponded about questions we should study in order to understand differentiability without mean value estimates; better understanding of Gâteaux differentiability featured most prominently. Unfortunately, Joram's health did not allow us to continue these discussions.

Gideon Schechtman

I first met Joram when I was an undergraduate student at The Hebrew University in Jerusalem. I took Introduction to Functional Analysis from him, but strangely enough I decided to try to recruit him as my PhD advisor only after I had a magnificent course in topology with him, an area which was to a large extent new to Joram as well. Until then I was seriously thinking of completely different directions of research (first game theory, then set theory). When I approached Joram and asked him to be my PhD advisor, he was already advising at least four PhD students, and I got the (probably completely unjustified) impression that he was trying to discourage me. He gave me three papers to read. The first was Dvoretzky's spherical section of convex bodies paper, an extremely important paper that only a handful of people managed to read. I'm not one of them even to date. The second was a paper on the geometry of L_p spaces that was very badly written and in a language I was not fluent in. It contained a very nice result, and I made a great effort to understand it but failed. It later turned out that both the proof and the result were wrong. I don't remember the third paper.

I don't know if it was the intention of Joram, but actually these two papers, in spite of the fact that they caused me such frustration (and maybe because of that), had a major influence on my later research. Most of my PhD thesis revolves around the geometry of L_p spaces, and some of my later research is very much connected with Dvoretzky's theorem. I remember vividly the few encouraging words that I heard from Joram after I proved my first result. I guess this was the first time I heard some compliments from him, and I must admit that even many years later I was struggling with mathematics mostly to squeeze a few good comments from him (I'm exaggerating a bit, but this is not far from the truth). During my PhD years Joram and I tried to cooperate twice. One of these periods came after I thought I had solved the distortion problem (that was solved almost twenty years later by Odell and Schlumprecht), but nothing written came out of it. Yet, I still learned a lot from these experiences. Also, more importantly, it helped me overcome a fear of him, and little by little we became colleagues rather than a master and a student. Our first fruitful cooperation came only a few years later.

So what was Joram's main influence on me? I can't say it is the direction of research he set me to; I would probably follow him in any direction he would be in. Also, I cannot honestly say that his mathematical power and insight (which were undoubtedly great) had a unique influence on me. What really set him apart from the point of view of his influence on me were the standards he set and lived by. He had very high standards as to what constitutes good mathematics and for scientific and personal integrity. These were also very easy to absorb from him: he always said what was on his mind whether asked for it or not. Until late in my career a major component in my decision of whether or how to write a paper on a result I got was trying to estimate what Joram's opinion of it would be and trying to avoid a sarcastic remark

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Joram and wife, Naomi, in Switzerland, 1994.

from him. On the other hand, any expression of appreciation from him had double the value, because he never said something different from what he really thought.

Andrzej Szankowski

Joram was for me a very important person; I think he influenced my life more than anyone outside my family. Although he was not my official advisor, he has been for me the main guidance in mathematics.

I first met Joram in Aarhus in spring 1970. Until I settled in Israel in 1980, every year I visited him in Jerusalem. During my first visit in December 1970, I witnessed a spectacular display of Joram's abilities. He worked then, with Lior Tzafriri, on the complemented subspaces problem. A complete solution seemed out of reach, and the main effort was to settle it in special cases. And then one morning Joram came beaming to the institute and said "I worked on it the whole night and here is the solution." So it was—a very clever, clear-cut, complete solution to a major problem. This was done with a "feedback technique" which Joram mastered: in order to prove that a quantity is bounded, it suffices to obtain an inequality in which it is bounded by a decreasing function of itself.

The 1970s were the golden period of Joram's seminar in Jerusalem. Almost every week he or one of his students came up with a new result. In 1976–77 Joram organized a Banach spaces year at the Institute of Advanced Studies of the Hebrew University. This was a great year for most of the participants, for me in particular: day by day Joram and I discussed the problem of the approximation property for $B(H)$. This problem was somewhat above my limits, and I don't think I could have coped with it without Joram's encouragement and advice.

In the 1980s I collaborated with Joram on several problems. We have a nice paper in nonlinear analysis which came up in a typical (for Joram) way: he got me interested in a paper from which I observed a generalization of the Mazur-Ulam theorem; after seeing it, Joram overnight figured out how to turn it into an "if and only if" theorem, a complete result. Another paper from this period perhaps would not be remarkable, except that it contains probably the first contribution of Elon to mathematics: Elon, then a high school student, wrote for us a computer program which computed the maximum of a monstrous function that came up from our computations.

Joram was a great lecturer. He had a very special style: writing rather little on the blackboard, he made an impression of improvising, but, miraculously, everything was very well organized. I think it came quite naturally to him, without making notes or much preparation. He wrote two beautiful textbooks in Hebrew: *Advanced Calculus* for second-year [undergrad students] and *Intro to Functional Analysis* (together with A. Pazy and B. Weiss), for MSc. students.

From the moment I first met Joram, I came to like him as a person. He had sharp opinions and wasn't reluctant to put them forward. This made him a poor politician but a valuable teacher and friend. Joram set high standards for what was publishable, both for himself and for his students. He was highly suspicious about general theories which didn't seem to have interesting models. Joram was a very modest man, handling in a relaxed way numerous honors which were bestowed on him. He was very careful with superlatives, rather consciously using his own scale of appreciation, in which "beautiful" or "deep" were used very seldom, and "profound" was apparently reserved for Dvoretzky's theorem.

Joram's world was centered about two subjects: mathematics and his family. He had many friends around the world, but as he used to say, these were either mathematicians or family. He was a social man and enjoyed entertaining people. I have fond memories of many evenings I spent at Naomi and Joram's home. He took special care of young people, not only his own students. Inviting them frequently, together with influential people, he helped them to establish contacts in a natural way. He obviously took care of his students well beyond the expected.

Joram's last years were marred by his deteriorating health, but he must have felt a sense of fulfillment, both as a mathematician and as a family man.

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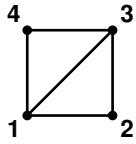
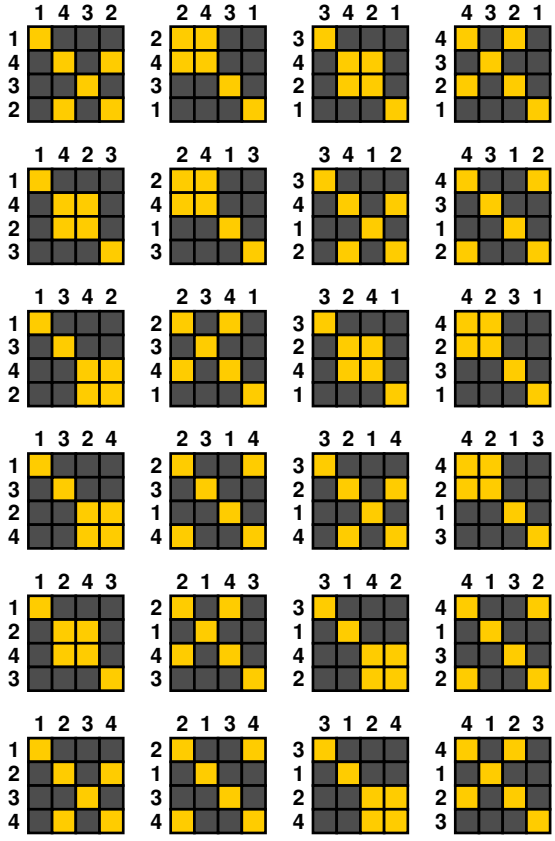
About the Cover

Twenty-four Views of 

This month's cover is explained by the essay in this issue on graphons, by Daniel Glasscock. It offers several ways to visualize the graph that would normally be pictured as



The theory of graphons sees it differently, however, as Glasscock explains. One chooses a labeling of the nodes of the graph, then lays out a square of pixels marking the edges (i, j) of the graph. The graphon, however, is the equivalence class of all such pixel maps obtained by varying the labeling. The cover can be enhanced to illustrate better what is going on:



One point is that the essential properties of a graph do not generally depend on how its nodes are labeled. For example, if the difference between two graphs is to be measured, one must be prepared to compare nodes and edges using all possible labeling. But of course as the size of a graph grows, the size of the graphon grows alarmingly large. It is almost miraculous that graphons can nonetheless be manipulated and analyzed.

—Bill Casselman
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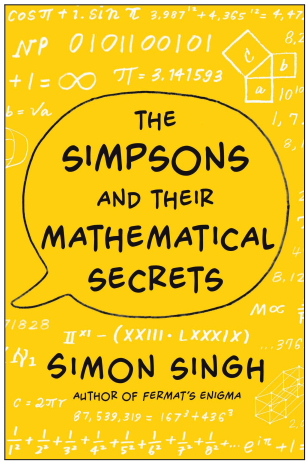

Animating Popular Mathematics: "The Simpsons and Their Mathematical Secrets"

Reviewed by Christopher Goff

The Simpsons and Their Mathematical Secrets
Simon Singh
Bloomsbury, USA (October 2013)
$22.85, 272 pages
ISBN: 978-14088-353-02

Your nonmathematical friends may have asked you about this book. Written by Simon Singh (who also wrote *Fermat's Enigma* [22]) and published by Bloomsbury (who also published the Harry Potter books), *The Simpsons and Their Mathematical Secrets* is wrapped in a bright yellow jacket and can probably be found in your nearest bookstore. Ostensibly about the mathematical references one can find in *The Simpsons*, the longest-running scripted show in television history [21], the book also covers *Futurama* [7] and the mathematical credentials of the two shows' writers. Through the lens of these programs, Singh glimpses the wider arena of mathematics and popular culture, describing several interesting ways in which the entertainment industry and the world of mathematics can interact.

The emerging field of mathematics and popular culture lies at the interface of these two seemingly disparate areas and examines how each can shape and be shaped by the other. As examples (though by no means an exhaustive list): mathematical models can be used to create special effects for animated and live-action films [1], [2], [18]; the ways in which characters with mathematical talent are portrayed (gender, race, age, and whether or not they are hyperintelligent) can affect audience attitudes towards mathematicians [16]; including popular culture references in the mathematics classroom can alleviate math anxiety and provide an access point to engage students in deep mathematical thinking [14]; new theorems can come from television shows [6]; and finally, the publishing market can support a popular work such as the book under review here.

The Simpsons was created by Matt Groening (of *Life in Hell* comic fame) as a set of vignettes for *The Tracey Ullman Show* on the Fox Network. Its success there led to a regular spot in the Fox lineup, where it has aired since the 1989–90 television season, garnering no fewer than ten Primetime Emmy Awards for Outstanding Animated Program. The Simpson family consists of nuclear plant safety technician Homer and his loving blue-haired wife, Marge; their troublemaking son, Bart; their academically talented daughter, Lisa; and their infant daughter, Maggie.

Still more success led Fox to ask Groening to create another animated show, resulting in the 1999 premiere of the science-fiction-themed *Futurama*, in which pizza delivery boy Fry accidentally falls into a cryogenic chamber on New Year's Eve 1999 and doesn't unfreeze until a thousand years later. In the future he befriends a robot named Bender and obtains a job as a delivery boy for a distant relative of his, the rather old and nerdy Professor Farnsworth. *Futurama* aired on Fox

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for four years, after which reruns were shown on the Cartoon Network for four more years. Underground popularity resurrected the show for four direct-to-video movies and an eventual return to series television on Comedy Central. The show won two Emmys for Outstanding Animated Program—one while at Fox and the other at Comedy Central—before coming to an end in 2013.

Both *The Simpsons* and *Futurama* are immensely popular, having been seen by millions of viewers. So, any mathematical references or jokes contained in their episodes are transmitted to many more people than a typical instructor of mathematics can ever hope to reach. As someone interested in the ways in which popular culture and mathematics interact, I am thrilled that a large publisher and a well-known author are shedding more light on some interesting examples of the interplay of mathematics and popular culture.

But the professional mathematical community is not Singh's target audience. Indeed, little in this book will be new to mathematicians who both observe and critique popular culture, especially those who are familiar with the work of scholars in this field. In particular, Dr. Sarah J. Greenwald and Dr. Andrew Nestler have been publishing specifically on *The Simpsons* and *Futurama* for over ten years and have created and maintained extensive websites [15], [19], [12]. I too have long been interested in this area, ever since I began giving conference presentations about mathematics and the movies in 2004. Shortly thereafter, Greenwald and I coedited a special issue of the journal *PRIMUS* [9] that focused on mathematics and popular culture. We have had another collaboration since then [4].

Singh interviewed Greenwald and Nestler for his book, and he quotes them throughout Chapter 8. He also includes an interesting anecdote about how the two mathematicians were implicitly responsible for adding mathematical content to an episode of *The Simpsons*. After Greenwald was interviewed for NPR's *Science Friday* in 2005, some of the writers heard the program. Intrigued that mathematicians were using material from the show in their classrooms, they invited Greenwald and Nestler to Fox Studios for a table-read, a key step in the process of writing any television script. After the mathematicians had left, however, the writers realized that the baseball-themed episode, titled "Marge and Homer Turn a Couple Play" (2006), contained no jokes of a mathematical nature. So they added three possible attendance numbers at a baseball game as a freeze-frame gag, that is, a joke that goes by so quickly that in order to see it fully, viewers have to record the show and pause the playback. Unbeknownst to most of the audience, the three numbers were a Mersenne prime (8191), a perfect number (8128), and a narcissistic number (8208).

Likely constrained by the fact that he was writing a popular book, Singh does not describe Greenwald and Nestler's (or others') prior contributions to the field in much detail, though he does mention them again in the acknowledgments and includes links to their definitive websites. For the academic audience of these *Notices*, however, I will continue to cite references in the area of mathematics and popular culture when they arise during the course of this review.

As do many mathematics books, *The Simpsons and Their Mathematical Secrets* begins with a Chapter Zero, in which Singh outlines some of the many ways that academia has interacted with the show. Professors of philosophy, psychology, and religion have written about how ideas in their disciplines arise in various plots and subplots revolving around the Simpson family. Even President George H. W. Bush famously criticized the Simpsons as antithetical to the wholesome all-American Waltons. The writers responded satirically (via Bart), "Hey, we're just like the Waltons. We're praying for an end to the Depression, too" [p. 2].

Singh rightly shines his spotlight on some of the writers themselves and their personal mathematical accomplishments. Since I also refer to these writers, I will list them by name: J. Stewart Burns (BS, mathematics, Harvard; MS, mathematics, Berkeley); David S. Cohen (BS, physics, Harvard; MS, computer science, Berkeley); Al Jean (BS, mathematics, Harvard); Ken Keeler (BS and PhD, applied mathematics, Harvard); and Jeff Westbrook (BS, physics, Harvard, and PhD, computer science, Princeton). Singh includes quotations in which some writers point out the similarities between mathematics and humor: Burns says that a mathematical puzzle and a joke share a common structure, and Cohen likens the task of telling a complex story in a short amount of time to solving a big logic puzzle. For more information about the writers, see [12], and for possible classroom uses of their interviews, see [11].

In Chapter 3, titled "Homer's Last Theorem," Singh mentions some connections between these writers and the story of Andrew Wiles's proof of Fermat's Last Theorem, the topic of Singh's 1997 book, *Fermat's Enigma* [22]. In particular, when Wiles spent a brief time at Harvard, Jean attended some of his lectures, and when Cohen was a graduate student at Berkeley, he attended some lectures of Ken Ribet. Singh mentions these connections while discussing a near-miss solution to Fermat's equation that appears as a background freeze-frame gag on Homer Simpson's chalkboard in the episode "The Wizard of Evergreen Terrace" (1998), namely, $3987^{12} + 4365^{12} = 4472^{12}$. Cohen

intentionally inserted this bit of mathematics as a prank, knowing that most calculators would, at first glance, not reveal its falsity, and he was thrilled to read the buzz that it generated online. As Cohen says in the book, "…when we get the opportunity to raise the level of discussion—particularly to glorify mathematics—it cancels out those days when I've been writing those bodily function jokes" [p. 37]. Interestingly, a couple of years after this near-miss example aired, Noam Elkies acknowledged it in a paper giving a new computational algorithm to obtain more general results [5].

Some might find it surprising that there are relatively close connections between the mathematics community and the entertainment industry. In Chapter 5, Singh introduces his audience to the Erdős number, which indicates how far removed someone is from Paul Erdős on the coauthor graph. Writer Westbrook has an Erdős number of 3, as does Cohen. A similar metric is playfully employed by fans of the movie business. An actor's "Bacon number" is her or his distance from Kevin Bacon on the costar graph, and Westbrook happens to have a Bacon number of 3. In the same way that one's Erdős number can be used as a proxy for one's connectedness to the mathematical community, so does one's Bacon number suggest prominence in Hollywood circles. Thus the tongue-in-cheek "Erdős-Bacon number" (i.e., the sum of the two numbers) can be used as a rough measure of someone's links to both Hollywood and the world of mathematics. As we have already seen, Westbrook's Erdős-Bacon number is 6. Surprising to me were the relatively low Erdős-Bacon numbers of the Hollywood stars Singh mentions in the book. Academy Award-winner Colin Firth's Erdős-Bacon number is 7, while Academy Award-winner Natalie Portman's is 6. Though not listed by Singh, Danica McKellar (from *The Wonder Years* and *The West Wing*) also has an Erdős-Bacon number of 6. Singh points out that Erdős himself has an Erdős-Bacon number of 4, but that this is not minimal. Apparently the lowest, 3, belongs to Bruce Reznick at the University of Illinois.

One more aspect about the writers that interested me was that they continued to study mathematics even while writing for television. In Chapter 9, Singh tells the story of how several writers formed a "math club" and took turns speaking to interested audiences or inviting others to speak, such as Ron Graham, and Greenwald and Nestler [13]. On an occasion when Cohen addressed the math club, he explained pancake numbers, the subject of a paper he wrote as an undergraduate [3]. I was amused by the story Cohen recounts in the book, that after a long journal lag time during which he began writing at Fox, his paper finally appeared in *Discrete Applied Mathematics*. He excitedly shared his good fortune with his colleague Keeler, who responded, "Oh yeah, I had a paper in that journal a couple of months ago." Keeler's paper [17] was even coauthored by Westbrook, another writer.

Interspersed between the stories of the writers and their mathematical credentials, Singh lists several instances of mathematics in *The Simpsons* and *Futurama* and explains them for a general audience. Many of these examples involve basic mathematics or statistics, and so I will focus on only a few that I believe are the most important in that they show interesting ways that mathematics and popular culture have the potential to interact. All of these are discussed in the book, starting with the 1990 joke that sparked Greenwald and Nestler's initial work and ending with the 2014 publication of the so-called "Futurama Theorem."

In Chapter 1, Singh describes the first official episode of *The Simpsons* to air, "Bart the Genius" (1990). In it, Bart writes his name on the completed aptitude test belonging to the class nerd, Martin Prince. Bart is thus "recognized" as gifted and placed into a different school, where the teacher writes $y = \frac{r^3}{3}$ on the board and says, "…if you determine the rate of change correctly, I think you will be pleasantly surprised." All the students except Bart solve the problem and begin to chuckle. The teacher works out the problem on the board and writes the answer $dy = r^2\ dr$ as "$r\ dr\ r$," saying, "har-de-har-har".

Unlike other examples, Singh avoids explaining the mathematics behind this one, other than a footnote reminding some readers how to differentiate r^n with respect to r. In a 2004 article [14], Greenwald and Nestler explain how they used this very scene as part of an assignment in a first-semester calculus course. They describe how it can help students review material before an exam and how it can even alleviate math anxiety in the classroom.

Greenwald and Nestler continue in the same paper to discuss the non-canon segment "Homer^3" (1995), in which Homer enters a futuristic three-dimensional world (as opposed to the presumably lower-dimensional nature of the Simpson universe) to escape an evening with his sisters-in-law. Classroom use of this vignette, an homage to a classic episode of *The Twilight Zone*, can spark a variety of interesting debates around two- and three-dimensional geometry and can initiate student thinking about the shape of four-dimensional space [14]. Singh devotes his Chapter 13 to "Homer^3," where he explains several of the freeze-frame jokes that the writers have inserted into the background, from statements like "P = NP" to Euler's equation, "$e^{\pi i} = -1$."

In addition to providing explanations of various mathematical tidbits, Singh also describes other ways that popular culture has the potential to comment on the mathematical community. The character Lisa Simpson, for example, is a bright young girl with obvious intellectual prowess in all disciplines, including science and mathematics. However, Lisa often experiences prejudice, either for being female or for being smart. The two come together in "Girls Just Want to Have Sums" (2006), which Singh focuses on in Chapter 7. This episode put the issue of women and mathematics front and center and treated it with the writers' usual satirical panache. In the episode, Principal Skinner makes tone-deaf comments about how girls are bad at mathematics (à la Larry Summers), prompting him to be replaced and the school to be split along gender lines. Frustrated by her new teacher's stereotypically "female" approach to mathematics instruction ("How do numbers make you feel?"), Lisa disguises herself as a boy, sneaks into the boys' class, and thrives so much that she ultimately receives the award for Outstanding Achievement in the Field of Mathematics. She unveils her true identity, proving that girls can do math too, at which point Bart claims that she succeeded only because she was acting like a boy.

This episode was the first to rely heavily on mathematics and its instruction as the main thematic material rather than as tangential references or freeze-frame gags. In the end, the writers explicitly side-stepped the question of why girls are underrepresented in mathematics by cutting Lisa off mid-sentence and replacing her with Martin Prince playing the flute. Singh goes on to describe similarities between Lisa Simpson and Sophie Germain (1776–1831), who had to use a male pseudonym to obtain Lagrange's lecture notes from the newly opened École Polytechnique. Greenwald also wrote about this episode, right before it aired. In an interview she and Nestler conducted with writer Westbrook in August 2005, he describes the then-upcoming episode and how the writers "didn't want to toe any ideologically obvious line either way" [10]. So while the writers did focus on the controversial debate about gender and mathematics, they tiptoed around it in the end.

Singh devotes the final four chapters to *Futurama*, also created by Matt Groening. David S. Cohen became head writer "David X. Cohen" (the name David S. Cohen having already been taken when television writers became unionized) and ramped up the quantity and quality of jokes involving mathematics, physics, and computer programming, such as the regular hexagonal cross-section of Madison Cube Garden and Bender's serial number of 1729. Singh describes these in detail, including the Ramanujan-Hardy story, and even explains Möbius strips and Klein bottles, which also show up on the *Futurama* screen. For more about these jokes and other examples of sums of cubes in the show, as well as possible classroom uses, see [8], [11].

In the last chapter, Singh describes something truly novel: the "Futurama Theorem." In the episode "The Prisoner of Benda" (2010), many of the characters use one of Professor Farnsworth's inventions, the Mind-switcher, to switch their brain into another character's body. Unfortunately, once the machine switches two minds, it will not work again on the same two. After several different exchanges, the characters wonder how they can get their minds back into their own bodies.

Keeler, while trying to complete the writing of the episode, cast the problem in the language of distinct transpositions and proved that in order to

guarantee a way to return everyone's mind back to her or his original body, at most two more individuals need to be included who have not previously swapped with anyone. In the episode, recurring characters "Sweet" Clyde Dixon and Ethan "Bubblegum" Tate (from the Globetrotter Homeworld and known for their mathematical, scientific, and basketball-playing talents) write Keeler's proof of the theorem on a glowing green blackboard and explain it to the professor, who is in Bender's body at the time.

Evans, Huang, and Nguyen [6] recently extended and optimized Keeler's original result, probably marking the first instance where a mathematical theorem created for a television show has entered the peer-reviewed world of academe. Mathematicians have long been inspired by problems that arise in other fields, but it seems surprising that a writing conundrum on a television show could lead to new mathematics. Perhaps mathematicians could benefit from the world of entertainment. In "The Prisoner of Benda," Keeler's proof was probably seen by 2.6 million viewers when it aired [23], while the paper by Evans et al. was likely seen by fewer than 16,000 [20]. Maybe those writers are on to something.

In sum, Singh writes engaging prose explaining interesting mathematics to a general audience. He also succeeds in continuing the conversation about many of the connections between the mathematical world and Hollywood, such as the pedagogical uses of *r dr r* and a 3-D Homer, raising public awareness of the issue of women in mathematics, and the creation and proof of the Futurama Theorem. These examples epitomize the exciting possibilities for interplay between mathematics and popular culture. Though *Futurama* was canceled (again) in 2013, we can only hope that *The Simpsons* and its writers (and Singh) will continue to provide the world with high-quality mathematical entertainment.

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WHAT IS . . .

a Graphon?

Daniel Glasscock

Large graphs are ubiquitous in mathematics, and describing their structure is an important goal of modern combinatorics. The most famous description is given by Szemerédi's Regularity Lemma (1978), which asserts that the vertices of any large enough finite graph may be partitioned into sets of roughly equal size in such a way that the edges between most of the sets appear to be nearly random.

One way to study large, finite objects is to pass from sequences of larger and larger such objects to ideal limiting objects. When done properly, properties of the limiting objects reflect properties of the finite objects which approximate them, and vice versa.

Graphons, short for graph functions, are the limiting objects for sequences of large, finite graphs with respect to the so-called cut metric. They were introduced and developed by C. Borgs, J. T. Chayes, L. Lovász, V. T. Sós, B. Szegedy, and K. Vesztergombi in [1] and [3]. Graphons arise naturally wherever sequences of large graphs appear: extremal graph theory, property testing of large graphs, quasi-random graphs, random networks, the thermodynamic limit of statistical physics systems, et cetera.

Let's begin with a few definitions and a motivating example. A *graph* G is a set of vertices $V(G)$ and a set of edges $E(G)$ whose elements are pairs of distinct vertices. A *graph homomorphism* from H to G is a map from $V(H)$ to $V(G)$ that preserves edge adjacency; that is, for every edge $\{v, w\}$ in $E(H)$, the edge $\{\varphi(v), \varphi(w)\}$ is in $E(G)$. Denote by $\hom(H, G)$ the number of homomorphisms from H to G. For example, $\hom(\bullet, G) = |V(G)|$, $\hom(\bullet\!-\!\bullet, G) = 2|E(G)|$, and $\hom(\triangle, G)$ is 6 times the number of triangles in G. Normalizing by the total number of possible maps, we get the *homomorphism density* of H into G,

$$t(H, G) = \frac{\hom(H, G)}{|V(G)|^{|V(H)|}},$$

the probability that a randomly chosen map from $V(H)$ to $V(G)$ preserves edge adjacency. This number also represents the density of H as a subgraph in G asymptotically as $n = |V(G)| \to \infty$. For example, $t(\bullet\!-\!\bullet, G) = 2|E(G)|/n^2$, while the density of edges in G is $2|E(G)|/n(n-1)$; these two expressions are nearly the same when n is large.

Consider the following problem from extremal graph theory:

How many 4-cycles must there be in a graph with edge density at least $1/2$*?*

It is easy to see that there are at most on the order of n^4 4-cycles in any graph with n vertices. A theorem of Erdős says that graphs with at least half the number of possible edges have *at least* on the order of n^4 4-cycles. More precisely, for any graph G,

$$t(\square, G) \geq t(\bullet\!-\!\bullet, G)^4;$$

in particular, if $t(\bullet\!-\!\bullet, G) \geq 1/2$, then $t(\square, G) \geq 1/16$. In light of this, the problem can be reformulated as a minimization one: *Minimize* $t(\square, G)$ *over finite graphs* G *satisfying* $t(\bullet\!-\!\bullet, G) \geq 1/2$. With some work, it can be shown that no finite graph G with $t(\bullet\!-\!\bullet, G) \geq 1/2$ achieves the minimum $t(\square, G) = 1/16$.

It's useful at this point to draw an analogy with a problem from elementary analysis: *Minimize* $x^3 - 6x$ *over rational numbers* x *satisfying* $x \geq 0$. This polynomial has a unique minimum on $[0, \infty)$ at $x = \sqrt{2}$, so the best we can do over the rationals is show that the polynomial achieves values approaching this minimum along a sequence of rationals approaching $\sqrt{2}$. We know well to avoid this complication by completing the rational numbers to the reals and realizing the limit of such a sequence as $\sqrt{2}$.

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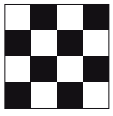
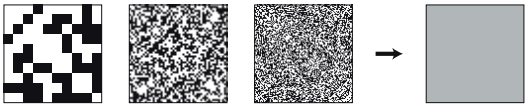
There is a sequence of finite graphs with edge density at least $1/2$ and 4-cycle density approaching $1/16$. Let R_n be an instance of a random graph on n vertices where each edge is decided independently with probability $1/2$. Throwing away those R_n's for which $t(\bullet\!\!-\!\!\bullet, R_n) < 1/2$, the 4-cycle density in the remaining graph sequence converges almost surely to $1/16$. Following the $\sqrt{2}$ analogy, we should look to realize the limit of this sequence of finite graphs and understand how it solves the minimization problem at hand.

What might the limit of this sequence of random graphs $(R_n)_n$ be? From the adjacency matrix of a labeled graph, construct the graph's *pixel picture* by turning the 1's into black squares, erasing the 0's, and scaling to the unit square $[0,1]^2$:

$$\begin{pmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \end{pmatrix} \longrightarrow$$

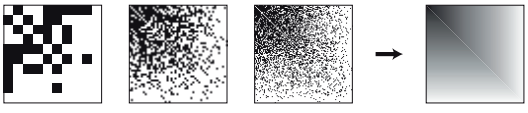


Pixel pictures can be seen to "converge" graphically; those of larger and larger random graphs with edge probability $1/2$, regardless of how they are labeled, seem to converge to a gray square, the constant $1/2$ function on $[0,1]^2$.

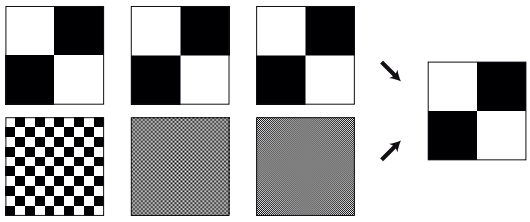


The constant $1/2$ function on $[0,1]^2$ is an example of a labeled graphon. A *labeled graphon* is a symmetric, Lebesgue-measurable function from $[0,1]^2$ to $[0,1]$ (modulo the usual identification almost everywhere); such functions can be thought of as edge-weighted graphs on the vertex set $[0,1]$. An *unlabeled graphon* is a graphon up to relabeling, where a *relabeling* is the result of applying an invertible, measure-preserving transformation to the $[0,1]$ interval. Note that any pixel picture is a labeled graphon, meaning that (labeled) graphs are (labeled) graphons.

As another example of this convergence, consider the *growing uniform attachment* graph sequence $(G_n)_n$ defined inductively as follows. Let $G_1 = \bullet$. For $n \geq 2$, construct G_n from G_{n-1} by adding one new vertex, then including each edge not already in $E(G_{n-1})$ independently with probability $1/n$. It turns out that this graph sequence converges almost surely to the graphon $1 - \max(x, y)$. (Since matrices are indexed with $(0,0)$ in the top left corner, so too are graphons.)



There are two natural ways to label a complete bipartite graph, and each suggests a different limit graphon for the complete bipartite graph sequence. Both sequences of labeled graphons in fact have the same limit, as indicated in the diagram; the reader is encouraged to return to this example after we define this convergence more precisely.



Homomorphism densities extend naturally to graphons. For a finite graph G, the density $t(\bullet\!\!-\!\!\bullet, G)$ can be computed by giving each vertex of G a mass of $1/n$ and integrating the edge indicator function over all pairs of vertices. In exactly the same way, the edge density $t(\bullet\!\!-\!\!\bullet, W)$ of a labeled graphon W is

$$\int_{[0,1]^2} W(x,y)\, dxdy,$$

and the 4-cycle density $t(\square, W)$ is

$$\int_{[0,1]^4} W(x_1,x_2)W(x_2,x_3)\, W(x_3,x_4)W(x_4,x_1)\, dx_1dx_2dx_3dx_4.$$

It is straightforward from here to write the expression for the homomorphism density $t(H, W)$ of a finite graph H into a graphon W. This allows us to see how the constant graphon $W \equiv 1/2$ solves the minimization problem: $t(\bullet\!\!-\!\!\bullet, W) = 1/2$ while $t(\square, W) = 1/16$.

To see the space of graphons as the completion of the space of finite graphs and make graphon convergence precise, define the *cut distance* $\delta_\square(W, U)$ between two labeled graphons W and U by

$$\inf_{\varphi,\psi} \sup_{S,T} \left| \int_{S\times T} W(\varphi(x),\varphi(y)) - U(\psi(x),\psi(y))\, dxdy \right|,$$

where the infimum is taken over all relabelings φ of W and ψ of U, and the supremum is taken over all measurable subsets S and T of $[0,1]$. The cut distance first measures the maximum discrepancy between the integrals of two labeled graphons over measurable boxes (hence the $\square$) of $[0,1]^2$, then minimizes that maximum discrepancy over all possible relabelings. (It is possible to define the cut distance between two finite graphs combinatorially, without any analysis, but the definition is quite involved.)

The infimum in the definition of the cut distance makes $\delta_\square$ well defined on the space of unlabeled graphons, but it is not yet a metric. Graphons W

and U for which $t(H,W) = t(H,U)$ for all finite graphs H are called *weakly isomorphic*; it turns out that W and U are weakly isomorphic if and only if $\delta_\square(W,U) = 0$. The cut distance becomes a genuine metric on the space $\mathcal{G}$ of unlabeled graphons up to weak isomorphism. The examples of pixel picture convergence above provide examples of convergent sequences and their limits in $\mathcal{G}$ (up to weak isomorphism).

We conclude by highlighting a few foundational results about graphons. The accompanying page references are from Lovász's book [2], to which the interested reader is encouraged to refer for more details.

Theorem 1 (Prop. 11.32, p. 185)**.** *Every graphon is the $\delta_\square$-limit of a sequence of finite graphs.*

To approximate a labeled graphon W by a finite labeled graph, let S be a set of n randomly chosen points from $[0,1]$, then construct a graph on S in which the edge $\{s_i, s_j\}$ is included with probability $W(s_i, s_j)$. With high probability (as $|S| \to \infty$), this labeled graph approximates W well in cut distance.

Theorem 2 (Thm. 9.23, p. 149)**.** *The space $(\mathcal{G}, \delta_\square)$ is compact.*

This implies that $(\mathcal{G}, \delta_\square)$ is a complete metric space. Combining this fact with Theorem 1, we see that the space of graphons is the completion of the space of finite graphs with the cut metric! This theorem also demonstrates the way in which graphons provide a bridge between different forms of Szemerédi's Regularity Lemma: Theorem 2 may be deduced from a weak form of the lemma, while a stronger regularity lemma follows from the compactness of $\mathcal{G}$.

Theorem 3 (Lem. 10.23, p. 167)**.** *For every finite graph H, the map $t(H,\cdot) : \mathcal{G} \to [0,1]$ is Lipschitz continuous.*

Theorems 2 and 3 combine with elementary analysis to show that minimization problems in extremal graph theory (such as the one considered above) are guaranteed to have solutions in the space of graphons. These graphon solutions provide "templates," via Theorem 1, for approximate solutions in the space of finite graphs.

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Introducing IST Austria

László Erdős and Robert Seiringer

A few years ago Klosterneuburg, a *gemütlich* small Austrian town near Vienna, was known for its magnificent 900-year-old monastery and the fertile vineyards on the slopes of the Vienna Woods. Since 2009 it has also been the location of a brand new scientific institute, a bold initiative of the Austrian government to foster research and graduate education in the natural sciences. While a large part of the new campus is still under construction and only about one third of the planned research groups are operational, it is already a vibrant intellectual community. Mathematics, as the common denominator of all quantitative sciences, is one of the key areas that anticipate a vigorous expansion in the next few years. In this article we present our new home, the Institute of Science and Technology Austria (IST Austria).

The Mission of IST Austria

IST Austria is a multidisciplinary research institution dedicated to cutting-edge basic research in the natural, mathematical, and computer sciences, both theoretical and experimental. It is not a university in the traditional sense; its focus is on curiosity-driven research and the training of graduate students. The long-term financial commitment from the Austrian federal government and from the state of Lower Austria, as well as the governance and management structures of IST Austria, guarantee the institute's freedom from political and commercial influences.

We believe IST Austria is almost unique in the world; its structure is probably closest to the Weizmann Institute. In fact, Professor Haim Harari, former president of the Weizmann Institute, has played a pivotal role in setting up the concept of IST Austria. The vision was to create a special environment where researchers from different disciplines have much more interaction than at a traditional institute that has separate faculties, departments, and schools.

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To foster a creative and interdisciplinary scientific atmosphere, all hierarchical and separating organizational structures, such as departments, are avoided. The scientists are organized into independent research groups, each headed by a professor or a tenure-track assistant professor.

Jointly designed courses, interdisciplinary seminars, an institute-wide hiring process, and joint social activities bring together mathematicians, physicists, computer scientists, neuroscientists, and biologists. Interdisciplinary research is not required, as scientific excellence is the only criterion for evaluating our performance, but the open environment strongly encourages interactions. The goal is to foster a culture of openness and pass it on to our students. The official language on the whole campus is exclusively English.

Facts and Figures

IST Austria, inaugurated in 2009, was established jointly by the federal government of Austria and the provincial government of Lower Austria. The campus is 18 km from the center of Vienna; the subway is accessible by a special shuttle service as well as with public buses in twenty-five minutes. The first laboratory building was completed in 2010 and the second in 2012. Further buildings are under construction or in the planning phase; our campus can accommodate several more office and lab buildings as well as student housing, sport, and recreational facilities.

For the period from 2007 until 2026, the federal government of Austria will provide up to 1,280 million euros (US $1,750 million) in operational funds. Two thirds of this budget is guaranteed, while the remaining third is conditional on performance-related criteria such as the raising of third-party funds. The state of Lower Austria contributes the budget for construction and campus maintenance, in a total amount of 510 million euros (US $700 million) from 2007 until 2026. By the end of 2013, IST Austria had obtained commitments for more than 36 million euros in research grants, among them fourteen European Research Council grants. We have also received 17 million euros in donations so far.

As of mid-2014, there were twenty-nine independent research groups on campus, with another

four to start in the coming months. Independence is especially attractive for younger scientists in experimental areas; IST Austria gives them the opportunity to build their own labs. The development plan of IST Austria allows for a growth to ninety research groups by 2026; i.e., we plan to hire five to six new faculty members every year in the next decade.

Faculty and Hiring

To keep the hierarchy minimal, there are only two levels of professors. Younger scientists are hired as tenure-track assistant professors, and they can immediately form their research group and supervise postdocs and students. Their promotion to the level of professor with a permanent contract is similar to the tenure procedure at leading US institutions. Research excellence and promise are the exclusive hiring criteria for all scientists at IST Austria.

The institute's choice of scientific topics is based solely on the availability of outstanding individuals. The institute does not allocate a predetermined number of positions to different disciplines, and every faculty member participates in every hiring discussion in a very open style. Currently half of our faculty works in life sciences, followed by computer science as the second most represented area. Mathematics and physics still lag behind, but concentrated efforts in the last two years have improved the balance.

Mathematics at IST Austria

The very first professor on campus was Nick Barton, an eminent British evolutionary biologist with strong connections to mathematics. He was followed by Herbert Edelsbrunner, a very broad Austrian mathematician and computer scientist working in computational geometry and topology. Several new mathematical directions have been established by hiring younger colleagues (Caroline Uhler, mathematical statistics; Uli Wagner, combinatorial geometry) in addition to computer scientists working in cryptography, machine learning, algorithms, and computational fluid dynamics. With the recent hiring of Robert Seiringer (quantum statistical mechanics) and László Erdős (random matrices and disordered systems), mathematical physics and analysis in a broader sense were established. A natural link between the discrete and continuous mathematics is our newest colleague, Jan Maas, working on discrete optimal transportation problems.

While our hiring concept is open to every direction in mathematics and its applications, we strive for a healthy balance and hope to hire colleagues in other key directions such as partial differential equations, probability theory, geometry, or algebra. We envision a development plan where every new colleague feels connected to at least one existing group without duplicating it.

Our mathematics-oriented faculty is well embedded in the interdisciplinary environment of IST Austria via their natural links to biology, computer science, and physics. While an interdisciplinary attitude is always welcome, we fully recognize that several core areas of mathematics do not have a direct interdisciplinary component. In order to promote integrity of mathematics on campus and bring IST Austria onto the world map of the mathematics community, we keep our doors open to excellent mathematicians working in such areas as well.

Opportunities

IST Austria is constantly seeking applications for full professor positions from experienced scientists with high international reputations. Every fall we also have a call for applications on the tenure-track level; a typical applicant is 3–8 years after the PhD and already has an outstanding record of independent research. Since hiring is done on an institute-wide level, attracting many excellent candidates in mathematics is a key to strengthening its presence at IST Austria.

For scientists with fresh PhDs, IST Austria has a centrally financed postdoctoral program, the IST Fellowship. Applications are solicited, with deadlines of March 15 and September 15. The selection is done by a single committee; hence candidates from different disciplines compete.

Our graduate school follows the US admission pattern: we admit students once a year; the application deadline is January 15. Currently we admit about thirty students per year, but the size of the graduate class will increase as IST Austria expands. Students are provided with a generous fellowship for the whole duration of their studies, assuming satisfactory progress.

We have a long-term visitor program with partial financing designed for experienced scientists spending a 3- to 12-month period at IST Austria; this is an opportunity for people on sabbatical.

Finally, we offer an internship program (called ISTernship) for talented and motivated undergraduate students who wish to spend 8–12 weeks during the summer at IST Austria.

In addition to the central programs, every research group has its own research budget (partly allocated from the central budget, partly from third-party fundings). At the discretion of the group leader, this budget can also be used to hire postdocs or to invite visitors.

A more detailed description of these opportunities may be found on our website `www.ist.ac.at`.

Blackwell, Chorin, Kailath Awarded National Medal of Science

On October 3, 2014, President Obama announced the recipients of the National Medal of Science for 2014. Among the ten honorees are three mathematicians: Alexandre J. Chorin, University of California Berkeley; Thomas Kailath, Stanford University; and David Blackwell, University of California Berkeley, honored posthumously.

The Work of Alexandre Chorin

The *Notices* asked Phillip Colella of Lawrence Berkeley Laboratory and James A. Sethian of the University of California Berkeley to comment on the work of Chorin. Colella and Sethian responded: "Alexandre Chorin's work is at the center of the mathematical formulation and algorithmic analysis of computer simulations in fluid dynamics over the past four decades. The wide impact of this work is due to Chorin's invention of algorithms which blend mathematical rigor with a physical insight and a deep attention to practical implementation.

"Beginning with his pioneering work nearly fifty years ago, Chorin developed the key mathematical and algorithmic ideas that underlie many of the most sophisticated, powerful computer codes in everyday practice. His work on artificial compressibility methods and projection methods provided mathematically sound approaches for imposing the key divergence-free constraint for incompressible flows. These methods are an integral part of finite difference and finite element techniques for computing flows for a host of complex applications and are ubiquitous throughout science and industry. His vortex methods are remarkably reliable techniques for computing the complex large transitory fluid structures critical to fluid mixing, wake development, and chemical transport. He was one of the pioneers of the development of high-resolution methods for gas dynamics and combustion, in particular through his work on random choice methods.

"His groundbreaking work continues, with current work on links between statistical physics and optimal prediction of underresolved systems. Chorin has pioneered an approach to problems directed towards finding ways of predicting the evolution of systems whose behavior is not readily analyzed by present computing methods because of lack of data, uncertainty in the equations, intrinsic chaos, computational complexity, and/or multiple scales. These systems include turbulence and many biological systems and are a major challenge for computational science and engineering.

"Chorin's scientific leadership extends beyond his notable research contributions and includes his steadfast commitment to educating the next generation of applied and computational mathematicians. The many scientists he has mentored have greatly benefited from his insight, generosity, and attention."

Alexandre Chorin was born in Warsaw, Poland, in 1938. He received his PhD in mathematics from the Courant Institute of Mathematics at New York University in 1966 under the direction of Peter D. Lax. He served on the faculty there until 1972, when he joined the faculty at Berkeley. He is currently University Professor at Berkeley and a senior scientist at the Lawrence Berkeley National Laboratory.

His awards include the National Academy of Sciences Award in Applied Mathematics and Numerical Analysis (1989); the Norbert Wiener Prize of the AMS and the Society for Industrial and Applied Mathematics (SIAM), (2000); and the Lagrange Prize of the International Council on Industrial and Applied Mathematics (2011). He was coauthor, with J. E. Marsden, of the book A *Mathematical Introduction to Fluid Mechanics* (Texts in Applied Mathematics, Springer, 1993) and, with O. H. Hald,

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of *Stochastic Tools in Mathematics and Science* (Springer, 2013). He is the author of *Vorticity and Turbulence* (Springer, 1994). He is a member of the National Academy of Sciences and a fellow of the American Academy of Arts and Sciences, SIAM, and the AMS.

The Work of Thomas Kailath

The *Notices* asked Roger Brockett of Harvard University to comment on the work of Kailath. Brockett responded: "Tom Kailath is widely known for his work on stochastic processes, communication theory, and applications of signal processing techniques to problems in engineering. In the late 1960s he formulated the innovations conjecture, a key concept in theory of estimation of a stochastic process. The question raised involves how the sigma fields associated with a process consisting of a signal plus additive noise relates to the sigma fields associated with expected value of the process, conditioned on the knowledge of the signal plus noise. This work gave rise to a large literature extending over decades. A second area, where, again, his work cast a long shadow, involves his extension of Levenson's work on the efficient solution of finite-dimensional Toeplitz systems. These systems arise in signal processing and, in particular, in the implementation of least-squares estimation procedures originating with Wiener. Kailath continued the investigation of fast algorithms, taking the subject in other directions involving low rank perturbations of matrices and so forth. Initially, the manufacture of integrated circuits involved the repeated exposure of photosensitive materials to light, using various masks to realize specific patterns. As the scale of the structures became smaller, the wavelength of light posed an obstacle. Kailath and his collaborators developed procedures based on Fourier analysis to overcome these limitations and worked with industry to implement practical manufacturing procedures. Kailath's PhD thesis at the Massachusetts Institute of Technology was devoted to the study of fading channels as they occur in communications. This work gained him a reputation of a rising star. Throughout his career at Stanford he has had a great influence on future generations through his textbooks and his work with students and postdoctoral fellows."

Thomas Kailath was born in Pune, India, in 1935. He received his PhD in electrical engineering from the Massachusetts Institute of Technology in 1961. He was employed at the Jet Propulsion Laboratory in Pasadena before joining the faculty of Stanford University in 1963. In 2007 he was awarded the Medal of Honor of the Institute of Electrical and Electronics Engineers (IEEE). He has also received the IEEE Jack S. Kilby Signal Processing Medal (2006) and Donald G. Fink Prize Paper Award (1996), as well as the Padma Bhushan, a high civilian award of the Government of India. He has been a fellow of the IEEE since 1970 and is a member of the US National Academy of Engineering (NAE), the National Academy of Sciences (NAS), the American Academy of Arts and Sciences (AAAS), the Indian National Academy of Engineering, and the Silicon Valley Engineering Hall of Fame.

The Work of David Blackwell

The *Notices* asked Peter Bickel of the University of California Berkeley to comment on the work of Blackwell. Bickel responded: "David Blackwell's National Medal of Science was awarded posthumously, apparently the very first such medal awarded after the recipient's death was known. Blackwell died on July 8, 2010, at the age of ninety-one. At the time of his death he was Professor Emeritus of Statistics and Mathematics at the University of California Berkeley. He was one of the foremost mathematical scientists in the world, contributing to mathematical statistics, probability theory, game theory, information theory, and mathematical logic. His work made a significant impact on these disciplines, as well as on economics, engineering, medicine, and other sciences.

"In statistics he is known for the Rao-Blackwell improvement scheme, for helping to lay the foundations of dynamic programming, and, with Arrow and Girshick, for applying the backward induction method to prove the fundamental theorem of sequential analysis. In a final major contribution, he asked: When can one statistical experiment be more informative than another? He defined this concept and provided a simple, necessary, and sufficient condition for experiments to satisfy this definition. This beautiful piece of mathematics has become one of the pillars of the current decision-theoretic approach to mathematical statistics.

"In probability, Blackwell is best known for the Blackwell renewal theorem, a key tool in queueing theory. In information theory, he contributed the Blackwell channel. In game theory, he was among the first to deal with games with imperfect information. This led to his interest in mathematical logic, to which he added Blackwell games.

"Blackwell's active career, from 1941 to 1988, was belatedly recognized with well-deserved honors: election to the National Academy of Sciences (1965) and the American Academy of Arts and Sciences (1968), with twelve honorary doctorates, and with other honors and prizes.

"His talents were recognized early but, because he was African American, the beginning of his career was harder than it should have been. To take one example of many, when he was a Fellow at the Institute for Advanced Studies, his thesis advisor, Joe Doob, had to intervene to ensure him privileges at Princeton University, which were normally granted to fellows of the Institute.

"Blackwell was a marvelous teacher. His lucid expositions made difficult ideas seem simple and clear. His students testified to this in "A tribute to David Blackwell", *Notices* **58** (2011), 912–928. With his students, colleagues, family, and friends, he was a man of exceptional kindness, wit, charm, and playfulness.

"David Blackwell deserved the National Medal of Science in his life. We celebrate the man himself and his mathematical work. We regret that he is not here with us to enjoy the honor."

David Blackwell was born in Centralia, Illinois, in 1919 and received his PhD from the University of Illinois at Urbana-Champaign in 1941 at the age of twenty-two. He held a fellowship at the Institute for Advanced Study in 1941–1942. He held positions at Southern University (1942–1943), Clark College (1943–1944), and Howard University (1944–1954). He went to Berkeley as a visiting professor in 1954 and became full professor in the statistics department in 1955. His book *Basic Statistics* (McGraw-Hill, 1969) was one of the first textbooks on Bayesian statistics. He received the John von Neumann Theory Prize in 1979, the R. A. Fisher Lectureship in 1986, and the Berkeley Citation in 1988. He served as president of the Institute of Mathematical Statistics in 1956 and vice president of the American Statistical Association in 1978. He is a member of the National Academy of Sciences (1965) and the American Academy of Arts and Sciences (1968) and an honorary fellow of the Royal Statistical Society (1976).

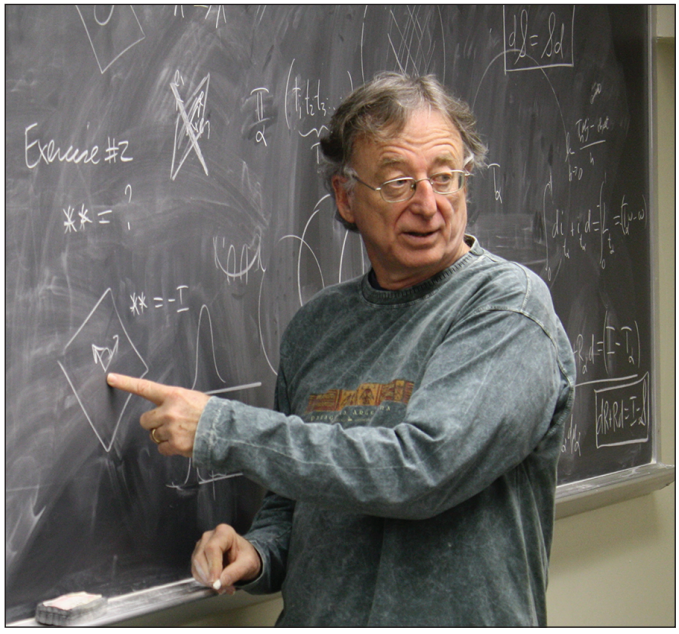
About the Medal

The National Medal of Science is the country's highest distinction for contributions to scientific research. According to a news release from the Office of Science and Technology Policy, "the National Medal of Science honors individuals for pioneering scientific research in a range of fields, including physical, biological, mathematical, social, behavioral, and engineering sciences, that enhances our understanding of the world and leads to innovations and technologies that give the United States its global economic edge." The National Science Foundation administers the award, which was established by Congress in 1959.

— Elaine Kehoe

Sullivan Awarded Balzan Prize

DENNIS SULLIVAN of the State University of New York at Stony Brook and the City University of New York has been awarded the International Balzan Prize for his "major contributions to topology and the theory of dynamical systems, opening new perspectives for generations to come" and for his "exceptional results in many fields of mathematics, such as topology, geometry, the theory of Kleinian groups, analysis and number theory." The Balzan Prizes are awarded to scholars, artists, and scientists who have distinguished themselves in their fields on an international level. The cash prize is 750,000 Swiss francs (approximately US$800,000). Sullivan was presented with the prize by the president of the Italian Republic during a ceremony held in Rome, Italy, on November 20, 2014.



Dennis Sullivan

The Work of Dennis Sullivan

The Balzan Foundation provided the following information about the work of Dennis Sullivan.

Algebraic topology is the study of topology using algebraic tools. The theory is particularly useful when algebra allows a complete description of topology.

At the beginning of his career, Dennis Sullivan was one of the main proponents of (mathematical!) surgery theory. He made a fundamental contribution to the *Hauptvermutung*, which concerns the different ways of triangulating space. He also obtained a complete classification of simply connected high-dimensional manifolds, for which the homotopy type is known. His article "Genetics of homotopy theory and the Adams conjecture" represents a remarkable step forward.

Later, he developed (along with Quillen) rational homotopy theory, which is one of the mathematical gems of the twentieth century. A purely algebraic structure—Sullivan's minimal model—makes it possible to completely reconstruct the rational homotopy type of a space. *Infinitesimal Computations in Topology* is one of the most important texts on algebraic topology in the twentieth century, of similar stature to Poincaré's seminal paper "Analysis Situs."

In the second part of his career, Sullivan transformed the theory of dynamical systems. The study of complex dynamics, initiated by Fatou and Julia at the beginning of the twentieth century, had been neglected until Sullivan applied and developed useful, "quasiconformal" tools from harmonic analysis. The theory was revolutionary. Among his other work on this theme, his "Nonwandering Theorem," with its magnificent proof, is particularly notable.

Sullivan has an overall unitary vision of mathematics. For example, the concept of the Sullivan Dictionary provides parallels for theories that might seem far apart, for example, the dynamics of rational fractions and Kleinian groups. At the end of the 1970s, the physicists Coullet-Tresser and Feigenbaum conceptualized the phenomenon of universality in the transition towards chaos. Sullivan succeeded in placing the problem in an appropriate context, thanks in particular to analogies with non-Euclidean geometry. The proofs for general forms of the renormalization conjectures followed the pattern of Sullivan's universality results on the period doubling cascade.

He is currently working on topological field theory and formalism in string theory. Once again, he is concerned with understanding the nature of space through the power of algebra. For example, with Moira Chas, he developed the field of "string topology." His universal vision of mathematics has led to an interest in fluid dynamics, to which he takes an extremely original approach.

Above and beyond his results and discoveries, Dennis Sullivan has a unique talent for animating research and inspiring enthusiasm in young people. He has discovered vast territories, most of which remain to be explored. His influence on the community of mathematicians has been enormous.

Biographical Sketch

Dennis Parnell Sullivan was born in Port Huron, Michigan, on February 12, 1941. He received his PhD in mathematics from Princeton University in 1966. He has been a NATO Fellow at Warwick University (1966), an instructor at Princeton University (1966–1967), a Miller Fellow at the University of California Berkeley (1967–1969), and a Sloan

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Fellow at the Massachusetts Institute of Technology (1969–1973). From 1973 to 1974 he was associate professor at the University of Paris-Orsay and in 1974 was appointed professor at the Institut des Hautes Études Scientifiques (IHES). In 1981 he was appointed to the Einstein Chair at the City University of New York, where he worked jointly with the IHES until 1996. He is currently Albert Einstein Professor of Science and Distinguished Professor of Mathematics at the City University of New York Graduate School and University Center and professor of mathematics at Stony Brook University.

Sullivan was awarded the U.S. National Medal of Science in 2005 and the AMS Steele Prize for Lifetime Achievement in 2006. His other honors include the Oswald Veblen Prize in Geometry (1970), the Elie Cartan Prize in Geometry (1981), the King Faisal International Prize for Science (1994), the Gold Medal of the Brazilian Academy of Sciences (1996), and the Wolf Prize for Mathematics (2010).

He is a member of the U.S. National Academy of Sciences and the New York Academy of Sciences, a fellow of the American Academy of Arts and Sciences, a corresponding member of the Brazilian National Academy of Sciences and the Irish Royal Society, and an honorary member of the London Mathematical Society. He served as vice president of the American Mathematical Society from 1990 to 1993 and was elected a Fellow of the AMS in 2012.

Also receiving the Balzan Prize in 2014 is IAN HACKING, a philosopher who has written about the philosophy of mathematics, including in his latest book, *Why Is There Philosophy of Mathematics at All?* (Cambridge University Press, 2014).

About the Prize

The International Eugenio Balzan Prize Foundation was established in 1956 by Lina Balzan, who had come into a considerable inheritance on the death of her father, Eugenio, and began the foundation to honor his memory. The aim of the International Balzan Prize Foundation is to promote culture, the sciences, and the most meritorious initiatives in the cause of humanity, peace, and brotherhood among peoples throughout the world. Currently, four annual awards are made: two in literature, moral sciences, and the arts and two in the physical, mathematical, and natural sciences and medicine. The award fields vary each year and can be related to either a specific or an interdisciplinary field; they look to go beyond the traditional subjects, both in the humanities (literature, moral sciences, and the arts) and in the sciences (medicine and the physical, mathematical, and natural sciences). They give priority to innovative research. Half of the amount received by the winner of each of the four prizes must be destined for research work, preferably involving young scholars and researchers.

— From Balzan Foundation announcements

Chris Stevens Joins AMS Executive Staff

Allyn Jackson

In August 2014, the AMS had the great pleasure of welcoming T. Christine Stevens as a member of the executive staff. Universally known as Chris, she embodies a rare combination of experience and personal qualities that make her ideally suited to her new post. The AMS is also fortunate to retain the experience and skill of Chris's predecessor, Ellen Maycock, who has shifted to part-time status, in advance of her retirement, and who will work on specific projects.

"The AMS is delighted to have Chris Stevens joining the staff," said AMS Executive Director Donald McClure. "She is an outstanding member of the mathematical community whose achievements have been recognized by the whole community and by many awards. She brings tremendous experience, insight, and expertise to the position, and her energy and enthusiasm are infectious. She will be a great asset to the Society."

Chris is the AMS associate executive director for Meetings and Professional Services, which, as she put it, is "such a long title that it conveys no information at all." This remark exhibits her characteristic subversive humor; almost any conversation with Chris is bound to be laced with laughter. Her light-hearted side coexists easily with her gravitas: Profoundly committed to mathematics and the mathematical community, Chris possesses keen insights into all aspects of the mathematics profession.

Chris is no doubt best known for her leadership of Project NExT, a longstanding and highly successful program sponsored by the Mathematical Association of America (MAA). In the spring of 1993, while Chris was a visiting mathematician at the MAA, James R. C. Leitzel brought up the idea of a conference for new PhDs who were interested in teaching issues. This was the starting point for Project NExT. The name, an acronym for "New Experiences in Teaching", evokes the idea of preparing the "next generation" of mathematics faculty. Chris directed Project NExT jointly with Leitzel from 1994 until his death in 1998. Chris then served as director from 1998 until 2009.

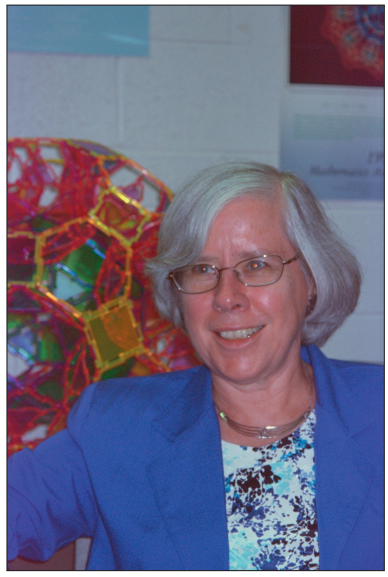

Photo courtesy of T. Christine Stevens.

T. Christine Stevens

"What Project NExT does is to welcome new PhDs into the mathematical community," Chris explained. The program helps young mathematicians successfully make the transition from graduate student to full-time faculty member. While attention is paid to research and scholarship, the main focus of Project NExT is excellence in teaching. One of its key features is a national network of peers, through which Project NExT Fellows can discuss the challenges they face, share ideas, and support each other. "They are all going through the same things: trying to teach a course they've never taught before—or trying to teach a course they've never even taken!" Chris said. "Part of what makes Project NExT work is this vibrant network." Some Fellows stay in touch over many years; indeed, there is still activity in the peer network of the initial Project NExT group of twenty years ago.

Several societies sponsor Project NExT Fellows; the AMS has been supporting six Fellows every year

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since 2001. To date, Project NExT has reached a total of 1,560 young mathematicians. Many of them have become national leaders and have helped to energize mathematical life and teaching across the country. Project NExT has also had an impact by serving as an existence proof of the great benefits of careful mentoring and support of young people entering the profession. For example, the success of Project NExT was surely an encouragement to the AMS when it launched the Mathematics Research Communities (MRC) program. Each year MRC hosts a set of research conferences aimed at young mathematicians, with the goal of helping them to build collaborations to sustain their research as they move through their careers. (Although MRC is in Chris' division at AMS, Ellen Maycock will continue to oversee the program.)

In 2004, Chris received the MAA's highest award for service, the Gung and Hu Award for Distinguished Service to Mathematics, primarily for her work on Project NExT. Her outstanding teaching has been recognized by the MAA's Haimo Award for Distinguished College and University Teaching (1997). An alumna of Smith College, she was awarded the Smith College Medal in 2010. She was among the inaugural class of AMS Fellows named in 2012. In October 2014, the Association for Women in Mathematics announced that Chris would receive the 2015 Louise Hay Award for Contributions to Mathematics Education.

Chris earned her PhD in 1978 from Harvard University, under the direction of Andrew Gleason. After faculty positions at Mount Holyoke College and Arkansas State University, she settled at Saint Louis University, where she worked for twenty-five years, five of them as chair of the Mathematics and Computer Science Department. Chris's interest in policy and administrative matters led her to serve as the AMS/MAA/SIAM Congressional Science Fellow (1984–1985). In addition, she was a rotator at the National Science Foundation, serving during 1987–89 as a program director in the Teacher Enhancement Program. She has served extensively in professional organizations, for example on the AMS Council (2011–2014) and the AMS Committee on Science Policy (2011–2014). Currently, she chairs the MAA's Council on Prizes and Awards and is a member of the MAA Board of Governors.

In the past couple of years, Chris has been involved in the response of the mathematical community to *Engage to Excel*, a 2012 report of the President's Council of Advisors on Science and Technology (PCAST). The report caused controversy by suggesting, among other things, that college mathematics courses would be better taught by nonmathematics faculty. Chris was one of eight leaders in the mathematical community who signed a statement about the PCAST report that appeared in the October 2012 issue of the *Notices*. "The PCAST report made many useful points, but it was also a real wake-up call for the mathematical community," Chris said. "Many scientists are unaware of all the good work that we have been doing to improve undergraduate mathematics education. We need to showcase our achievements in providing effective teaching, and we need to share our experience that there is no single approach that will work for all students and all instructors at all institutions. On the other hand, there are some serious issues in mathematics instruction that must be addressed, if we are going to reach the goals set forth in the PCAST report, and they will require resources and hard work."

Chris's interest in education, policy, and administration has been the main focus of her career, but it has not eclipsed her research. A noted scholar in topological groups, she supervised two PhD theses, and her most recent research paper was published this year. Also this year, she spent five months at the Universidad Complutense de Madrid as a Fulbright Senior Researcher. The demands of her AMS position probably mean she will now have less time for research, but she hopes to keep at it."I'm not going cold turkey on research," she said.

The fit between the needs of the AMS and Chris's experience and interests is just about perfect. In describing what she will be doing at the AMS, Chris noted the various ways mathematicians interact with the Society. One of the main ones is through "print and pixels"—that is, through books, journals, and online services like MathSciNet. Other ways mathematicians interact with the AMS come under the heading of "activities and programs": meetings, travel grants, fellowships such as the Centennial Research Fellowships, and so on. These are the kinds of things Chris will oversee.

"One of the roles of professional organizations is to do things that mathematicians can't do individually but can do collectively, like publishing books or holding meetings," she said. "A second role is to be the public face of mathematics and to articulate to the government and to society at large the importance, significance, and beauty of mathematics and the importance of mathematics education. I see the AMS as one of a group of mathematical professional organizations that contributes to these activities, and I'm looking forward to playing a role in its efforts."

Mathematical Sciences Center
Tsinghua University, Beijing, China

Positions:

Distinguished Professorship; Professorship;
Associate Professorship;
Assistant Professorship (tenure-track).

The MSC invites applications for the above positions in the full spectrum of mathematical sciences: ranging from pure mathematics, applied PDE, computational mathematics to statistics. The current annual salary range is between 0.15-1.0 million RMB. Salary will be determined by applicants' qualification. Strong promise/track record in research and teaching are required. Completed applications must be electronically submitted, and must contain curriculum vitae, research statement, teaching statement, selected reprints and /or preprints, three reference letters on academic research and one reference letter on teaching, sent electronically to msc-recruitment@math.tsinghua.edu.cn.

The review process starts in December 2014, and closes by April 30, 2015. Applicants are encouraged to submit their applications before December 15, 2014.

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Positions: post-doctorate fellowship

Mathematical Sciences Center (MSC) will hire a substantial statistics, number of post-doctorate fellows in the full spectrum of mathematical sciences. New and recent PhDs are encouraged for this position.

A typical appointment for post-doctorate fellowship of MSC is for two-years, renewable for the third years. Salary and compensation package are determined by qualification, accomplishment, and experience. MSC offers very competitive packages.

Completed applications must contain curriculum vitae, research, statement, teaching statement, selected reprints and/or preprints, three reference letters with referee's signature, sent electronically to msc-recruitment@math.tsinghua.edu.cn

The review process starts in December 2014, and closes by April 30, 2015. Applicants are encouraged to submit their applications before December15, 2014.

Tsinghua Sanya International Mathematics Forum (TSIMF)
Call for Proposal

We invite proposals to organize workshops, conferences, research-in-team and other academic activities at the Tsinghua Sanya International Mathematics Forum (TSIMF).

TSIMF is an international conference center for mathematics. It is located in Sanya, a scenic city by the beach with excellent air quality. The facilities of TSIMF are built on a 140-acre land surrounded by pristine environment at Phoenix Hill of Phoenix Township. The total square footage of all the facilities is over 28,000 square meter that includes state-of-the-art conference facilities (over 9,000 square meter) to hold two international workshops simultaneously, a large library, a guesthouse (over 10,000 square meter) and the associated catering facilities, a large swimming pool, two tennis courts and other recreational facilities.

Because of our capacity, we can hold several workshops simultaneously. We pledge to have a short waiting period (6 months or less) from proposal submission to the actual running of the academic activity.

The mission of TSIMF is to become a base for scientific innovations, and for nurturing of innovative human resource; through the interaction between leading mathematicians and core research groups in pure mathematics, applied mathematics, statistics, theoretical physics, applied physics, theoretical biology and other relating disciplines, TSIMF will provide a platform for exploring new directions, developing new methods, nurturing mathematical talents, and working to raise the level of mathematical research in China.

For information about TSIMF and proposal submission, please visit: http://msc.tsinghua.edu.cn/sanya/ or write to Ms. Yanyu Fang yyfang@math.tsinghua.edu.cn.

Writing a Teaching Statement

James Oxley

This note is addressed to a mathematics graduate student who has been asked to write a Teaching Statement. Almost all academic jobs will require you to teach. Many will require you to do research too. But you will have preprints and talks and several letters to attest to your research abilities as well as a research statement laying out your future goals. By comparison, you will probably have just one letter commenting on your classroom performance, and even that may not be based on an actual observation of your teaching. In addition, you will have a cover letter, which you'll probably want to tailor to the particular job for which you are applying. You may also have some teaching evaluations, and you will have a Teaching Statement. This Teaching Statement is your chance to convince a potential employer that, out of the hundreds of applicants, you should be chosen to get a phone call or, even better, an on-campus interview. Your Teaching Statement is your opportunity to transport a potential employer into your class to see you in action, to see what you do and how you do it, and to understand what is driving your actions and your choices. Writing something as compelling as this sounds hard, doesn't it? Is teaching any easier? Do you really want that job?

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A Teaching Statement is sometimes referred to as a "statement of teaching philosophy," and this description captures the purpose of the statement. Your Teaching Statement should not include a detailed listing of your teaching experiences. That belongs in a section in your vita entitled "Teaching Experience." Fundamentally, in writing a Teaching Statement, you are being asked to describe what you are aiming to achieve with a class and how you will go about achieving these goals. Since you will be teaching mathematics, part of the statement should address how you view mathematics and how that influences what and how you teach.

I urge all writers of Teaching Statements not to look at other such statements prior to writing their own. Once you have read some examples of these statements, your chances of writing something personal are dramatically reduced. It is very easy for a Teaching Statement to look as if it has been copied from a how-to-teach manual and, as a result, to appear generic and insincere. I encourage the writers of Teaching Statements to think, in big-picture terms, about several questions, which appear below. Each needs to be answered in sufficient generality that the answer will cover all classes the writer may be required to teach. I have deliberately refrained from trying to guide the direction of your writing by being very specific in what I have asked. My hope is that this will result in you producing a more personal and original statement than you otherwise might. In this, as in the research domain, novelty attracts attention.

It is always helpful to have done some teaching prior to writing a Teaching Statement, since a

complete lack of experience makes you unaware of many of the important issues. In the event that you are called upon to write such a statement when you have done little or no teaching, my advice is to think in terms of modeling your teaching style after those of your most effective teachers, answering these questions from that perspective.

- What are the most important things I want my students to take from my course?
- What role do the students play in my classroom?
- How do I view the role of mathematics within a college education, and how does this view translate into what and how I teach?
- What general techniques do I use to ensure that my students are able to achieve the targets I have set for them for the course?
- Is there a brief anecdote that I can include from my own experience that captures the spirit of what I am trying to achieve with a class or why I want to be a mathematics teacher?

Concerning the last of these, you may not have had an experience that you feel warrants recounting in your Teaching Statement. In that case, do not try to give some minor incident disproportionate weight. It will look contrived, and you will damage your credibility.

I take it as axiomatic that you are thoroughly prepared for each class and that you know your subject well. Even in this context, there will be times when you make mistakes or get confused. What lesson will your students learn from how you handle these situations?

When writing your Teaching Statement, be aware that you are not writing up a high school science experiment where you studiously try to remain objective. Instead, you are offering a very personal reflection, and doing this may make you feel uncomfortable as you confront the potential for humiliation. Will you be any less vulnerable when you are teaching?

The usual length of a Teaching Statement is one page. A prospective employer may well not finish something longer, while anything that is too short conveys the impression that you have not thought enough about the whole process of teaching. Every time you teach a class, you have to make a multitude of decisions about what to include and what to omit. In preparing your Teaching Statement, you are faced with a similar array of decisions. If you are unable to prioritize your thoughts on teaching and to condense them into a single page, what does that say about your ability to teach?

In writing your Teaching Statement, it is important to avoid making sweeping assertions about what all good teachers do. Given your lack of teaching experience relative to potential readers of your statement, such pronouncements can easily produce a negative response. Instead, say what it is that you try to do with a class and why you do things this way. A well-justified methodology is unlikely to offend even a reader who does things differently. Your Teaching Statement may address how particular experiences have influenced your current thinking on teaching. It should not consist solely of a description of class procedures. Nor should it be overloaded with accounts of specific personal experiences. Your Teaching Statement needs to be a skillful blend of **what** you are trying to achieve and **how** you go about achieving those things. A statement that leans too heavily toward a purely philosophical discussion of teaching will not convince the reader of your ability to deal with the practicalities of teaching.

Try to avoid overused sayings, which inevitably grate, or simplistic statements of the obvious. For the latter, suppose we agree that everyone likes apple pie. If I write "my students like apple pie," a reader learns nothing and, worse still, is potentially insulted. But if I write, "because my students like apple pie, I structure my lesson so that …," then I am saying to the reader that we both recognize my students' need for apple pie and that I have a plan to address this need.

Your statement should be well written and free of both grammatical and typographical errors. Read it aloud to ensure that it flows smoothly and sounds plausible. Because writing your Teaching Statement will severely test your language skills, particularly if English is not your first language, I recommend getting feedback from an experienced mentor as you progress through what may be several drafts. When I act in this role, I am very conscious of not taking over the writing. Rather, I try to help the writers to crystallize their ideas and then to express them clearly.

While readers of your statement may only scan it, they are likely to look at the beginning and the end, so you should pay particular attention to ensuring that each of these contains a strong, succinct summary of your teaching philosophy. Overall, you are trying to project yourself through your statement into the room with the reader. Your Teaching Statement should be an honest, deeply considered document that is a genuine reflection of what you think about a task that will consume at least half of your working life, and it should convey to the reader a powerful sense of what it is like to be one of your students.

Alternative Approaches

Helen Grundman has written a very concrete guide [1] to preparing a Teaching Statement that includes a number of exercises designed to help with this task. Indeed, her first exercise asks a number of

questions that are very similar to the bullet-point questions I have asked above. Moreover, she and I agree on the importance of originality in your statement. As she says, "Try to make your teaching philosophy statement unique to you." But we have some basic disagreements on how to achieve this aim. She gives some very specific suggestions of common teaching goals, and she advocates having discussions with peers in addition to reading 15–25 Teaching Statements of others. This approach exposes you to a broad range of thoughts and then asks you to prioritize these, incorporating the most important ones into your own statement. Some readers may find this approach preferable to the one I have suggested above. Both approaches require prolonged consideration of what you try to do in the classroom and how you try to do it.

Gabriela Montell talked to dozens of professors and administrators to learn what they look for in a statement of teaching philosophy, and she summarized her findings in an article in *The Chronicle of Higher Education* [3]. Her article is not aimed specifically at mathematicians, but most of its advice is universal. One point where a mathematician may depart from the advice given in her article relates to varying your Teaching Statement for different types of teaching institutions. I feel that the main principles of your teaching philosophy should be sufficiently robust that they encompass all of the environments in which you will be asked to teach. Specific demands of particular institutions can be addressed in your cover letter. Reading Montell's article will not unduly harm your ability to maintain a unique perspective and will probably help you to write a better Teaching Statement, particularly if you heed the advice that heads her last section "Just Be Yourself."

Acknowledgments

I thank Jimmie Lawson, Bogdan Oporowski, Judith Oxley, Geetanjali Soni, and several anonymous referees for helpful suggestions offered during the preparation of this note. My own writing, and that of many others, has been profoundly influenced by Halmos's famous paper on how to write mathematics [2]. I strongly encourage all mathematics graduate students to read that paper and to reflect on the guidance it gives.

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[1] Helen G. Grundman, Writing a teaching philosophy statement, *Notices Amer. Math. Soc.* **53** (2006), 1329–1333.

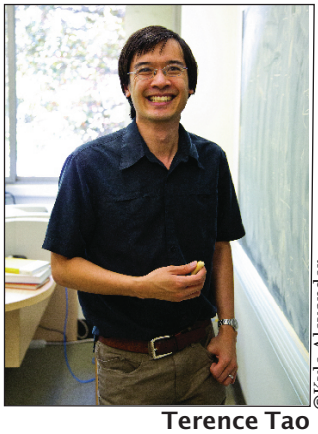
[2] P. R. Halmos, How to write mathematics, *Enseignement Math. (2)* **16** (1970), 123–152.

[3] Gabriela Montell, How to write a statement of teaching philosophy, *The Chronicle of Higher Education*, March 27, 2003, chronicle.com/article/How-to-Write-a-Statement-of/45133.

Mathematics People

Tao Awarded Royal Medal

TERENCE TAO of the University of California Los Angeles has been awarded the 2014 Royal Medal for Physical Sciences by the Royal Society of London "for his many contributions to math, including those in harmonic analysis, prime number theory, partial differential equations, combinatorics, computer science, statistics, representation theory, and much more".



Terence Tao

Tao was awarded the Fields Medal in 2006 and a Breakthrough Prize worth US$3 million in 2014. Among his many honors and awards are the Salem Prize (2000), the AMS Bôcher Prize (2002) and Conant Award (2005), the Clay Research Award (2003), the SASTRA Ramanujan Prize (2006), the Ostrowski Prize (2007), the National Science Foundation Waterman Award (2008), the King Faisal International Prize (2010), and a MacArthur Fellowship (2007–2011).

The Royal Society, based in London and founded in 1660, is the oldest scientific academy in continuous existence. The organization awards three Royal Medals each year in the physical, biological, and applied sciences.

—Elaine Kehoe

Lipton Awarded Knuth Prize

RICHARD J. LIPTON of the Georgia Institute of Technology has been named the recipient of the 2014 Donald E. Knuth Prize for inventing new computer science and mathematical techniques to tackle foundational and practical problems in a wide range of areas in graph algorithms, computation, communication, program testing, and DNA computing.

According to the prize citation, "Together with ACM A. M. Turing Award winner Robert Tarjan, Lipton developed the planar separator theorem. It shows that a small number of intersections can be efficiently found in any road network, which, when removed, will split the network into disconnected pieces of at most half its original size. This operation facilitates a very efficient 'divide and conquer' approach to solving problems on such networks by breaking down a problem into two or more subproblems of the same or related type.

"Lipton pioneered the design of algorithms that make random choices in order to solve computational problems, particularly as a way to test programs. He confronted the 'chicken and egg' problem that can occur when building software designed to solve a complex problem: how to check the answers that a program produces without a way to compute the correct answers. In solving complex algebraic problems, Lipton showed that it was sufficient to check a program by running it against itself on randomly chosen but related inputs and comparing the results for consistency.

"Working with another ACM Turing Award recipient, Richard Karp, Lipton developed a fundamental theorem in circuit complexity. It demonstrated that NP-complete problems are unlikely to be efficiently solved by the best of algorithms even when given specially designed hardware. This critically important class of problems in computational complexity is the subject of intensive research. A purely algorithmic solution to this problem has long been the holy grail of computer science and is the object of a million-dollar challenge from the Clay Mathematics Institute.

"Lipton was an early developer of communication complexity, the study of the number of bits of communication needed for agents to solve computational tasks. He and his coauthors developed a multiparty version based on analogues of 'hat puzzles' in recreational mathematics. This work showed its relevance for understanding the complexity of computations and gave surprising solutions to the problems that arise. Lipton is also one of the original pioneers in DNA computing, which uses the combination and replication of the vast numbers of DNA strands that fit in a test tube as a basis for parallel computation."

The Knuth Prize, named in honor of Donald E. Knuth of Stanford University, is given every eighteen months by the Association for Computing Machinery (ACM) Special Interest Group on Algorithms and Computation Theory (SIGACT) and the Institute of Electrical and Electronics Engineers (IEEE) Technical Committee on the Mathematical Foundations of Computing. It carries a cash award of US$5,000.

—From an ACM announcement

Mirzakhani and Scholze Receive Clay Research Awards

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Maryam Mirzakhani

MARYAM MIRZAKHANI of Stanford University and PETER SCHOLZE of the University of Bonn have been selected to receive 2014 Clay Research Awards by the Clay Mathematics Institute (CMI).

Mirzakhani was recognized for her many and significant contributions to geometry and ergodic theory, in particular to the proof of an analogue of Ratner's theorem on unipotent flows for moduli of flat surfaces. She was awarded a Fields Medal this year.

Scholze was honored for his many and significant contributions to arithmetic algebraic geometry, particularly in the development and applications of the theory of perfectoid spaces. He was appointed a Clay Research Fellow for a term of five years in 2011 and received the 2013 SASTRA Ramanujan Prize.

The CMI presents Clay Research Awards annually to recognize major breakthroughs in mathematical research.

—From a CMI announcement

AWM Hay and Humphreys Awards Announced

T. CHRISTINE STEVENS, associate executive director of the AMS and formerly of St. Louis University, has been chosen the recipient of the Louise Hay Award of the Association for Women in Mathematics (AWM). She was cofounder and codirector (with James R. C. Leitzel) of Project NExT (New Experiences in Teaching), a program of the Mathematical Association of America (MAA) that helps new faculty members transition into full-time teaching. She served as the program's sole director from 1998 to 2009. She has made numerous contributions to mathematics education as an AMS/MAA/SIAM Congressional Science Fellow, as chair of the MAA's Science Policy Committee, and as a member of the Society for Industrial and Applied Mathematics (SIAM) Science Policy Committee and the MAA Committee on Minority Participation in Mathematics. She has also served as an associate program director for the Teacher Enhancement Program at the National Science Foundation (NSF). She received her PhD from Harvard University. The Louise Hay Award recognizes outstanding achievements in any area of mathematics education.

RUTH HAAS of Smith College has been selected as the recipient of the AWM M. Gweneth Humphreys Award. According to the prize citation, Haas "has nurtured and supported a generation of women mathematics students at Smith. An impressive alumnae body attests enthusiastially to the crucial role Haas played in their decision to major in mathematics, attend graduate school, and ultimately pursue careers in the mathematical sciences." She was instrumental in establishing the Center for Women in Mathematics and the postbaccalaureate program at Smith, as well as an undergraduate research course, the annual Women in Mathematics in the Northeast conference, and other programs. The award recognizes the commitment to and influence of M. Gweneth Humphreys on undergraduate students of mathematics.

—From AWM announcements

Godin Receives 2014 CMS Graham Wright Award

SHAWN GODIN of Cairine Wilson Secondary School, Ottawa, Ontario, has been named the recipient of the 2014 Graham Wright Award for Distinguished Service by the Canadian Mathematical Society (CMS). Godin has contributed to provincial tests, served as a mathematics consultant, written and reviewed district-wide exams, and consulted on math texts. Working with universities, he helped establish university and high school dialogues and to craft mathematics competitions and math camps. He has also worked with the Ontario Ministry of Education to create technology-based activities and provide support materials for students and teachers implementing changes to the mathematics syllabus.

The Graham Wright Award for Distinguished Service is presented annually to an individual who has made significant contributions to the Canadian mathematics community and in particular the CMS.

—From a CMS announcement

Thamwattana Awarded 2014 Michell Medal

NGAMTA (NATALIE) THAMWATTANA of University of Wollongong has been awarded the 2014 J. H. Michell Medal of the Australian Mathematical Society for work that involves the interaction of atomic and molecular nanostructures, producing accurate and simply expressed analytical results for calculations that had previously been

attempted only by numerical methods. The award is given for distinguished research in applied and/or industrial mathematics, with a significant proportion of the research work having been carried out in Australia and/or New Zealand.

—From an ANZIAM announcement

NCTM Lifetime Achievement Awards

The National Council of Teachers of Mathematics (NCTM) has presented Mathematics Education Trust (MET) Lifetime Achievement Awards for Distinguished Service to Mathematics Education to MIRIAM A. LEIVA, University of North Carolina, Charlotte, and CHRISTIAN R. HIRSCH, Western Michigan University. Leiva was the founding president of TODOS: Mathematics for All. According to the prize citation, "she has been an avid, persuasive spokesperson on issues that affect the mathematics achievement of all students and in particular of Latino/a students in the United States. She is recognized as that rare person who makes everyone consider the disparities that exist in mathematics education for underrepresented, underserved students, and through her leadership, she has provided a call to action and reform of that environment. That mission—the mission of TODOS—still remains at the forefront of her leadership efforts today." She has been a member of the *Journal for Research in Mathematics Education* editorial panel and of the Research Advisory Committee and the Nominations and Elections Committee of the NCTM. She has served on the NCTM *Principles to Actions* author committee, with particular emphasis on equity. She has been a member of the NCTM Board of Directors. Other honors she has received include the Ross Taylor/Glenn Gilbert Memorial Award for Excellence in Mathematics Education from the National Council of Supervisors of Mathematics, the Iris Carl Equity and Leadership Award from TODOS, the North Carolina Diamante Award for contributions to the Hispanic/Latino community in the state, and the Rankin Award, which recognizes and honors individuals for their outstanding contributions to the North Carolina Council of Teachers of Mathematics (NCCTM) and to mathematics education in North Carolina.

Hirsch "was the driving force behind the Core-Plus Mathematics Project (CPMP), which, with support from the National Science Foundation, developed a research-based high school curriculum organized around mathematical strands of algebra and functions, statistics and probability, geometry and trigonometry, and discrete mathematics. This integrated curriculum was the first such curriculum to have a significant impact on national adoptions, and over a period of more than twenty years, it has moved to second and subsequent editions, including a new Common Core State Standards (CCSS) edition." He has served on the NCTM Board of Directors, was a member of the first Commission on Standards for School Mathematics, and chaired the grades 9–12 working group for the NCTM's *Curriculum and Evaluation Standards for School Mathematics* (1989). He was editor of the 1985 Yearbook and the Addenda Series for grades 9–12 and was general editor of the 1990–1992 Yearbooks. He edited several additional NCTM publications and wrote numerous articles appearing in the NCTM journals and those of other professional organizations. He served as a referee for both research and professional practice journals within and outside NCTM, chaired the NCTM review group for College Board Standards for Success in College Mathematics and Statistics, and was both a member and chair of the Education Materials Committee.

—From NCTM announcements

Pi Mu Epsilon Student Paper Presentation Awards

Pi Mu Epsilon (PME), the US honorary mathematics society, makes annual awards to recognize the best papers by undergraduate students presented at a PME student paper session. PME held a session in conjunction with the Mathematical Association of America MathFest held July 31–August 3, 2014, in Hartford, Connecticut. The AMS and the American Statistical Association sponsor awards to student speakers for excellence in exposition and research. Each awardee received a check for US$150. The names, institutions, and paper titles of the award-winning students follow.

MARCUS ELIA, State University of New York, Geneseo, "The Collatz conjecture"; MARISSA HARTZHEIM, St. Norbert College, "A particular polarity, part I"; TAYLOR MILLER, St. Norbert College, "A particular polarity, part II"; CRYSTAL MACKEY, Youngstown State University, "Factorization theory of numerical monoids"; JONATHAN MARINO, Roanoke College, "Integer compositions applied to the probability analysis of blackjack and infinite deck assumption"; ROBERT LEHR, Southwestern University, "An irrational decomposition of generalized Fibonacci numbers"; SAMANTHA PARSONS, Roanoke College, "Protecting confidentiality and scientific integrity through synthetic data and mediator servers"; MATTHEW BUHR, University of South Dakota, "The flour beetle: A discrete mathematical model"; MAX GOERING, Kansas State University, "Modulus of families of walks on graphs"; DANIEL MILLER, Texas A&M University, "Data-driven forecasting of available and required energy for a solar water heating system"; HEATHER GRONEWALD, Southwestern University, "Computing cophylogenetic invariants"; ERIC SHEHADI, Youngstown State University, "Safeguard fair voting: Mathematically diagnosing gerrymanders"; ERIC LAI, University of California Irvine, "The distance between finite groups"; ELIZABETH GRECO, Kenyon College, "Brownian motion in the complex plane"; DAYNA MANN, Pepperdine University, "An individual-based model of chaparral vegetation response to frequent wildfires"; ANDRE BUNTON, University of Alaska Southeast, "Simultaneous generation of a simple basis B and a corresponding B-CZDS".

—Pi Mu Epsilon announcement

Mathematics Opportunities

AMS-Simons Travel Grants Program

Starting February 1, 2015, the AMS will begin accepting applications for the AMS-Simons Travel Grants program, with support from the Simons Foundation. Each grant provides an early-career mathematician with US$2,000 per year for two years to reimburse travel expenses related to research. Sixty new awards will be made in 2015. Starting February 1, 2015, applications will be accepted through www.mathprograms.org. The deadline for 2015 applications is **March 31, 2015**.

Applicants must be located in the United States or be US citizens to apply. For complete details of eligibility and application instructions, visit: www.ams.org/programs/travel-grants/AMS-SimonsTG or contact Steven Ferrucci, email: ams-simons@ams.org , telephone: 800-321-4267, ext. 4113.

—AMS announcement

Proposal Due Dates at the DMS

The Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) has a number of programs in support of mathematical sciences research and education. Listed below are some of the programs and their proposal due dates for the year 2015. Please refer to the program announcement or contact the program director for more information.

January 5, 2015 (letter of intent): Industry/University Cooperative Research Centers Program

January 14, 2015 (full proposal): Secure and Trustworthy Cyberspace

January 22, 2015 (full proposal): Major Research Instrumentation Program

March 3, 2015 (full proposal): Industry/University Cooperative Research Centers Program

April 24, 2015 (full proposal): NSF-CBMS Regional Research Conferences in the Mathematical Sciences

May 22, 2015 (full proposal): Research Experiences for Undergraduates (REU), Antarctica Program

June 2, 2015 (full proposal): Research Training Groups in the Mathematical Sciences

June 9, 2015 (full proposal): Innovation Corps Sites Program

June 26, 2015 (letter of intent): Industry/University Cooperative Research Centers Program

July 8, 2015 (full proposal): Enriched Doctoral Training in the Mathematical Sciences

August 26, 2015 (full proposal): Research Experiences for Undergraduates (REU)

September 15, 2015 (full proposal): Joint DMS/NIGMS Initiative to Support Research at the Interface of the Biological and Mathematical Sciences (DMS/NIGMS)

September 18, 2015 (full proposal): Focused Research Groups in the Mathematical Sciences (FRG)

September 21, 2015 (full proposal): Secure and Trustworthy Cyberspace

September 25, 2015 (full proposal): Industry/University Cooperative Research Centers Program

September 30, 2015 (full proposal): Computational and Data-Enabled Science and Engineering (CDS&E)

October 5, 2015 (letter of intent): ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers

October 6, 2015 (full proposal): Analysis; Combinatorics; Foundations

October 9, 2015 (full proposal): Algebra and Number Theory

For further information see the website www.nsf.gov/funding/pgm_list.jsp?org=DMS&ord=date. The mailing address is Division of Mathematical Sciences, National Science Foundation, Room 1025, 4201 Wilson Boulevard, Arlington, VA 22230. The telephone number is 703-292-5111.

—From the DMS website

NSF Major Research Instrumentation Program

The National Science Foundation (NSF) Major Research Instrumentation (MRI) program seeks to increase access to shared scientific and engineering instruments for research and research training in institutions of higher education, museums, science centers, and not-for-profit organizations in the United States. This program especially seeks to improve the quality and expand the scope of

research and research training in science and engineering by providing shared instrumentation that fosters the integration of research and education in research-intensive learning environments. Proposals must be for either acquisition or development of a single instrument or for equipment that, when combined, serves as an integrated research instrument (physical or virtual). Proposals may be submitted only by institutions of higher education in the United States or its territories or possessions or by nonprofit organizations such as museums, science centers, observatories, research laboratories, professional societies, and similar organizations involved in research or educational activities. The deadline for full proposals is **January 22, 2015**. For more information see www.nsf.gov/pubs/2013/nsf13517/nsf13517.htm.

—From an NSF announcement

National Academies Research Associateship Programs

The Policy and Global Affairs Division of the National Academies is sponsoring the 2014 Postdoctoral and Senior Research Associateship Programs. The programs are meant to provide opportunities for PhD, ScD, or MD scientists and engineers of unusual promise and ability to perform research at more than 100 research laboratories throughout the United States and overseas. Full-time associateships will be awarded for research in the fields of mathematics, chemistry, earth and atmospheric sciences, engineering, applied sciences, life sciences, space sciences, and physics. Most of the laboratories are open to both US and non-US nationals and to both recent doctoral recipients and senior investigators. Amounts of stipends depend on the sponsoring laboratory. Support is also provided for allowable relocation expenses and for limited professional travel during the period of the award. Awards will be made four times during the year, in February, May, August, and November. The deadline for application materials to be postmarked or for electronic submissions for the February 2015 review is **February 1, 2015**. Materials for the May review are due **May 1, 2015**; for the August review, **August 1, 2015**; and for the November review, **November 1, 2015**. Note that not all sponsors participate in all four reviews. Applicants should refer to the specific information for the laboratory to which they are applying. For further information and application materials, see the National Academies website at 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.

—From an NRC announcement

PIMS Education Prize

The Pacific Institute for the Mathematical Sciences (PIMS) awards an annual prize to a member of the PIMS community who has made a significant contribution to education in the mathematical sciences. This prize is intended to recognize individuals from the PIMS universities, or other educational institutions in Alberta, British Columbia, and Saskatchewan, who have played a major role in encouraging activities that have enhanced public awareness and appreciation of mathematics, as well as fostering communication among various groups and organizations concerned with mathematical training at all levels. The deadline for nominations is **March 15, 2015**. For more information see the website www.pims.math.ca/pims-glance/prizes-awards.

—From a PIMS announcement

CAIMS/PIMS Early Career Award

The Canadian Applied and Industrial Mathematics Society (CAIMS) and the Pacific Institute for Mathematical Sciences (PIMS) sponsor the Early Career Award in Applied Mathematics to recognize exceptional research in any branch of applied mathematics, interpreted broadly. The nominee's research should have been conducted primarily in Canada or in affiliation with a Canadian university. The prize is to be awarded every year to a researcher less than ten years past the date of PhD at the time of nomination. The award consists of a cash prize of C$1,000 and a commemorative plaque presented at the CAIMS Annual Meeting. The recipient will be invited to deliver a plenary lecture at the CAIMS annual meeting in the year of the award. A travel allowance will be provided. The deadline for nominations is **January 31, 2015**. For more information see www.pims.math.ca/pims-glance/prizes-awards.

—From a PIMS announcement

Mathematical Competitive Game 2014–2015: Uncertainties in GPS Positioning

Each year for the past six years, the Fédération Française des Jeux Mathématiques and the Société de Calcul Mathématique SA have organized Mathematical Competitive Games. Each game centers on the resolution of a significant "real life" problem whose mathematical aspects have been simplified. Even with the simplification, the resolution typically requires several months of work. Previous problems involved designing transportation and electricity networks, mapping efficient automobile

itineraries, fighting forest fires, and checking industrial processes. Prizes of up to 500 euros are given for individual and group work, and the winning solutions are published on the websites of the sponsoring organizations. A prize ceremony is held at the Salon de la Culture et des Jeux Mathématiques (Fair for Mathematical Culture and Games) in Paris in May.

The topic of the latest Mathematical Competitive Game is "Uncertainties in GPS Positioning." Everyone nowadays knows what a GPS receiver is: it receives a signal from several satellites, and, using this information and a built-in map, it tells you where you are on the map. The computation is usually quite fast. The question that is seldom addressed is: what is the uncertainty in this position, and how is it computed?

The game opened on November 1, 2014. No preliminary registration is required. Everyone can participate. Participants should send their solutions, in PDF format, in English or in French, no later than **April 30, 2015**, to the email address ffjm@wanadoo.fr.

A complete statement of the topic of the competition is available on the web at scmsa.eu/archives/SCM_FFJM_Competitive_Game_2014_2015.pdf.

—Allyn Jackson
Senior Writer and
Deputy Editor, Notices
axj@ams.org

Call for Nominations for the Ostrowski Prize, 2015

The aim of the Ostrowski Foundation is to promote the mathematical sciences. Every second year it provides a prize for recent outstanding achievements in pure mathematics and in the foundations of numerical mathematics. The value of the prize for 2015 is 100,000 Swiss francs.

The prize has been awarded every two years since 1989. The most recent winners are Ben Green and Terence Tao in 2005, Oded Schramm in 2007, Sorin Popa in 2009, Ib Madsen, David Preiss and Kannan Soundararajan in 2011, and Yitang Zhang in 2013. See www.ostrowski.ch/index_e.php?ifile=preis for the complete list and further details.

The jury invites nominations for candidates for the 2015 Ostrowski Prize. Nominations should include a CV of the candidate, a letter of nomination, and 2–3 letters of reference. The chair of the jury for 2015 is Christian Berg of the University of Copenhagen, Denmark. Nominations should be sent to berg@math.ku.dk by **April 15, 2015**.

—Christian Berg
University of Copenhagen
berg@math.ku.dk

Inside the AMS

Math in Moscow Scholarships Awarded

The AMS has made awards to five mathematics students to attend the Math in Moscow program in the spring of 2015. Following are the names of the undergraduate students and their institutions: ETHAN ACKELSBERG, Bard College at Simon's Rock; AARON CALDERON, University of Nebraska-Lincoln; JARED HILLIARD, University of North Texas; JEREMY MYERS, Virginia Commonwealth University; and AJAY RAGHAVENDRA, Embry-Riddle Aeronautical University. Each received a cash award of US$9,500.

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

The AMS awards several scholarships for US students to attend the Math in Moscow program. The scholarships are made possible through a grant from the National Science Foundation. For more information about Math in Moscow, consult `www.mccme.ru/mathinmoscow` and the article "Bringing Eastern European mathematical traditions to North American students," *Notices*, November 2003, pages 1250–1254.

—Elaine Kehoe

My Summer at *Wired* Magazine

Each year the AMS sponsors a fellow to participate in the Mass Media Fellowship program of the American Association for the Advancement of Science (AAAS). This program places science and mathematics graduate students in summer internships at media outlets. In this article the 2014 Fellow, Joshua Batson, describes his experiences during his fellowship at *Wired* magazine. For information about applying for the fellowship, see the "Mathematics Opportunities" section in this issue of the *Notices* or visit the website `www.ams.org/programs/ams-fellowships`. The application deadline is **January 15, 2015**.

On Sunday, June 8th, the day before I started work on the science desk at *Wired* magazine, a milestone in artificial intelligence was announced. A chatbot had apparently fooled judges into thinking it was a person, passing the famous Turing Test a conveniently precise sixty years after Alan Turing's death. As the first credulous headlines flashed across the Internet—"Turing Test breakthrough as super-computer becomes first to convince us it's human"—the science team at *Wired* started investigating. (*The Washington Post*, in contrast, had a foreign affairs correspondent push out a short brief citing only the press release.) We quickly answered three questions:

1. Was there actually a computing breakthrough? No. The bot was comically bad.

2. Should we cover the story anyway? Yes. Anything Turing is in our wheelhouse, and someone has to set the record straight.

3. Could we use this PR stunt as an occasion to talk about something interesting? Yes.

We settled on an immediate debunker for Monday morning, to be followed by a deeper look at benchmarks in artificial intelligence. I was assigned the latter story, and by 11 am on my first day at the office, I had sent out a dozen emails titled "URGENT: Journalist request on Turing Test." I was shocked as responses poured in minutes later in from researchers in robotics, computer vision, and cognitive science. Having grown used to the pace of academic communication, where an email might go weeks without reply, it was rather surprising to hear an eminent professor say "Call me back any time today if you need more, I know how deadlines work."

Deadlines are a fact of life, but they are not a feature of nature. The timescale of scientific progress tends to be orders of magnitude slower than the news cycle. This can make science reporting a strange activity. As veteran NPR correspondent Joe Palca says, "At the end of every year, there are dozens of stories in politics and economics where if you didn't cover them, you screwed up. In science, there might only be one or two." I would add that the one or two big science stories of the year are usually premature declarations of victory, if not outright frauds. Think of how the triumphant announcement of gravity waves last March was subsequently clouded by intimations of interstellar dust, or of how the *Nature* paper showing how to make stem cells using just an acid bath turned out to be full of fabricated data. A recent event or publication or controversy can provide a good hook for a story, but since most people know so little of the science which has already been worked out, a fresh take on an interesting topic can make it news.

The most popular piece I wrote this summer actually featured some very old geometry and a personal hero, Felix Klein. Here's how I tried to get the reader ready for some math:

> The doors to MIT are always unlocked. If you slip in at night and take a long walk down the fluorescent hallway called the Infinite Corridor, you will pass flatscreen monitors displaying friendly robots, gleaming lab equipment behind large plate glass, and advertisements for the bitcoin club. Turn off the main drag into an alcove in the building numbered 2, and you'll find something that seems out of place: a locked display case stuffed with strange forms made of plaster and string. Were they not dulled by age and covered with dust, they might pass for products of a modern fab lab or the nearby school of design. But those mysterious surfaces were made more than a century ago by mathematicians to answer a simple question: What does an equation look like?

The piece was hardly timely, as these models of algebraic surfaces were almost a century old, but it was new material for the majority of the readers. The comments were surprisingly positive, like, "wow… THIS is an excellent reminder of what *Wired* used to be like. Wonderful article." (Significantly uglier were the comments on my piece on ocean vortices and climate change.) A few thousand people shared the piece on Facebook, and, as is typical for online content, social media brought traffic to the story for days after it left the *Wired* homepage. The *Daily Mail* soon published an almost identical story, featuring photographs of different mathematical models and fresh quotes from my sources. I expect this was Klein's first tabloid appearance.

Common wisdom states that most Americans fear and mistrust mathematics, but in fact there is an enormous hunger for mathematical ideas and stories. In 2013, one of the most popular articles on `Wired.com` was about Yitang Zhang and his theorem on bounded gaps between primes. The author, former mathematician Erica Klarreich, led with Zhang's rags-to-mathematical-riches story, brought in some basics on primes, and then invited the reader into the strange caverns of sieve theory. In 2010, Steven Strogatz wrote a fifteen-part series for *The New York Times* that repeatedly topped the list of most-emailed articles and attracted hundreds of appreciative comments. He began with the virtues of having counting numbers and ended with curvature and orders of infinity. If we meet the readers where they are, in the busy everyday world, and make a friendly invitation to go on a journey somewhere interesting, tens of thousands of them will walk with us.

Figuring out how to write an engaging introduction was nevertheless quite hard for me. Math papers tend to introduce a lot of characters quickly, then start describing their relationships. So when writing an article on new electronic displays, I naturally began with structure:

Whether you're on a laptop, a tablet, or a smartphone, you're probably reading this article on an LCD screen. The letters are black where tiny liquid crystals are twisted to block the constant white backlight. Unless you're on a Samsung Galaxy, where the white around the letters is emitted by glowing LEDs and the black letters are just the diodes that are off. Maybe you saved the text to your Kindle to read on a picnic. Then sunlight is bouncing to your eyes off its electronic paper. In any case, a bunch of electrodes just made some high-tech material contort itself to render these words.

My editor admonished me to make it easier for the reader to get interested, so I wrote this instead:

We are surrounded by imperfect screens. Our smartphones, laptops, televisions, watches, billboards, thermostats and even glasses all have screens with drawbacks: Some don't work in sunlight, others mercilessly drain your battery; some can't do rich color, and some can't display a true black; most can't be rolled up and tucked in your pocket. But something better may be on the way.

The narrative style isn't necessarily better than the analytic one, but it is more inviting for a casual reader. As my uncle likes to say, the striptease artist and the anatomist work with the same details, but they reveal them differently.

Writing for the public was difficult and rewarding, and I highly recommend trying it. Just like math is made by a few thousand people around the world, of which you are likely one, the popular understanding of math and science is generated by a relatively small and overworked group of people. Every week, a handful of writers and editors comb through hundreds of papers and press releases, call dozens of sources, and make the articles that get shared across the Internet. As I learned when researching a piece on the Higgs boson, even a single blog post can have outsize impact if it helps a reporter understand something and share it with the world. So write, blog, speak, or if you're feeling especially cheeky, tweet.

—Joshua Batson
`@thebasepoint`

Deaths of AMS Members

RICHARD C. BROWN, professor, University of Alabama, died on November 12, 2012. Born on January 5, 1939, he was a member of the Society for 41 years.

ADAM BURACZEWSKI, of Poland, died on January 2, 2012. Born on April 14, 1926, he was a member of the Society for 42 years.

HERBERT J. CURTIS, of Kirkwood, Missouri, died on October 16, 2007. Born on August 18, 1918, he was a member of the Society for 60 years.

PAUL DEDECKER, of Belgium, died on July 27, 2007. Born on June 15, 1921, he was a member of the Society for 49 years.

M. JEAN MCKEMIE, professor, Saint Edward's University, died on August 21, 2012. Born on May 15, 1954, he was a member of the Society for 32 years.

RICHARD SANTORO, of Chicago, Illinois, died on March 31, 2011. Born on November 7, 1952, he was a member of the Society for 3 years.

P. EMERY THOMAS, of Berkeley, California, died on June 13, 2005. Born on February 15, 1927, he was a member of the Society for 50 years.

DAYA-NAND VERMA, professor, Tata Institute of Fundamental Research, India, died on June 10, 2012. Born on June 25, 1933, he was a member of the Society for 48 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 features, memorials, 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 **production editor** is the person to whom to send items for "Mathematics People", "Mathematics Opportunities", "For Your Information", "Reference and Book List", and "Mathematics Calendar".

Permissions requests should be sent to: reprint-permission@ams.org.

Contact the **editor** at: notices@math.wustl.edu or by fax at 314-935-6839.

Contact the **production editor** at: notices@ams.org or by fax at 401-331-3842. Postal addresses for both may be found in the masthead.

Upcoming Deadlines

December 19, 2014: Proposals for 2016 AMS Short Courses. Submit by email to aed-mps@ams.org.

December 24, 2014: Registration for AMS Department Chairs Workshop. See https://bit.ly/1ph9nJl to register.

December 24, 2014: Registration for AMS-NSF-EHR free grant-writing workshop. See https://bit.ly/1uUq9hU.

January 11, 2015: Final proposals for Intensive Research Programs at Centre de Recerca Matematica (CRM). See www.crm.cat/en/Host/Sci-Events/IRP/Pages/default.aspx.

January 12, 2015: Applications for Jefferson Science Fellows Program. For more information, email jsf@nas.edu; telephone 202-334-2643, or see the website sites.nationalacademies.org/PGA/Jefferson/PGA_046612.

January 15, 2015: Applications for AMS-AAAS Mass Media Summer Fellowships. See the website at www.aaas.org/program/aaas-mass-mediascience-engineering-fellows-program . Applicants may contact Dione Rossiter, project director, AAAS Mass Media Science & Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone 202-326-6645; email drossite@aaas.org. Further information is also available at www.ams.org/programs/ams-fellowships/media-fellow/mass-mediafellow.

Where to Find It

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

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NSF Mathematical and Physical Sciences Advisory Committee—*February 2014, p. 202*

Program Officers for Federal Funding Agencies—*October 2013, p. 1188 (DoD, DoE); December 2014, p. 1369 (NSF Mathematics Education)*

Program Officers for NSF Division of Mathematical Sciences—*November 2014, p. 1264*

January 22, 2015: Full proposals for NSF Major Research Implementation (MRI) program. See "Mathematics Opportunities" in this issue.

January 31, 2015: Nominations for Early Career Award of the Canadian Applied and Industrial Mathematics Society (CAIMS) and the Pacific Institute for Mathematical Sciences (PIMS). See "Mathematics Opportunities" in this issue.

January 31, 2015: Entries for AWM Essay Contest. Contact Heather Lewis at hlewis5@naz.edu or see the website https://sites.google.com/site/awmmath/home.

February 1, 2015: Applications for February review for National Academies Research Associateship programs. See "Mathematics Opportunities" in this issue.

February 1, 2015: Applications for AWM Travel Grants, Mathematics Education Research Travel Grants, Mathematics Mentoring Travel Grants, and Mathematics Education Research Mentoring Travel Grants. See the website https://sites.google.com/site/awmmath/programs/travel-grants ; telephone: 703-934-0163; or email: awm@awm-math.org ; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

February 9, 2015: Applications for travel support for IPAM Latinas in Mathematical Sciences Conference. See the website www.ipam.ucla.edu.

February 12, 2015: Applications for IPAM Research in Industrial Projects for Students (RIPS) programs. See the website www.ipam.ucla.edu.

March 2, 2015: Applications for EDGE for Women 2015 Summer Program. See the website www.edgeforwomen.org/.

March 15, 2015: Nominations for PIMS Education Prize. See "Mathematics Opportunities" in this issue.

March 31, 2015: Applications for AMS-Simons Travel Grants program. See "Mathematics Opportunities" in this issue.

March 31, 2015: Applications for IPAM graduate summer school on Games and Contracts for Cyber-Physical Security. See the website www.ipam.ucla.edu.

April 15, 2015: Applications for fall 2015 semester of Math in Moscow. See http://www.mccme.ru/mathinmoscow , or contact: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7095-291-65-01; email: mim@mccme.ru. Information and application forms for the AMS scholarships are available on the AMS website at www.ams.org/programs/travel-grants/mimoscow, or contact: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email student-serv@ams.org.

May 1, 2015: Applications for May review for National Academies Research Associateship programs. See "Mathematics Opportunities" in this issue.

May 1, 2015: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants ; telephone: 703-934-0163; or email: awm@awm-math.org ; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

August 1, 2015: Applications for August review for National Academies Research Associateship programs. See "Mathematics Opportunities" in this issue.

October 1, 2015: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants ; telephone: 703-934-0163; or email: awm@awm-math.org ; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

November 1, 2015: Applications for November review for National Academies Research Associateship programs. See "Mathematics Opportunities" in this issue.

National Science Board

The National Science Board is the policymaking body of the National Science Foundation. Listed below are the current members of the NSB. For further information, visit the website www.nsf.gov/nsb/.

Dan E. Arvizu (Chair)
Director and Chief Executive
National Renewable Energy Laboratory

John L. Anderson
President
Illinois Institute of Technology

Deborah L. Ball
William H. Payne Collegiate Chair
Arthur F. Thurnau Professor
Dean, School of Education
University of Michigan

Bonnie Bassler
Howard Hughes Medical Institute Investigator
Squibb Professor of Molecular Biology
Princeton University

Roger Beachy
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University of California Davis

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Stanford University

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Vicki Chandler
Chief Program Officer, Science
Gordon and Betty Moore Foundation

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Analytic Services, Inc.

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American Association for the Advancement of Science

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Vice President for Research
Massachusetts Institute of Technology

The contact information for the Board is: National Science Board, 4201 Wilson Boulevard, Room 1225N, Arlington, VA 22230; telephone 703-292-7000; email NationalScienceBrd@nsf.gov; World Wide Web www.nsf.gov/nsb/members.

Book List

The Book List highlights recent books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. 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.

Alan M. Turing: Centenary Edition, by Sara Turing. Cambridge University Press, April 2012. ISBN-13: 978-11070-205-80. (Reviewed September 2014.)

Alan Turing: The Enigma, The Centenary Edition, by Andrew Hodges. Princeton University Press, May 2012. ISBN-13: 978-06911-556-47. (Reviewed September 2014.)

Alan Turing: His Work and Impact, edited by S. Barry Cooper and J. van Leeuwen. Elsevier, May 2013. ISBN-13: 978-01238-698-07. (Reviewed September 2014.)

Alan Turing's Electronic Brain: The Struggle to Build the ACE, the World's Fastest Computer, by B. Jack Copeland et al. Oxford University Press, May 2012. ISBN-13: 978-0-19-960915-4. (Reviewed September 2014.)

André-Louis Cholesky: Mathematician, Topographer and Army Officer, by Claude Brezinski and Dominique Tournès. Birkhäuser, August 2014. ISBN: 978-33190-813-42.

Beyond Banneker: Black Mathematicians and the Paths to Excellence, by Erica N. Walker. State University of New York Press, June 2014. ISBN-13: 978-14384-521-59.

Computability: Turing, Gödel, Church, and Beyond, edited by B. Jack Copeland, Carl J. Posy, and Oron Shagrir. MIT Press, June 2013. ISBN-13: 978-02620-189-99.

A Curious History of Mathematics: The Big Ideas from Early Number Concepts to Chaos Theory, by Joel Levy. Andre Deutsch, February 2014. ISBN-13: 978-02330-038-56.

Doing Data Science: Straight Talk from the Frontline, by Rachel Schutt and Cathy O'Neil. O'Reilly Media, November 2013. ISBN: 978-1-449-35865-5. (Reviewed October 2014.)

Enlightening Symbols: A Short History of Mathematical Notation and Its Hidden Powers, by Joseph Mazur. Princeton University Press, March 2014. ISBN-13: 978-06911-546-33.

Four Lives: A Celebration of Raymond Smullyan, edited by Jason Rosenhouse. Dover Publications, February 2014. ISBN-13: 978-04864-906-70.

Fractals: A Very Short Introduction, by Kenneth Falconer. Oxford University Press, December 2013. ISBN-13: 978-01996-759-82.

**From Mathematics in Logic to Logic in Mathematics: Boole and Frege,* by Aliou Tall. Docent Press, July 2014, ISBN-13: 978-0-9887449-7-4.

The Grapes of Math: How Life Reflects Numbers and Numbers Reflect Life, by Alex Bellos. Simon and Schuster, June 2014. ISBN: 978-14516-400-90.

Henri Poincaré: A Scientific Biography, by Jeremy Gray. Princeton University Press, November 2012. ISBN- 13: 978-06911-527-14. (Reviewed April 2014.)

A History in Sum: 150 Years of Mathematics at Harvard (1825–1975), by Steve Nadis and Shing-Tung Yau. Harvard University Press, October 2013. ISBN-13: 978-06747-250-03. (Reviewed June/July 2014.)

The Improbability Principle: Why Coincidences, Miracles, and Rare Events Happen Every Day, by David J. Hand. Scientific American/Farrar, Straus and Giroux, February 2014. ISBN-13: 978-03741-753-44. (Reviewed December 2014.)

Infinitesimal: How a Dangerous Mathematical Theory Shaped the Modern World, by Amir Alexander. Scientific American/Farrar, Straus and Giroux, April 2014. ISBN-13: 978-03741-768-15.

Jane Austen, Game Theorist, by Michael Suk-Young Chwe. Princeton University Press, April 2013. ISBN-13: 978-06911-557-60.

L. E. J. Brouwer—Topologist, Intuitionist, Philosopher: How Mathematics Is Rooted in Life, by Dirk van Dalen. Springer (2013 edition), December 2012. ISBN-13: 978-14471-461-55. (Reviewed June/July 2014.)

Levels of Infinity: Selected Writings on Mathematics and Philosophy, by Hermann Weyl (edited and with an introduction by Peter Pesic). Dover

Publications, January 2013. ISBN: 978-04864-890-32.

The Logic of Infinity, by Barnaby Sheppard. Cambridge University Press, May 2014. ISBN-13: 978-11076-786-68.

Love and Math: The Heart of Hidden Reality, by Edward Frenkel. Basic Books, October 2013. ISBN-13: 978-04650-507-41. (Reviewed October 2014.)

Magnificent Mistakes in Mathematics, by Alfred S. Posamentier and Ingmar Lehmann. Prometheus Books, August 2013. ISBN-13: 978-16161-474-71.

Math Bytes: Google Bombs, Chocolate-Covered Pi, and Other Cool Bits in Computing, by Tim Chartier. Princeton University Press, April 2014. ISBN-13: 978-06911-606-03.

Mathematical Expeditions: Exploring Word Problems Across the Ages, by Frank J. Swetz. Johns Hopkins University Press, June 2012. ISBN: 978-14214-043-87.

The Mathematician's Shiva, by Stuart Rojstaczer. Penguin Books, September 2014. ISBN-13: 978-014312-631-7.

**Mathematics and the Making of Modern Ireland: Trinity College Dublin from Cromwell to the Celtic Tiger*, by David Attis. Docent Press, October 2014, ISBN-13:978-0-9887449-8-1.

Mathematics and the Real World: The Remarkable Role of Evolution in the Making of Mathematics, by Zvi Artstein. Prometheus Books, September 2014. ISBN-13: 978-16161-409-15.

**The Mathematics Devotional: Celebrating the Wisdom and Beauty of Mathematics,* by Clifford Pickover. Sterling, November 2014. ISBN-13: 978-14549-132-21.

Mathematics of the Transcendental, by Alain Badiou (translated by A. J. Bartlett and Alex Ling). Bloomsbury Academic, March 2014. ISBN-13: 978-14411-892-40.

Math in Minutes: 200 Key Concepts Explained in an Instant, by Paul Glendinning. Quercus, September 2013. ISBN-13: 978-16236-500-87.

Math in 100 Key Breakthroughs, by Richard Elwes. Quercus, December 2013. ISBN-13: 978-16236-505-44.

A Mind For Numbers: How to Excel at Math and Science (Even If You Flunked Algebra), by Barbara Oakley. Tarcher, July 2014. ISBN-13:*978-03991-652-45.*

The New York Times Book of Mathematics: More Than 100 Years of Writing by the Numbers, edited by Gina Kolata. Sterling, June 2013. ISBN-13: 978-14027-932-26. (Reviewed May 2014.)

Numbers Are Forever, by Liz Strachan. Constable, March 2014. ISBN-13: 978-14721-110-43.

Our Mathematical Universe: My Quest for the Ultimate Nature of Reality, by Max Tegmark. Knopf, January 2014. ISBN-13: 978-03075-998-03.

Parables, Parabolas and Catastrophes: Conversations on Mathematics, Science and Philosophy, by René Thom. Translated by Roy Lisker and edited by S. Peter Tsatsanis. Thombooks Press, November 2014 (distributed only by `amazon.ca` or `amazon.com`). ISBN-13:978-09939-269-07.

The Perfect Theory: A Century of Geniuses and the Battle over General Relativity, by Pedro G. Ferreira. Houghton Mifflin Harcourt, February 2014. ISBN-13: 978-05475-548-91.

Philosophy of Mathematics in the Twentieth Century, by Charles Parsons. Harvard University Press, March 2014. ISBN-13: 978-06747-280-66.

**Pearls from a Lost City: The Lvov School of Mathematics,* by Roman Duda (translated by Daniel Davies). AMS, July 2014. ISBN-13: 978-14704-107-66.

Probably Approximately Correct: Nature's Algorithms for Learning and Prospering in a Complex World, by Leslie Valiant. Basic Books, June 2013. ISBN-13: 978-04650-327-16. (Reviewed November 2014.)

**Professor Stewart's Casebook of Mathematical Mysteries,* by Ian Stewart. Basic Books, October 2014. ISBN-13: 978-04650-549-78.

Quantum Computing since Democritus, by Scott Aaronson. Cambridge University Press, March 2013. ISBN-13: 978-05211-995-68. (Reviewed November 2014.)

Ramanujan's Place in the World of Mathematics: Essays Providing a Comparative Study, by Krishnaswami Alladi. Springer, 2013. ISBN: 978-81322-076-65.

The Simpsons and Their Mathematical Secrets, by Simon Singh. Bloomsbury, October 2013. ISBN-13: 978-14088-353-02. (Reviewed in this issue.)

Struck by Genius: How a Brain Injury Made Me a Mathematical Marvel, by Jason Padgett and Maureen Ann Seaberg. Houghton Mifflin Harcourt, April 2014. ISBN-13: 978-05440-456-06.

Synthetic Philosophy of Contemporary Mathematics, by Fernando Zalamea. Urbanomic/Sequence Press, January 2013. ISBN: 978-09567-750-16.

A Tale of Two Fractals, by A. A. Kirillov. Birkhäuser, May 2013. ISBN-13: 978-08176-838-18.

Théorème vivant, by Cédric Villani (in French). Grasset et Fasquelle, August 2012. ISBN-13: 978-2246798828. (Reviewed February 2014.)

The Tower of Hanoi: Myths and Maths, by Andreas M. Hinz, Sandi Klavzar, Uros Milutinovic, and Ciril Petr. Birkhäuser, January 2013. ISBN: 978-303-48023-69.

Turing: Pioneer of the Information Age, by Jack Copeland. Oxford University Press, January 2013. ISBN-13: 978-01996-397-93. (Reviewed September 2014.)

Turing's Cathedral: The Origins of the Digital Universe, by George Dyson. Pantheon/Vintage, December 2012. ISBN-13: 978-14000-759-97. (Reviewed August 2014.)

Undiluted Hocus-Pocus: The Autobiography of Martin Gardner. Princeton University Press, September 2013. ISBN-13: 978-06911-599-11. (Reviewed March 2014.)

Why Is There Philosophy of Mathematics At All?, by Ian Hacking. Cambridge University Press, April 2014. ISBN-13: 978-11070-501-74. (Reviewed in this issue.)

Zombies and Calculus, by Colin Adams. Princeton University Press, September 2014. ISBN-13: 978-06911-619-07.

Mathematics Calendar

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

January 2015

* 5–9 **The Mathematics of Michelle Wachs**, University of Miami, Coral Gables, Florida.
Description: This conference is devoted to algebraic, enumerative and topological combinatorics. In addition to lectures on topics of current research interest, the conference will provide sufficient time for informal collaboration. With this conference, we want to honor Professor Michelle Wachs of the University of Miami, who is a leader in the field. Professor Wachs has made many important contributions to the mathematical community through her research and service, and has served as a role model for a large group of successful women in her field. The conference should provide inspiration to the next generation.
Information: www.math.miami.edu/~galloway/wachsfest.html

* 14–15 **Second International Conference on Information, Communication and Computer Networks (ICI2CN 2015)**, Hotel Holiday Inn, London, United Kingdom
Description: ICI2CN 2015 is a premier international conference dedicated to advances in Communications Systems and Computer Networks. The conference is a yearly event for a world-class gathering of researchers from academia and industry, practitioners, and business leaders, providing a forum for discussing cutting edge research, and directions for new innovative business and technology.
Information: www.ici2cn.com

February 2015

* 4–7 **XXIst Oporto Meeting on Geometry, Topology and Physics**, Instituto Superior Técnico, Lisbon, Portugal
Description: This meeting is focused on "Applications of Topology". As in previous editions the meeting is based around mini-courses given by four main speakers, supplemented by invited and contributed talks. Our main speakers this year are: Dmitry Feichtner-Kozlov (Bremen): Combinatorial Algebraic Topology and applications to Distributed Computing, Michael Farber (Queen Mary, London): Topological Robotics, Piotr Sulkowski (Warsaw): Random matrices, topological recursion, and applications of topology to biomolecules, Ulrich Bauer (IST Austria/TU Muenchen): Topological Data Analysis. The talks should be of interest to anyone wishing to learn about the applications of topology, including applications in robotics and theoretical computing. Some funding is available. There is no registration fee. You are invited to register on the webpage, where you can also propose a contributed talk (deadline November 25).
Information: cmup.fc.up.pt/cmup/omgtp/2015

* 27–March 1 **RTG Local Cohomology Workshop at UIC (for Graduate Students, Postdocs, and Young Researchers)**, University of Illinois at Chicago (UIC), Chicago, IL.
Description: This workshop, aimed at graduate students and young postdocs, will expose participants to a number of current research topics on Local Cohomology. The workshop will have three minicourses by experts on topics close to their own research, with each minicourse consisting of a mix of lectures and problem sessions in groups. Over the course of the weekend, we hope to present a number of open questions with sufficient background to be worked on both during and after the workshop.
Information: kftucker.people.uic.edu/localcohom

March 2015

* 9–13 **Hot Topics: Kadison-Singer, Interlacing Polynomials, and Beyond**, Mathematical Sciences Research Institute, Berkeley, California
Description: In a recent paper, Marcus, Spielman and Srivastava solve the Kadison-Singer Problem by proving Weaver's KS2

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: www.ams.org/.

conjecture and the Paving Conjecture. Their proof involved a technique they called the "method of interlacing families of polynomials" and a "barrier function" approach to proving bounds on the locations of the zeros of real stable polynomials. Using these techniques, they have also proved that there are infinite families of Ramanujan graphs of every degree, and they have developed a very simple proof of Bourgain and Tzafriri's Restricted Invertibility Theorem. The goal of this workshop is to help build upon this recent development by bringing together researchers from the disparate areas related to these techniques, including Functional Analysis, Spectral Graph Theory, Free Probability, Convex Optimization, Discrepancy Theory, and Real Algebraic Geometry.
Information: www.msri.org/workshops/754

* 27–29 **Conference on Complex Analysis and Geometry on the occasion of Sidney Webster's 70th birthday**, University of Wisconsin-Madison, Madison, Wisconsin
Description: The conference will feature recent developments in the normal form theory in several complex variables and dynamical systems, extension property of biholomorphic mappings, d-bar-Neumann problems, rigidity of holomorphic mappings between balls and their classifications, local and global theory of CR manifolds, Levi-flat hypersurfaces and lamination theory in complex projective spaces. Partial travel support will be provided for graduate students and recent PhD's by funds from the National Science Foundation, the Institute for Mathematics and its Applications, and the University of Wisconsin-Madison. Women and members from underrepresented groups are encouraged to participate in the conference.
Information: www.math.wisc.edu/~street/webster-2015

April 2015

* 7–10 **International Conference "Probability, Reliability and Stochastic Optimization" (PRESTO-2015)**, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine
Description: International Conference "Probability, Reliability and Stochastic Optimization" (PRESTO-2015) is dedicated to the anniversaries of prominent scientists: 90th anniversary of academician of National Academy of Sciences of Ukraine V. Korolyuk, 80th anniversary of academician of National Academy of Sciences of Ukraine I. Kovalenko, 75th anniversary of corresponding member of National Academy of Sciences of Ukraine P. Knopov and 75th anniversary of Professor Yu. Kozachenko. The aim of the conference is to bring together national and international researchers for discussing recent results and new trends in a wide range of research areas: probability, mathematical statistics, theory of stochastic processes and fields, fractional and multifractional processes, fractal analysis, stochastic analysis, stochastic differential equations, stochastic models of evolution systems, stochastic reliability theory, information security, queuing theory, risk processes, actuarial and financial mathematics.
Information: probability.univ.kiev.ua/prestoconf/

* 13–17 **The Mathematics of High Frequency Financial Markets: Limit Order Books, Frictions, Optimal Execution and Program Trading**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, CA
Description: The notion of one price, publicly known, at which transactions can happen in arbitrary sizes has seriously been challenged over the last few years. The existence and the importance of liquidity friction and price impact due to the size and frequency of trades are recognized as the source of many of the most spectacular failures (e.g., LTCM, Amaranth, Lehman) prompting new research in applications of stochastic optimization to optimal execution and predatory trading. Also, the impact of algorithmic and high frequency trading on the stability and the integrity of the financial system is a growing concern. Research on the developments of Limit Order Book (LOB) and algorithmic trading models and their impact on trading are clearly some of the most exciting emerging topics in quantitative finance research. A short course of four 1hr-20-minute lectures will be given at the beginning of the workshop. Applications received by Monday, February 16, 2015 will receive fullest consideration.
Information: www.ipam.ucla.edu/programs/workshops/workshop-ii-the-mathematics-of-high-frequency-financial-markets-limit-order-books-frictions-optimal-execution-and-program-trading/

* 14 **1st Cyber-Physical System Security Workshop (CPSS 2015)**, Singapore.
Description: Cyber-Physical Systems (CPS) consist of large-scale interconnected systems of heterogeneous components interacting with their physical environments.
Topics: Adaptive attack mitigation for CPS - Authentication and access control for CPS - Availability, recovery and auditing for CPS - Data security and privacy for CPS - Embedded systems security - EV charging system security - Intrusion detection for CPS - Key management in CPS - Legacy CPS system protection - Lightweight crypto and security - SCADA security - Security of industrial control systems - Smart grid security - Threat modeling for CPS - Urban transportation system security - Vulnerability analysis for CPS - Wireless sensor network security
Information: icsd.i2r.a-star.edu.sg/cpss15

* 18 **Overview of Current Research and Applications in Financial Mathematics**, Farmingdale State College, Farmingdale, NY 11735
Description: The Mathematics Department at Farmingdale State College is sponsoring this one-day conference as part of its new concentration in Financial Mathematics. The conference will feature keynote presentations and invited talks by academicians and business professionals in the actuarial and financial fields. The objective is to foster conversation and potential collaboration among researchers and practitioners in these fields. Graduate students and those considering graduate studies in financial mathematics, computational mathematics and applied statistics are especially encouraged to attend.
Contact: Prof. Chunhui Yu (chunhui.yu@farmingdale.edu).
Information: www.farmingdale.edu/academics/arts-sciences/mathematics/

* 27–30 **The Cape Verde International Days on Mathematics**, Mindelo, Cape Verde.
Description: The main aim of the conference is to promote, encourage, and bring together researchers in the fields of Optimization and Variational Analysis, Mathematical Systems Theory, Ordinary and Partial Differential Equations, Geometric Nonlinear Control and Applications, Fractional Calculus and Applications, and Calculus on Time Scales and Applications. It will be a mathematically enriching and socially exciting event.
Information: sites.google.com/site/cvim2015/home

May 2015

* 5–8 **The 11th Information Security Practice and Experience Conference (ISPEC 2015)**, Beijing, China.
Description: ISPEC is an annual conference that brings together researchers and practitioners to provide a confluence of new information security technologies, their applications and their integration with IT systems in various vertical sectors.
Topics: Access control, Network security, Applied cryptography, Privacy and anonymity, Availability, resilience, and usability, Risk evaluation and security certification, Big data and Cloud security, Security for cyber-physical systems, Cryptanalysis, Security of smart cards and RFID systems, Embedded system security, Security policy, Database security, Security protocols, Digital Forensics, Security systems, Digital rights management, Smart Grid Security, Information security in vertical applications, Smartphone Security, Intrusion detection, Trust model and management, Multimedia security, Trusted computing.

Information: icsd.i2r.a-star.edu.sg/ispec2015/.

* 14–16 **49th Spring Topology and Dynamics Conference**, Bowling Green State University, Bowling Green, Ohio, USA
Description: There will be 7 plenary and 12 semi-plenary talks covering various areas of topology and dynamics. In addition, there will be 5 special sessions: Continuum theory, dynamical systems, set-theoretic topology, geometric group theory, and geometric topology.
Information: personal.bgsu.edu/~xiex/STDC2015.speakers.html

* 14–17 **Modern Aspects of Complex Geometry: A Conference in Honor of Taft Professor David Minda**, University of Cincinnati Cincinnati, OH
Description: This conference is supported by generous grants from NSF, Taft Research Center, McMicken College of Arts and Sciences of the University of Cincinnati, and the Department of Mathematical Sciences of the University of Cincinnati. Some partial travel support is available for graduate students and early career mathematicians in the field of Geometric Analysis.
Conference Organizers: Nages Shanmugalingam, David Herron, Jeremy Tyson, John Lewis
Information: www.artsci.uc.edu/departments/math/complex_geometry_conference.html

* 15–19 **The 28th International Conference of The Jangjeon Mathematical Society**, Sherwood Club Kemer Hotel, Antalya, Turkey
Description: This event is being held as a sequel of two rather big and long history conferences, International Conference on the 28th International Conference of The Jangjeon Mathematical Society. This conference welcomes speakers whose talk contents are mainly related to the following subjects: Pure and Computational and Applied Mathematics & Statistics Mathematical Physics (related to p-adic Analysis, Umbral Algebra and Their Applications) Special Sessions: Linear and multilinear algebra, Real and complex functions, Orthogonal polynomials and special numbers and functions, Fractional calculus and q-theory, Number theory and combinatorics, Approximation theory and optimization, Integral transformations equations and operational calculus, Partial differential equations, Numerical methods and algorithms, Scientific computation, Mathematical methods in physics and engineering.
Information: jms.akdeniz.edu.tr/en

* 17–23 **Sixteenth International Conference on Functional Equations and Inequalities (16th ICFEI)**, Mathematical Research and Conference Center of the Institute of Mathematics of the Polish Academy of Sciences, Bedlewo, Poland
Description: The 16th ICFEI is organized by the Department of Mathematics of the Pedagogical University of Cracow with financial support from the Stefan Banach International Mathematical Center.
Organizing Committee: Janusz Brzdek (chairman), Krzysztof Ciepliński (co-chairman), Anna Bahyrycz (vice-chairman), Magdalena Piszczek (vice-chairman), Zbigniew Leśniak (scientific secretary), Jolanta Olko (scientific secretary), Pawel Solarz and Janina Wiercioch.
Topics: The conference is devoted to functional equations and inequalities, their applications in various branches of mathematics and other scientific disciplines, as well as related topics. Besides regular (15–20 minutes long) talks, there will be also a few longer lectures delivered by leading specialists in the field. Moreover, a special session on the occasion of the 75th anniversary of Ulam's stability problem is planned, and several sessions devoted to problems and remarks will be organized.
Information: icfei.up.krakow.pl/16ICFEI/

* 19–21 **The 2015 Midwest Combinatorics Conference**, University of Minnesota, Minneapolis, MN USA
Description: The main topic of this NSF RTG supported conference is algebraic combinatorics. There is ample travel support for graduate students and postdocs, who are encouraged to attend.
Information: www.math.umn.edu/~stant001/MCC2015.html

* 26–29 **Conference on Risk Analysis ICRA 6/RISK 2015**, Barcelona, Spain
Description: The Centre de Recerca Matemàtica (CRM) as a collaborator in the Conference on Risk Analysis ICRA 6/RISK 2015 that will take place in Barcelona from May 26 to 29, 2015.
Further Information: www.uoc.edu/portal/en/symposia/icra6/index.html

* 27–29 **6th International Conference on Modeling, Simulation and Applied Optimization**, Yildiz Technical University, Istanbul,Turkey
Description: The ICMSAO conferences started in 2005 at the American University of Sharjah (AUS), United Arab Emirates (UAE) as an effort to bring together engineers and scientists from around the world to share research results and to discuss future activities related to the areas of modeling, simulation, and optimization. The great success of the first conference with about 300 papers continued at the Petroleum Institute in Abu Dhabi, UAE, at AUS, UAE, in Kuala Lumpur, Malaysia, in Hammamat, Tunis. Istanbul has been the capital of the Roman Empire, the Byzantine Empire, and the Ottoman Empire. The 2010 European Capital of Culture offers exciting historical and natural attractions. Please visit the website for special sessions.
Information: www.icmsao.org/

June 2015

* 1–5 **MAMERN VI-2015: 6th International Conference on Approximation Methods and Numerical Modeling in Environment and Natural Resources**, University of Pau, Pau, France
Description: Contact: mamern@univ-pau.fr. Deadline for submission of abstracts: February 1, 2015.
Topics: Approximation and modeling applied to environment sciences and natural resources; New applications and developments in approximation methods; Mathematics and computation in geosciences; Modeling of ecosystems; Oceanographic and coastal engineering; Numerical modeling of flow and transport in porous media; Mathematical analysis of models in porous media; Multi-Scale Modeling of Flow and Transport in Porous Media; Statistical modeling in geosciences; Stochastic partial differential equations. Selected papers from MAMERN VI-2015 will be published, after a refereeing process, as a special issue of the *Journal Mathematics and Computers in Simulation.* sciencedirect.com/science/journal/03784754/102
Information: mamern15.sciencesconf.org/

* 15–18 **Summer School, Mathematics in Savoie, MIS 2015 on "Evolution Equations: Long time behavior and control"**, Departement Mathematics, Laboratoire de Mathématiques, Université de Savoie, Campus scientifique, Chambéry, France
Description: The summer school consists in, 4 mini-courses of 1h30 given by Farid Ammar Khodja, entitled "Controllability of parabolic systems", 4 mini-courses of 1h30 given by Emmanuel Trélat entitled "Control and stabilization of nonlinear PDE's: Several tools and applications", 10 invited lectures and posters sessions. Young researchers are welcome to present a poster. There are no fees for people attending the workshop and the lunch meals are taken in charge by the organization. The lunch meals and the Conference dinner are free (taken in charge by the organization). The inscription is mandatory.
Organizers: Kaïs Ammari, UR Analysis and Control of PDE, University of Monastir, TUNISIA (kais.ammari@fsm.rnu.tn), Stéphane Gerbi, Laboratoire de Mathématiques, Université de Savoie, France (stephane.gerbi@univ-savoie.fr)
Information: lama.univ-savoie.fr/MIS2015/

* 15–19 **Nordfjordeid Summer School 2015 "Lie groups and pseudogroups actions: From classical to differential invariants"**, Sophus Lie Conference Center, Nordfjordeid, Norway.
Description: Three lectures and one practical session per day for five days in the inspiring atmosphere of Sophus Lie birthplace. The goal

of this summer school is to provide an introduction to the modern theory of classical and differential invariants and the methods for their computations. Recent years have seen advances in this theory, of which we name Lie-Tresse type theorems for finite generation of invariants, Bernstein-Gelfand-Gelfand technique in parabolic geometries, development of Cartan's method of equivalence and the method of equivariant moving frame, and the novel applications of Bott-Borel-Weil theorem. The invited speakers of the school are: Mike Eastwood (ANU, Canberra), Valentin Lychagin (UiT, Tromso), Peter Olver (UMN, Minnesota).
Information: serre.mat-stat.uit.no/slcc2015/Nordfjordeid-2015-Lie-theory.htm.

* 25 **7th National Dyscalculia & MLD Conference**, The Cumberland Hotel, London
Description: The Cumberland Hotel, London Target Audience: For all teachers of numeracy and maths, SENCos and Learning Support teachers, LA inclusion and numeracy support teams and Educational Psychologists.
Speakers: 2 keynotes: Professor Mike Askew, Freelance Consultant; Professor Brian Butterworth, Emeritus Professor of Cognitive Neuropsychology, UCL 3 Breakout sessions 12 Different workshops.
Information: www.dyscalculia-maths-difficulties.org.uk/

* 28–July 4 **CNRS-PAN Mathematics Summer Institute in Krakow**, Krakow, Poland
Description: CNRS-PAN Mathematics Summer Institute in Krakow Monday, June 29, 2015 (All day) to Saturday, July 4, 2015 (All day) CNRS-PAN Mathematics Summer Institute in Krakow, Monday June 28–Saturday July 4, 2015. *(6hrs)
Minicourses: Eric Carlen, Ansgar Juengel and Ari Laptev.
Invited talks, Sessions of contributed talks and young researchers/PhD students presentations: Analysis and its Applications, Partial Differential Equations, Probability and Stochastics, History of Mathematics.
Information: www.impan.pl/~peszat/workshop5.html

* 29–July 3 **Geometry and Symmetry**, University of Pannonia, Veszprém, Hungary
Description: The conference will celebrate the 60th birthdays in 2015 of Karoly Bezdek and Egon Schulte. The theme of the conference will be "Geometry and Symmetry", with emphasis on recent progress on aspects of discrete geometry in which Egon and Karoly have made remarkable contributions. The program of the conference will consist of invited lectures and contributed talks.
Information: geosym.mik.uni-pannon.hu/

* 28–July 4 **The Fifth International Mathematical Conference on Quasigroups and Loops -LOOPS 2015**, Faculty of Computer Science and Engineering, UKIM University, Congress Center, Ohrid, R. Macedonia.
Description: The fifth edition of the International Mathematical Conference on Quasigroups and Loops -LOOPS 2015- will take place in Ohrid, Macedonia from June 28 to July 4, 2015. It will be organized by the Faculty of Computer Science and Engineering, at UKIM University, Macedonia. All contributions in algebra, geometry, but also physics, coding theory and cryptography that use and contribute to the development of nonassociative structures are welcome at the conference.
Information: loops.finki.ukim.mk.

July 2015

* 6–10 **International Workshop on Operator Theory and Applications, IWOTA 2015**, Tbilisi, Georgia
Description: The IWOTA workshops bring together mathematicians and engineers working in operator theory and its applications to related fields, ranging from classical analysis, differential and integral equations, complex and harmonic analysis to mathematical physics, mathematical system and control theory, signal processing and numerical analysis. IWOTA gathers leading experts from all over the world for an intensive exchange of information and opinion, and for tracing the future developments in the field. A short history of IWOTA workshops, founded by Israel Gohberg, and the list of its managing body, the Steering Committee, can be found on the Web www.cs.vu.nl/~kaash/iwota.htm. The 26th International Workshop on Operator Theory and Applications (IWOTA 2015) will be organized in Tbilisi, Georgia, July 6 to 10, 2015 (arriving day July 5, departure day July 11). The venue of the conference will be chosen later among universities in Tbilisi.
Organizer: Georgian Mathematical Union
Hosted by: Georgian National Academy of Sciences & Ivane Javakhishvili Tbilisi State University,
Information: www.gmu.ge/iwota2015

* 12–16 **VI Annual International Conference of the Georgian Mathematical Union**, Batumi, Georgia
Description: VI Annual International Conference of the Georgian Mathematical Union, organized by Georgian mathematical union together with in Shota Rustaveli State university, Batumi, Black Sea resort of Georgia, is a satellite conference of IWOTA 2015 and will run from July 12, a day later after closing IWOTA 2015 in Tbilisi. There will be 4 plenary 1 hour and 16 invited 50 minute lectures in the mornings given by prominent mathematicians. Parallel session with 30 minute contributed talks are scheduled in the afternoon, where all participants might have a possibility to present their works. July 14 is a day of excursions. Batumi is a very fast developing city with the beautiful boulvard along the seashore and with plenty of possibilities to relax between or after sessions.
Organizer: Georgian Mathematical Union
Hosted by: Shota Rustaveli State University
Information: www.gmu.ge/Batumi2015

* 20–23 **ACA 2015: Applications of Computer Algebra**, Kalamata, Greece
Description: This conference is an annual meeting, devoted to promoting the applications and development of Computer Algebra and Symbolic Computation. Topics include computer algebra and symbolic computation in engineering, the sciences, medicine, pure and applied mathematics, education, communication and computer science.
Information: www.singacom.uva.es/ACA2015/

* 20–24 **9th International Symposium on Imprecise Probability: Theories and Applications**, Pescara, Italy
Description: ISIPTA is the primary international forum to present and discuss new results related to imprecise probability. We welcome both theoretical and applied original contributions. In this edition, we especially welcome papers connecting imprecise probabilities with related research in fields such as economics, philosophy, sociology, and engineering. There will be no parallel sessions.
Important Dates: January 30: Paper abstracts & preliminary papers; due February 13: Review-ready papers; due March 31: Conference hotel pre-reservation; deadline April 8: Paper notification; April 17: Poster-only abstracts; due May 6: Poster-only notification; May 29: Early-bird registration deadline (Euro350 full; Euro200 student)
Already Confirmed Invited Speakers: Massimo Marinacci, Department of Decision Sciences, Bocconi University, Milan, Italy; Itzhak Gilboa, Eitan Berglas School of Economics, Tel-Aviv University, Israel & HEC, Paris, France
Information: www.sipta.org/isipta15

August 2015

* 16–18 **Mathematics for Nonlinear Phenomena: Analysis and Computation - International Conference in honor of Professor Yoshikazu Giga on his sixtieth birthday**, Sapporo Convention Center, Sapporo, Japan.

Description: This conference, held in honor of Professor Yoshikazu Giga on his sixtieth birthday, brings together world-leading specialists in pure and applied mathematics to present latest topics in various fields. The primary aim of the conference is to boost interactions and in-depth discussions among researchers working in mathematics and related fields. The scope of the conference is intended to have a relatively broad appeal for both experts and young researchers including graduate students.
Organizers: Shuichi Jimbo (Hokkaido University)[Head], Shun'ichi Goto (Hokkaido University of Education), Yoshihito Kohsaka (Kobe University), Hideo Kubo (Hokkaido University), Yasunori Maekawa (Tohoku University), Masaki Ohnuma (The University of Tokushima)
Scientific Committee: Hideo Kozono (Waseda University), Takayoshi Ogawa (Tohoku University), Tohru Ozawa (Waseda University), Yoshihiro Tonegawa (Hokkaido University), Eiji Yanagida (Tokyo Institute of Technology)
Information: www.math.sci.hokudai.ac.jp/sympo/150816/index_en.html

* 25–27 **7th International Conference on Research and Education in Mathematics (ICREM7)**, Kuala Lumpur, Malaysia
Description: ICREM is a biennial event with the aims to bring together academicians, scientists and industrialists from around the country and the world for knowledge sharing, exchange idea, collaborate and present research results about all aspects of mathematics and its application. The conference will provide opportunities for the delegates to exchange new ideas and application experiences, to establish research or business relations, and to find global partners for future collaboration. The conference will include several invited papers on important and timely topics from well-known leaders in the field, and parallel tracks of oral presentation sessions of the accepted papers.
Information: einspem.upm.edu.my/icrem7/

September 2015

* 14–18 **The Seventh Symposium on Nonlinear Analysis**, Faculty of Mathematics and Computer Sciences, Nicolaus Copernicus University, Toruń, Poland
Objectives: This is the seventh conference in the series of Symposia on Nonlinear Analysis organized by the Schauder Center for Nonlinear Studies in Toruń, Poland (see www.cbn.umk.pl/en/). The main aim of the conference is to bring together specialists in different branches of nonlinear analysis and to offer them good opportunities for exchange of ideas, personal contacts, informal meetings and discussions.
Special Events: Two special events will be held during the conference. On September 14, 2015, the Awarding Ceremony of the Juliusz Schauder Medal for Professor Paul H. Rabinowitz from the University of Madison-Wisconsin, USA, which has been awarded for his outstanding achievements in the field of topological methods in nonlinear analysis. On September 17, the special session will be devoted to celebrate the 70th anniversary of the birth of Professor Andrzej Szulkin from the Stockholm University.
Information: www.sna2015.mat.umk.pl

* 27–October 2 **Mathematical Foundations of Traffic**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, CA
Description: The goal of this workshop is precisely to bring together communities which can mutually benefit from each other: Traffic engineering and mathematics. The mathematics community has historically provided the engineering community with the proper ways to scientifically derive results used in practice, and the engineering community has provided the mathematics community with a variety of interesting problems to study. The workshop will be divided into three parts.
Subtopics: The first subtopic, fundamental models, will assemble experts who have made initial models such as the LWR model progressively more complex because of the need to incorporate new data and paradigms. The second subtopic will assemble experts who have worked on integral forms of the LWR model, in particular the Hamilton-Jacobi model. In the third topic, extensions of traffic flow models to better fit reality will be discussed. Applications received by Monday, August 3, 2015 will receive fullest consideration.
Information: www.ipam.ucla.edu/programs/workshops/workshop-i-mathematical-foundations-of-traffic/?tab=overview

November 2015

* 16–December 25 **Stochastic Methods in Game Theory**, Institute for Mathematical Sciences, National University of Singapore, Singapore
Description: The program aims at showing the role of stochastic methods in strategic situations. Three workshops will focus on some aspects of the interaction between strategy and stochastics and its interest from a mathematical viewpoint. The first workshop will focus on learning. The second workshop will be about stochastic games. The third workshop will deal with congestion games.
Information: www2.ims.nus.edu.sg/Programs/015game/index.php

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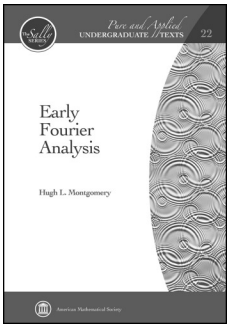
Analysis



Early Fourier Analysis

Hugh L. Montgomery, *University of Michigan, Ann Arbor, MI*

Hugh Montgomery has written a book which both students and faculty should appreciate. I wish it had been written 15 years ago so I could have shared it with students. It is a gem.

*–**Richard Askey**,*
University of Wisconsin-Madison

Montgomery has written an exquisite text combining basic material, exciting examples, advanced topics, wonderful historical notes, and excellent exercises. It is absolutely compelling and masterful!

*—**John Benedetto, University of Maryland***

This nice book is likely to be especially successful. I feel that the author has managed admirably to bring to light both the beauty and the usefulness of Fourier's idea, thus making the first introduction to Fourier analysis a joy for undergraduates. All the details are included in a way that is both attractive and easy for students to follow.

*—**Palle Jorgensen, University of Iowa, author of "Wavelets Through a Looking Glass"***

Fourier Analysis is an important area of mathematics, especially in light of its importance in physics, chemistry, and engineering. Yet it seems that this subject is rarely offered to undergraduates. This book introduces Fourier Analysis in its three most classical settings: The Discrete Fourier Transform for periodic sequences, Fourier Series for periodic functions, and the Fourier transform for functions on the real line.

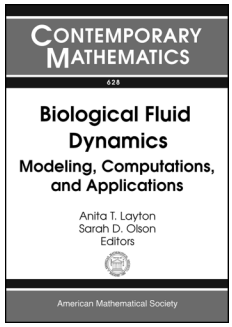
The presentation is accessible for students with just three or four terms of calculus, but the book is also intended to be suitable for a junior-senior course, for a capstone undergraduate course, or for beginning graduate students. Material needed from real analysis is quoted without proof, and issues of Lebesgue measure theory are treated rather informally. Included are a number of applications of Fourier Series, and Fourier Analysis in higher dimensions is briefly sketched. A student may eventually want to move on to Fourier Analysis discussed in a more advanced way, either by way of more general orthogonal systems, or in the language of Banach spaces, or of locally compact commutative groups, but the experience of the classical setting provides a mental image of what is going on in an abstract setting.

Contents: Background; Complex numbers; The discrete Fourier transform; Fourier coefficients and first Fourier series; Summability of Fourier series; Fourier series in mean square; Trigonometric polynomials; Absolutely convergent Fourier series; Convergence of Fourier series; Applications of Fourier series; The Fourier transform; Higher dimensions; Appendix B. The binomial theorem; Appendix C. Chebyshev polynomials; Appendix F. Applications of the fundamental theorem of algebra; Appendix I. Inequalities; Appendix L. Topics in linear algebra; Appendix O. Orders of magnitude; Appendix T. Trigonometry; References; Notation; Index.

Pure and Applied Undergraduate Texts, Volume 22

January 2015, 388 pages, Hardcover, ISBN: 978-1-4704-1560-0, LC 2014035196, 2010 *Mathematics Subject Classification:* 42-01, **AMS members US$61.60**, List US$77, Order code AMSTEXT/22

Applications



Biological Fluid Dynamics: Modeling, Computations, and Applications

Anita T. Layton, *Duke University, Durham, NC*, and **Sarah D. Olson**, *Worcester Polytechnic Institute, MA*, Editors

This volume contains the Proceedings of the AMS Special Session on Biological Fluid Dynamics: Modeling, Computations, and Applications, held on October 13, 2012, at Tulane University, New Orleans, Louisiana.

In recent years, there has been increasing interest in the development and application of advanced computational techniques for simulating fluid motion driven by immersed flexible structures. That interest is motivated, in large part, by the multitude of applications in physiology and biology. In some biological systems, fluid motion is driven by active biological tissues, which are typically constructed of fibers that are surrounded by fluid. Not only do the fibers hold the tissues together, they also transmit forces that ultimately result in

fluid motion. In other examples, the fluid may flow through conduits such as blood vessels or airways that are flexible or active. That is, those conduits may react to and affect the fluid dynamics.

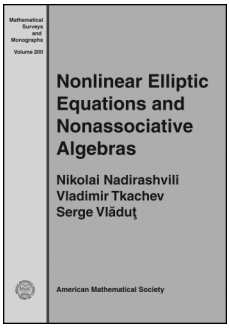
This volume responds to the widespread interest among mathematicians, biologists, and engineers in fluid-structure interactions problems. Included are expository and review articles in biological fluid dynamics. Applications that are considered include ciliary motion, upside-down jellyfish, biological feedback in the kidney, peristalsis and dynamic suction pumping, and platelet cohesion and adhesion.

Contents: S. D. Olson and **A. T. Layton**, Simulating biofluid-structure interactions with an immersed boundary framework—A review; **L. T. Zhang**, **C. Wang**, and **X. Wang**, The development and advances of the immersed finite element method; **K. J. Karpman**, Simulating mucociliary transport using the method of regularized Stokeslets; **K. Leiderman**, **E. L. Bouzarth**, and **H.-N. Nguyen**, A regularization method for the numerical solution of doubly-periodic Stokes flow; **Y.-N. Young**, Dynamics of a primary cilium in time-periodic flows; **S. D. Olson**, Motion of filaments with planar and helical bending waves in a viscous fluid; **A. Baird**, **T. King**, and **L. A. Miller**, Numerical study of scaling effects in peristalsis and dynamic suction pumping; **T. Skorczewski**, **B. Griffith**, and **A. L. Fogelson**, Multi-bond models for platelet adhesion and cohesion; **C. L. Hamlet** and **L. A. Miller**, Effects of grouping behavior, pulse timing, and organism size on fluid flow around the upside-down jellyfish, *Cassiopea xamachana*; **A. T. Layton**, Impacts of facilitated urea transporters on the urine-concentrating mechanism in the rat kidney; **H. Ryu** and **A. Layton**, Feedback-mediated dynamics in a model of coupled nephrons with compliant short loop of Henle.

Contemporary Mathematics, Volume 628

November 2014, 240 pages, Softcover, ISBN: 978-0-8218-9850-5, LC 2014011913, 2010 *Mathematics Subject Classification:* 76M25, 76Z05, 74F10, 35Q92, 92C35, 92B05, 92C05, 92C10, 62P10, **AMS members US$72.80**, List US$91, Order code CONM/628

Differential Equations



Nonlinear Elliptic Equations and Nonassociative Algebras

Nikolai Nadirashvili, *Aix-Marseille University, France*, **Vladimir Tkachev**, *Linköping University, Sweden*, and **Serge Vlăduţ**, *Aix-Marseille University, France*

This book presents applications of noncommutative and nonassociative algebras to constructing unusual (nonclassical and singular) solutions to fully nonlinear elliptic partial differential equations of second order. The methods described in the book are used to solve a longstanding problem of the existence of truly weak, nonsmooth viscosity solutions. Moreover, the authors provide an almost complete description of homogeneous solutions to fully nonlinear elliptic equations. It is shown that even in the very restricted setting of "Hessian equations", depending only on the eigenvalues of the Hessian, these equations admit homogeneous solutions of all orders compatible with known regularity for viscosity solutions provided the space dimension is five or larger. To the contrary, in dimension four or less the situation is completely different, and our results suggest strongly that there are no nonclassical homogeneous solutions at all in dimensions three and four.

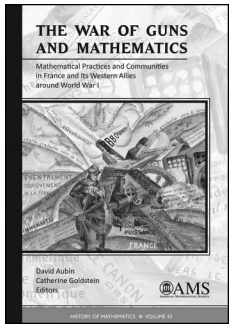
Thus this book gives a complete list of dimensions where nonclassical homogeneous solutions to fully nonlinear uniformly elliptic equations do exist; this should be compared with the situation of, say, ten years ago when the very existence of nonclassical viscosity solutions was not known.

Contents: Nonlinear elliptic equations; Division algebras, exceptional Lie groups, and calibrations; Jordon algebras and the Cartan isoparametric cubics; Solutions from trialities; Solutions from isoparametric forms; Cubic minimal cones; Singular solutions in calibrated geometries; Bibliography; Notation; Index.

Mathematical Surveys and Monographs, Volume 200

January 2015, 240 pages, Hardcover, ISBN: 978-1-4704-1710-9, LC 2014028806, 2010 *Mathematics Subject Classification:* 17Cxx, 17Dxx, 35J60; 16H05, 17A35, 49Q05, 53C38, **AMS members US$72**, List US$90, Order code SURV/200

General Interest



The War of Guns and Mathematics

Mathematical Practices and Communities in France and Its Western Allies around World War I

David Aubin, *Sorbonne Universités, Université Pierre et Marie Curie, Institut de mathématiques de Jussieu-Paris Rive Gauche, France*, and **Catherine Goldstein**, *CNRS, Institut de mathématiques de Jussieu-Paris Rive Gauche, France*, Editors

For a long time, World War I has been shortchanged by the historiography of science. Until recently, World War II was usually considered as the defining event for the formation of the modern relationship between science and society. In this context, the effects of the First World War, by contrast, were often limited to the massive deaths of promising young scientists.

By focusing on a few key places (Paris, Cambridge, Rome, Chicago, and others), the present book gathers studies representing a broad spectrum of positions adopted by mathematicians about the conflict, from militant pacifism to military, scientific, or ideological mobilization. The use of mathematics for war is thoroughly examined.

This book suggests a new vision of the long-term influence of World War I on mathematics and mathematicians. Continuities and discontinuities in the structure and organization of the mathematical sciences are discussed, as well as their images in various milieux. Topics of research and the values with which they were defended

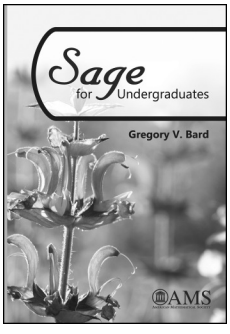
are scrutinized. This book, in particular, proposes a more in-depth evaluation of the issue of modernity and modernization in mathematics.

The issue of scientific international relations after the war is revisited by a close look at the situation in a few Allied countries (France, Britain, Italy, and the USA). The historiography has emphasized the place of Germany as the leading mathematical country before WWI and the absurdity of its postwar ostracism by the Allies. The studies presented here help explain how dramatically different prewar situations, prolonged interaction during the war, and new international postwar organizations led to attempts at redrafting models for mathematical developments.

Contents: D. Aubin and **C. Goldstein**, Placing World War I in the history of mathematics; *Starting Up:* **J. Barrow-Green**, Cambridge mathematicians' responses to the First World War; **D. Aubin**, **H. Gispert**, and **C. Goldstein**, The total war of Paris mathematicians; *Joining In:* **P. Nastasi** and **R. Tazzioli**, Italian mathematicians and the First World War: Intellectual debates and institutional innovations; **T. Archibald**, **D. Dumbaugh**, and **D. Kent**, A mobilized community: Mathematicians in the United States during the First World War; *Moving On:* **J.-L. Chabert** and **C. Gilain**, Debating the place of mathematics at the École polytechnique around World War I; **D. Aubin**, "I'm just a mathematician": Why and how mathematicians collaborated with military ballisticians at Gâvre; *Crossing Through:* **L. Rollet** and **P. Nabonnand**, Why aerodynamics failed to take off in Nancy: An unexpected casualty of World War I; Index.

History of Mathematics, Volume 42

October 2014, 391 pages, Hardcover, ISBN: 978-1-4704-1469-6, LC 2014012563, 2010 *Mathematics Subject Classification:* 01-02, 01A60, 65-03, 70-03, 97-03, **AMS members US$100.80**, List US$126, Order code HMATH/42



Sage for Undergraduates

Gregory V. Bard, *University of Wisconsin–Stout, Menomonie, WI*

Professor Bard has provided a valuable service by carefully explaining everything an undergraduate student of mathematics, or a teacher of these topics, needs to get started with Sage quickly and easily. It will also be useful for any student or teacher of another STEM discipline. There is an excellent mix of the most frequently used commands, along with warnings about common pitfalls or caveats. I highly recommend it for anyone new to Sage, or who desires an overview of the system's impressive capabilities.

—Robert A. Beezer, University of Puget Sound

This book is a sort of "Missing Manual" that explains how Sage can be used in a range of standard mathematics courses, instead of targeting specialists like much existing Sage documentation. The depth of content is very impressive, and describes—in a single coherent narrative—how to successfully use Sage for a wide swath of undergraduate applied topics.

—William Stein, University of Washington, Seattle

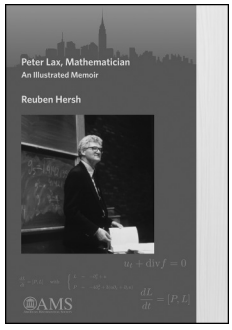
As the open-source and free competitor to expensive software like Maple™, Mathematica®, Magma, and MATLAB®, Sage offers anyone with access to a web browser the ability to use cutting-edge mathematical software and display his or her results for others, often with stunning graphics. This book is a gentle introduction to Sage for undergraduate students toward the end of Calculus II (single-variable integral calculus) or higher-level course work such as Multivariate Calculus, Differential Equations, Linear Algebra, or Math Modeling.

The book assumes no background in computer science, but the reader who finishes the book will have learned about half of a first semester Computer Science I course, including large parts of the Python programming language. The audience of the book is not only math majors, but also physics, engineering, finance, statistics, chemistry, and computer science majors.

This item will also be of interest to those working in number theory, analysis, and applications.

Contents: Welcome to Sage!; Fun projects using Sage; Advanced plotting techniques; Advanced features of Sage; Programming in Sage and Python; Building interactive webpages with Sage; What to do when frustrated!; Transitioning to SageMathCloud; Other resources for Sage; Linear systems with infinitely many solutions; Installing Sage on your personal computer; Index of commands by name and by section.

February 2015, approximately 362 pages, Softcover, ISBN: 978-1-4704-1111-4, 2010 *Mathematics Subject Classification:* 15-04, 34-04, 65-04, 90-04, 97M10; 11-04, 12-04, 28-04, 40-04, 68U05, **All Individuals US$21.75**, List US$29, Institutional member US$23.20, Order code MBK/87



Peter Lax, Mathematician

An Illustrated Memoir

Reuben Hersh, *University of New Mexico, Albuquerque, NM*

This book is a biography of one of the most famous and influential living mathematicians, Peter Lax. He is virtually unique as a preeminent leader in both pure and applied mathematics, fields which are often seen as competing and incompatible. Although he has been an academic for all of his adult life, his biography is not without drama and tragedy. Lax and his family barely escaped to the U.S. from Budapest before the Holocaust descended. He was one of the youngest scientists to work on the Manhattan Project. He played a leading role in coping with the infamous "kidnapping" of the NYU mathematics department's computer, in 1970.

The list of topics in which Lax made fundamental and long-lasting contributions is remarkable: scattering theory, solitons, shock waves, and even classical analysis, to name a few. His work has been honored many times, including the Abel Prize in 2005. The book concludes with an account of his most important mathematical contributions, made accessible without heavy prerequisites.

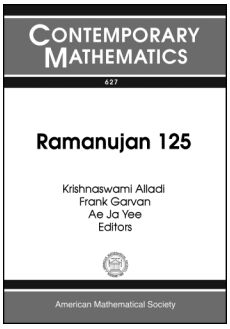
Reuben Hersh has written extensively on mathematics. His book with Philip Davis, *The Mathematical Experience*, won the National Book Award in science. Hersh is emeritus professor of mathematics at the University of New Mexico.

Contents: A prodigy and his family have a narrow escape; Manhattan, NY, and Manhattan Project. An army private among the "Martians"; Photo section; Family life: Son, husband, father, grandfather; Early career; The famous CDC 6600 bomb-scare adventure; Later career; The queen of Norway; Books; Pure AND applied, not VERSUS applied; Difference schemes. Shocks. Solitons. Scattering. Lax-Milgram. Polya's curve. Etc.; Epilogue; Anneli Lax; John von Neumann: The early years, the years at Los Alamos, and the road to computing; The life of

Richard Courant; Curriculum vitae; The closed graph theorem; List of doctoral students (from the Mathematics Genealogy Project); *John Lax:* Introduction to John Lax; From *A Liberal Education*, by Abbott Gleason, pages 314–317, on John Lax; John Lax article on Chicago jazz musicians; Notes; References; Index.

February 2015, approximately 275 pages, Softcover, ISBN: 978-1-4704-1708-6, 2010 *Mathematics Subject Classification:* 01A60, 01A70, 01A72, 35A21, 35L05, 35L40, 76L05, 65M06, 35C08, 35Q53, **AMS members US$28**, List US$35, Order code MBK/88

Number Theory



Ramanujan 125

Krishnaswami Alladi and **Frank Garvan**, *University of Florida, Gainesville, FL*, and **Ae Ja Yee**, *Pennsylvania State University, University Park, PA*, Editors

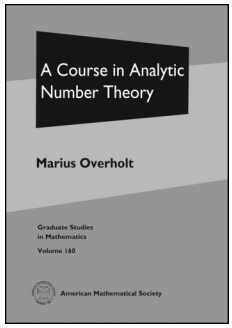
This volume contains the proceedings of an international conference to commemorate the 125th anniversary of Ramanujan's birth, held from November 5–7, 2012, at the University of Florida, Gainesville, Florida.

Srinivasa Ramanujan was India's most famous mathematician. This volume contains research and survey papers describing recent and current developments in the areas of mathematics influenced by Ramanujan. The topics covered include modular forms, mock theta functions and harmonic Maass forms, continued fractions, partition inequalities, q-series, representations of affine Lie algebras and partition identities, highly composite numbers, analytic number theory and quadratic forms.

Contents: S. Ahlgren and **N. Andersen**, Hecke grids and congruences for weakly holomorphic modular forms; **G. E. Andrews**, Knots and q-series; **A. Berkovich** and **K. Grizzell**, A partition inequality involving products of two q-Pochhammer symbols; **B. C. Berndt**, **S. Kim**, and **A. Zaharescu**, Analogues of Koshliakov's formula; **G. Bhatnagar**, How to prove Ramanujan's q-continued fractions; **H. M. Farkas**, **J. Y. Kaminski**, and **E. Yakubov**, A nonsingular Z_3 curve of genus 4; **A. Folsom**, **K. Ono**, and **R. C. Rhoades**, Ramanujan's radial limits; **M. D. Hirschhorn**, An identity that may have changed the course of history; **C. Krattenthaler** and **M. J. Schlosser**, The major index generating function of standard Young tableaux of shapes of the form "staircase minus rectangle"; **L. Lorentzen**, Convergence of random continued fractions; **K. C. Misra** and **E. A. Wilson**, Tensor product decomposition of $\widehat{\mathfrak{sl}}(n)$ modules and identities; **J.-L. Nicolas** and **J. Sondow**, Ramanujan, Robin, highly composite numbers, and the Riemann hypothesis; **C.-T. Perng**, A quaternionic proof of the representation formulas of two quaternary quadratic forms.

Contemporary Mathematics, Volume 627

October 2014, 174 pages, Softcover, ISBN: 978-1-4704-1078-0, LC 2014010726, 2010 *Mathematics Subject Classification:* 05A19, 11A25, 11E25, 11F33, 11F37, 11P84, 14K25, 17B67, 30B70, 33D15, **AMS members US$62.40**, List US$78, Order code CONM/627



A Course in Analytic Number Theory

Marius Overholt, *University of Tromso, Norway*

This book is an introduction to analytic number theory suitable for beginning graduate students. It covers everything one expects in a first course in this field, such as growth of arithmetic functions, existence of primes in arithmetic progressions, and the Prime Number Theorem. But it also covers more challenging topics that might be used in a second course, such as the Siegel-Walfisz theorem, functional equations of L-functions, and the explicit formula of von Mangoldt. For students with an interest in Diophantine analysis, there is a chapter on the Circle Method and Waring's Problem. Those with an interest in algebraic number theory may find the chapter on the analytic theory of number fields of interest, with proofs of the Dirichlet unit theorem, the analytic class number formula, the functional equation of the Dedekind zeta function, and the Prime Ideal Theorem.

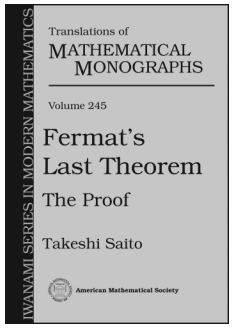
The exposition is both clear and precise, reflecting careful attention to the needs of the reader. The text includes extensive historical notes, which occur at the ends of the chapters. The exercises range from introductory problems and standard problems in analytic number theory to interesting original problems that will challenge the reader.

The author has made an effort to provide clear explanations for the techniques of analysis used. No background in analysis beyond rigorous calculus and a first course in complex function theory is assumed.

Contents: Arithmetic functions; Topics on arithmetic functions; Characters and Euler products; The circle method; The method of contour integrals; The prime number theorem; The Siegel-Walfisz theorem; Mainly analysis; Euler products and number fields; Explicit formulas; Supplementary exercises; Bibliography; List of notations; Index.

Graduate Studies in Mathematics, Volume 160

January 2015, 371 pages, Hardcover, ISBN: 978-1-4704-1706-2, LC 2014030882, 2010 *Mathematics Subject Classification:* 11-01, 11A25, 11Mxx, 11N05, 11N13, 11P55, 11R42, 11R44, **AMS members US$63.20**, List US$79, Order code GSM/160



Fermat's Last Theorem

The Proof

Takeshi Saito, *University of Tokyo, Japan*

This is the second volume of the book on the proof of Fermat's Last Theorem by Wiles and Taylor (the first volume is published in the same series; see MMONO/243). Here the detail of the proof announced in the first volume is fully exposed. The book also includes basic materials and constructions in number theory and arithmetic geometry that are used in the proof.

In the first volume the modularity lifting theorem on Galois representations has been reduced to properties of the deformation rings and the Hecke modules. The Hecke modules and the Selmer

groups used to study deformation rings are constructed, and the required properties are established to complete the proof.

The reader can learn basics on the integral models of modular curves and their reductions modulo p that lay the foundation of the construction of the Galois representations associated with modular forms. More background materials, including Galois cohomology, curves over integer rings, the Néron models of their Jacobians, etc., are also explained in the text and in the appendices.

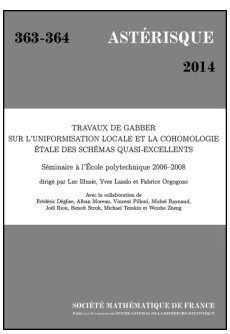
Contents: Modular curves over **Z**; Modular forms and Galois representations; Hecke modules; Selmer groups; Curves over discrete valuation rings; Finite commutative group scheme over $\mathbf{Z}_p$; Jacobian of a curve and its Néron model; Bibliography; Symbol index; Subject index.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*), Volume 245

January 2015, approximately 234 pages, Softcover, ISBN: 978-0-8218-9849-9, LC 2013023932, 2010 *Mathematics Subject Classification:* 11D41; 11F11, 11F80, 11G05, 11G18, **AMS members US$43.20**, List US$54, Order code MMONO/245

New AMS-Distributed Publications

Algebra and Algebraic Geometry



Travaux de Gabber sur L'uniformisation Locale et la Cohomologie Étale des Schémas Quasi-Excellents

Luc Illusie, *Université Paris-Sud, Orsay, France*, **Yves Laszlo**, *École Normale Supérieure, Paris, France*, and **Fabrice Orgogozo**, *École Polytechnique, Palaiseau, France*, Editors
with the collaboration of F. Déglise, A. Morau, V. Pilloni, M. Raynaud, J. Riou, B. Stroh, M. Temkin, and W. Zheng

A note to readers: This book is in French.

The work of Ofer Gabber presented in this book can be roughly divided into two closely related parts: a geometric one and a cohomological one. The first part contains local uniformization theorems which state that any pair consisting of a quasi-excellent noetherian scheme and a nowhere dense closed subscheme becomes isomorphic, after localization by suitable étale morphisms and alterations, to a pair consisting of a regular scheme and a normal crossings divisor. These are local results, but their proofs have global theorems as corollaries, refining alteration theorems of de Jong for schemes of finite type over a field or a Dedekind ring. Techniques from logarithmic geometry and, concerning the finest results, canonical desingularization in characteristic zero, play a key role in the proofs.

In the second part, the book gives applications, with examples and counterexamples, to abelian finiteness theorems, as well as theorems on cohomological dimension and duality in étale cohomology over quasi-excellent schemes. In particular, Grothendieck's local duality conjecture is proved, and his absolute cohomological purity conjecture is proved by a new method. Non-abelian rigidity and finiteness results are also established in the final exposés.

This item will also be of interest to those working in number theory.

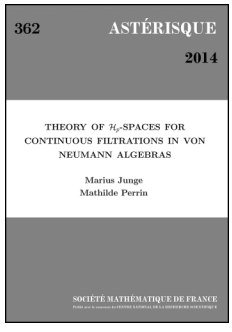
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

For the table of contents, go to `www.ams.org/bookstore`.

Astérisque, Number 363, Number 364

October 2014, 619 pages, Softcover, ISBN 978-2-85629-790-2, 2010 *Mathematics Subject Classification:* 12F15, 12G05, 12G10, 12L10, 13B02, 13B40, 13F40, 13H05, 13J10, 14B05, 14E15, 14F17, 14F20, 14L30, 18F10, 20M32, **AMS members US$168**, List US$210, Order code AST/363/364

Analysis



Theory of $\mathcal{H}_p$-Spaces for Continuous Filtrations in von Neumann Algebras

Marius Junge, *University of Illinois at Urbana-Champaign*, and **Mathilde Perrin**, *Consejo Superior de Investigaciones Cientificas, Madrid, Spain*

The authors introduce Hardy spaces for martingales with respect to continuous filtration for von Neumann algebras. In particular they prove the analogues of the Burkholder-Gundy and Burkholder-Rosenthal inequalities in this setting. The usual arguments using stopping times in the commutative case are replaced by tools from noncommutative function theory and allow the authors to obtain the analogue of the Feffermann-Stein duality and prove a noncommutative Davis decomposition.

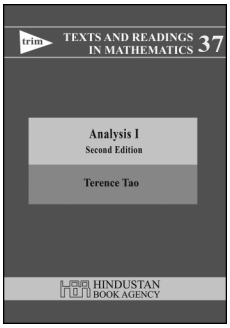
This item will also be of interest to those working in probability and statistics.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Preliminaries; The $\mathcal{H}_p^c$-spaces; Burkholder-Gundy inequalities; The h_p^c-spaces; Davis and Burkholder-Rosenthal inequalities; Appendix; Bibliography.

Astérisque, Number 362

October 2014, 134 pages, Softcover, ISBN: 978-2-85629-789-6, 2010 *Mathematics Subject Classification:* 46L53, 46L52; 46L51, 60G44, **AMS members US$28.80**, List US$36, Order code AST/362



Analysis I

Third Edition

Terence Tao, *University of California, Los Angeles*

From a review of the first edition:

…it would be an error not to stick very close to the text—it's very well crafted indeed and deviating from the score would mean an unacceptable dissonance.

I hope to use Analysis I, II *in an honors course myself, when the opportunity arises.*

– ***Michael Berg, for MAA Reviews***

This is part one of a two-volume introduction to real analysis and is intended for honours undergraduates who have already been exposed to calculus. The emphasis is on rigour and on foundations. The material starts at the very beginning—the construction of the number systems and set theory—then goes on to the basics of analysis (limits, series, continuity, differentiation, Riemann integration), through to power series, several variable calculus and Fourier analysis, and finally to the Lebesgue integral. These are almost entirely set in the concrete setting of the real line and Euclidean spaces, although there is some material on abstract metric and topological spaces. There are also appendices on mathematical logic and the decimal system. The entire text (omitting some less central topics) can be taught in two quarters of twenty-five to thirty lectures each.

The course material is deeply intertwined with the exercises, as it is intended that the student actively learn the material (and practice thinking and writing rigorously) by proving several of the key results in the theory.

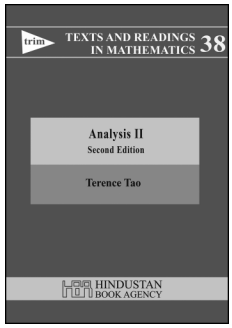
In the third edition, several typos and other errors have been corrected and a few new exercises have been added.

A publication of Hindustan Book Agency; distributed within the Americas by the American Mathematical Society. Maximum discount of 20% for all commercial channels.

Contents: *Volume 1:* Introduction; Starting at the beginning: The natural numbers; Set theory; Integers and rationals; The real numbers; Limits of sequences; Series; Infinite sets; Continuous functions on **R**; Differentiation of functions; The Riemann integral; Appendix A: The basics of mathematical logic; Appendix B: The decimal system.

Hindustan Book Agency

October 2014, 368 pages, Hardcover, ISBN: 978-93-80250-64-9, 2010 *Mathematics Subject Classification:* 26A03, 26A42, 26B05, 26B10, **AMS members US$40**, List US$50, Order code HIN/66



Analysis II

Third Edition

Terence Tao, *University of California, Los Angeles*

This is part two of a two-volume introduction to real analysis and is intended for honours undergraduates who have already been exposed to calculus. The emphasis is on rigour and on foundations. The material starts at the very beginning—the construction of the number systems and set theory—then goes on to the basics of analysis (limits, series, continuity, differentiation, Riemann integration), through to power series, several variable calculus and Fourier analysis, and finally to the Lebesgue integral. These are almost entirely set in the concrete setting of the real line and Euclidean spaces, although there is some material on abstract metric and topological spaces. There are also appendices on mathematical logic and the decimal system. The entire text (omitting some less central topics) can be taught in two quarters of twenty-five to thirty lectures each.

The course material is deeply intertwined with the exercises, as it is intended that the student actively learn the material (and practice thinking and writing rigorously) by proving several of the key results in the theory.

In the third edition, several typos and other errors have been corrected and a few new exercises have been added.

A publication of Hindustan Book Agency; distributed within the Americas by the American Mathematical Society. Maximum discount of 20% for all commercial channels.

Contents: *Volume 2:* Metric spaces; Continuous functions on metric spaces; Uniform convergence; Power series; Fourier series; Several variable differential calculus; Lebesgue measure; Lebesgue integration.

Hindustan Book Agency

October 2014, 236 pages, Hardcover, ISBN: 978-93-80250-65-6, 2010 *Mathematics Subject Classification:* 26A03, 26A42, 26B05, 26B10, **AMS members US$32**, List US$40, Order code HIN/67

Geometry and Topology

Abstract Analogues of Flux as Symplectic Invariants

Paul Seidel, *Massachusetts Institute of Technology, Cambridge, MA*

The author studies families of objects in Fukaya categories, specifically ones whose deformation behaviour is prescribed by the choice of an odd degree cohomology class. This leads to invariants of symplectic manifolds, which we apply to blowups along symplectic mapping tori.

This item will also be of interest to those working in algebra and algebraic geometry.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Families of objects; The two-torus; Symplectic automorphisms; Symplectic mapping tori; Blowing up; Bibliography.

Mémoires de la Société Mathématique de France, Number 137

October 2014, 135 pages, Softcover, ISBN: 978-2-85629-788-9, 2010 *Mathematics Subject Classification:* 53D40, 16E45, **AMS members US$36**, List US$45, Order code SMFMEM/137

Classified Advertisements

Positions available, items for sale, services available, and more

CALIFORNIA

UNIVERSITY OF CALIFORNIA LOS ANGELES
Institute for Pure and Applied Mathematics

The Institute for Pure and Applied Mathematics (IPAM) at UCLA is seeking an Associate Director (AD), to begin a two-year appointment on August 1, 2015. The AD is expected to be an active and established research mathematician or scientist in a related field, with experience in conference organization. The primary responsibility of the AD will be running individual programs in coordination with the organizing committees. The selected candidate will be encouraged to continue his or her personal research program within the context of the responsibilities to the institute. For a detailed job description and application instructions, go to www.ipam.ucla.edu/adsearch. Applications will receive fullest consideration if received by February 15, 2015, but we will accept applications as long as the position remains open. UCLA is an Equal Opportunity/Affirmative Action Employer.

000007

MISSOURI

UNIVERSITY OF CENTRAL MISSOURI
Tenure-Track Position in Actuarial Science and Mathematics (#998450)

The Department of Mathematics and Computer Science at the University of Central Missouri (UCM) invites applications for a tenure-track assistant professor position in Actuarial Science and Mathematics to begin in August 2015.

Applicants must have a PhD degree in actuarial science, mathematics, or statistics by August 10, 2015. Successful candidates should be able to teach a variety of undergraduate and master's level courses, including graduate courses in analysis and statistics. Preference will be given to candidates who are in the process of, or interested in, achieving an Associate or Fellow designation in the Society of Actuaries and can contribute to UCM earning the Centers of Actuarial Excellence designation. The Associate or Fellow designation in the Society of Actuaries must be obtained before promotion and tenure consideration.

Initial screening of applications begins January 15, 2015, and continues until position is filled. For more information about the position and the application process, visit www.ucmo.edu/math-cs/openings.cfm.

000006

NEW YORK

CLARKSON UNIVERSITY
Department of Mathematics

Clarkson University Department of Mathematics (www.clarkson.edu/math) invites applications for a tenure-track Assistant Professor position in statistics or applied mathematics starting in August 2015.

We are especially interested in candidates with expertise in statistics and computational areas of applied mathematics, but all areas of applied mathematics will be considered. Responsibilities will include teaching undergraduate and graduate level mathematics courses, and directing graduate students. Minimum requirements are a PhD in mathematics or statistics by the date of appointment, demonstrated excellence in both research potential and teaching ability, and fluency in English. In addition, the candidate should be able to interact with other faculty in the department and the university.

Applications including vita and three reference letters should be submitted to https://clarkson.peopleadmin.com/. Completed applications will be reviewed starting immediately. Women and minorities are urged to apply. Clarkson University is an AA/EOE Employer.

000002

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 2015 rate is $3.50 per word with a minimum two-line headline. 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: February 2015 issue–December 8, 2014; March 2015 issue–January 2, 2015; April 2015 issue–January 29, 2015; May 2015 issue–March 2, 2015; June/July 2015 issue–April 29, 2015; August 2015 issue –May 29, 2015.

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.

RHODE ISLAND

ICERM
Institute for Computational and Experimental Research in Mathematics
Director Search Announcement

The Board of Trustees of the Institute for Computational and Experimental Research in Mathematics (ICERM) and Brown University seek a new director of ICERM for an appointment to begin between August 2015 and July 2016. The Director will serve as the scientific and administrative leader of the institute and will be a distinguished member of the Brown faculty.

The successful candidate will possess outstanding scholarly credentials, including a PhD, as well as demonstrated academic leadership experience. The Director will hold a tenured position at Brown University in the Department of Mathematics or the Division of Applied Mathematics, or jointly in at least one of these departments. Preference will be given to applicants whose research interests align with the mission of ICERM. Although the Director will have no formal teaching obligations, the Director's faculty appointment will carry some expectation of service both to the department(s) in which the Director is appointed and to the university. The term of the appointment as Director of ICERM ends August 2020, and may be renewed.

The search committee consists of members of the ICERM Board of Trustees and faculty in Mathematics and Applied Mathematics.

Applicants should submit a cover letter and CV to director@icerm.brown.edu. Review of applications will begin January 15, 2015, and applications will be accepted until the position is filled. For more information, contact Jeffrey Brock, Chair of Mathematics or Bjorn Sandstede, Chair of Applied Mathematics, or go to icerm.brown.edu.

Brown University is committed to fostering a diverse and inclusive academic global community; as an EEO/AA Employer, Brown considers applicants for employment without regard to, and does not discriminate on the basis of, gender, race, protected veteran status, disability, or any other legally protected status.

000004

TEXAS

TEXAS TECH UNIVERSITY
Department of Mathematics and Statistics

The Department of Mathematics and Statistics (M&S) at Texas Tech University invites applications for four tenure-track assistant professor positions beginning fall 2015. A PhD degree at the time of appointment is required. M&S has active research groups in both pure and applied mathematics and in statistics (see www.math.ttu.edu/FacultyStaff/research.shtml). The department fosters a spirit of interdisciplinary collaboration across areas of mathematics and statistics as well as with engineering and the physical and biological sciences. M&S is seeking candidates who will be engaged in nationally visible scholarship, establish externally-funded research programs, interact with the existing research groups in the department, participate in interdisciplinary collaborations and service, involve graduate students in their research, and show excellence in teaching at the graduate and undergraduate levels.

One position will be in statistics, with a preference for candidates in probability theory/stochastic processes. The second position will be in biostatistics, with a preference for candidates who will collaborate with researchers in environmental toxicology, biological sciences and/or public health. The third position will be complex analysis and/or applications of complex analysis. The fourth position will be in mathematical and computational modelling, with a preference for candidates who will collaborate with researchers in biomathematics, applied mathematics and/or computational mathematics. Candidates with very strong records who will bring externally sponsored research to Texas Tech will be considered for associate or full professor ranks.

Please apply, using the Requisition ID 1818BR, at www.texastech.edu/careers/. Include a completed AMS standard cover sheet and a vita.

Three letters of reference plus any material in addition to that completed online should be sent to:

Alex Wang, Hiring Committee Chair, Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042. alex.wang@ttu.edu.

Review of applications will begin immediately.

Texas Tech University is committed to diversity among its faculty. We strongly encourage applications from women, minorities, persons with disabilities, and veterans, and we consider the needs of dual career couples.

Texas Tech University is an Affirmative Action/Equal Opportunity Employer.

000104

WASHINGTON, DC

HOWARD UNIVERSITY
Chair, Department of Mathematics

The Howard University College of Arts & Sciences invites applications for the position of Chairperson, Department of Mathematics, to begin as soon as possible but no later than July 1, 2015. The successful candidate will have excellent interpersonal and leadership skills and will have the vision and ability to bring the department to the next level of both national and international recognition and achievement.

The candidate will hold a PhD in mathematics; will have achieved an outstanding record of teaching experience, scholarly productivity, and professional and community service; will have an easily understood vision for the department; will have exhibited leadership in planning, budgeting, and other fiscal affairs; and will exhibit an understanding of and a commitment to the mission of Howard University.

In addition, the candidate should meet the following criteria:

- Ability to build an effective team and inspire teamwork in accomplishing the goals of the Department of Mathematics.
- Ability to recruit and retain high quality students and faculty members for the Department of Mathematics.
- Ability to manage a budget and administer it in the best interests of the Department of Mathematics.
- Ability to obtain financial support from government, foundations, agencies, and private sources.
- A keen sensitivity to the needs of staff members in the area of professional development.
- An awareness of curricular and pedagogical designs necessary for the production of educators who must meet the demands of their disciplines.
- An understanding of the connectedness between the Department of Mathematics and other departments, schools and colleges of the Univesity and its constituent community.

Each candidate should submit a CV, a letter of application that addresses his/her teaching, research, service, and administrative experience, and contact information for at least three references to: NHindman@howard.edu.

A statement of the mission of Howard University is available at www.founders.howard.edu/presidentReports/Mission.htm. More information about the position is available at www.coas.howard.edu/positions/.

Howard University is an Equal Opportunity/Affirmative Action Employer.

000005

WISCONSIN

THE MILWAUKEE SCHOOL OF ENGINEERING
Mathematics Faculty

The Milwaukee School of Engineering (MSOE) invites applications for a full-time mathematics faculty position starting in Fall 2015. The department has new and growing programs in Actuarial Science and Operations Research. The candidate is expected to teach the mathematics courses in the undergraduate curriculum.

Those with expertise in areas such as Probability, Applied Probability Models and Game Theory will be preferred. Candidates should possess an appropriate doctoral degree at the time of hiring. MSOE offers degrees in engineering, engineering technology, construction management, business, actuarial science, operations research, technical communications and nursing. We are located in the heart of downtown Milwaukee and are recognized in several national publications for our "applications-oriented" approach. Faculty is judged primarily on excellence in teaching. MSOE graduates are in high demand, as evidence by our strong job placement rate. The review of candidates will begin immediately and continue until the position is filled. To apply, please submit a single file which includes a detailed resume, evidence of teaching excellence and three reference letters. For more information and to apply, visit our website at `www.msoe.edu`. EEO Employer F/M/Vet/Disabled

000003

PUBLICATIONS FOR SALE

Conferences

Mathematics at the 2015 AAAS Meeting

San Jose Convention Center
San Jose, California
February 12–16, 2015

The American Association for the Advancement of Science (AAAS), founded in 1848, is the world's largest general scientific society and is the publisher of *Science*. The AAAS is divided into twenty-four disciplinary-based sections, including Section A (Mathematics). The 2015 annual meeting of the AAAS will be held in San Jose on February 12–16. The theme of this year's meeting is "Innovations, Information, and Imaging," and this year's meeting features sessions that will be of special interest to mathematicians, mathematics educators, and students of mathematics.

The AAAS Annual Meeting is organized into symposia which have three or more speakers and often a discussant who reflects on the talks that are given. Section A is sponsoring three symposia this year, featuring outstanding expository talks by prominent mathematicians and scientists. The three symposia sponsored by Section A this year are:

From Art to Mathematics: A Visual Mode of Communication

Recent years have witnessed an explosion of scholarly activity in which mathematics inspires artists to communicate innovative ideas through artistic channels. This symposium showcases three experts who crosscut between the world of mathematics and technology and the world of the practicing artist. They will present examples of their artwork, explain how each work represents or images a mathematical idea, and discuss the relevance of artistic modes of thought to solving practical problems in communicating science.
Organizer: George W. Hart, Stony Brook University

DOI: http://dx.doi.org/10.1090/noti1214

Preparing Researchers for the Quantitative Biology of the Future

Advances in quantification of biology and medicine will soon render obsolete researchers and practitioners who are not fluent in quantitative assessment of data and mechanistic understanding of biological and medical systems through modeling and simulation. Stakeholder disciplines include genomics, bioinformatics, molecular and systems biology, medicine, statistics, mathematics, and computer science. Speakers, experts in these areas and in STEM education and evaluation, will address the justifications and challenges for quantitative curricular reform. A final panel discussion will identify national actions in the US to overcome cultural obstacles, share methods, and build consensus.
Organizer: Frederick R. Adler, University of Utah

Bounded Gaps between Prime Numbers: Individual Research vs. Crowdsourcing

Studied since antiquity, our knowledge of prime numbers recently took a giant leap forward. This leap was accomplished both by the old-school method of an individual quietly working out intricate details and the decidedly new-school paradigm of crowdsourcing. What was not known before had been famously conjectured for centuries: infinitely often there are two primes a bounded distance away from each other. A proof was announced a year ago by Yitang Zhang. It was quickly realized that his proof was correct, and then many people chipped away at Zhang's initial bound of 7 x 107. Now, the bound is down to 246. So should mathematics progress with single researchers plugging away, as did Zhang? Or is crowdsourcing really the wave of the future?
Organizer: Carl Pomerance, Dartmouth College

These symposia are only a few of the more than one hundred fifty AAAS symposia this year in the physical, life, social, and biological sciences. For further information, including the schedule of talks, go to `www.aaas.org/meetings`. Section A acknowledges the generous contributions of the American Mathematical Society for travel support for speakers this year, continuing a multidecade commitment to the mathematics program at the AAAS.

The AAAS Annual Meeting is the showcase of American science, with about 10,000 people attending some part of the meeting each year. The AAAS Program Committee is genuinely interested in offering symposia on topics in pure and applied mathematics. In recent years there have been symposia on subjects such as compressive sensing, multiscale modeling of cancer, quantum computing, and the changing nature of mathematical proof.

The 2016 meeting will be February 11–15, 2016, in Washington DC, and the Steering Committee for Section A seeks organizers and speakers who can present substantial new material in an accessible manner to a large scientific audience. All are invited to attend the Section A Committee business meeting in San Jose on Friday, February 13, 2015, at 7:30 p.m., where we will brainstorm ideas for symposia. In addition, I invite you to send me, and encourage your colleagues to send me, ideas for future AAAS Annual Meeting symposia.

The following are the members of the Steering Committee for Section A from February 2014 to February 2015.

Chair: David M. Bressoud (Macalester College)
Chair-elect: Martin Golubitsky (Ohio State University)
Retiring Chair: Juan C. Meza(University of California, Merced)
Secretary: Andy R. Magid (University of Oklahoma)

Members-at-Large:
Joceline Lega (University of Arizona)
Sheldon Katz (University of Illinois, Urbana-Champaign)
Susan Friedlander (University of Southern California)
Irene Fonseca (Carnegie Mellon University)

General Information Regarding Meetings & Conferences of the AMS

Speakers and Organizers: The Council has decreed that no paper, whether invited or contributed, may be listed in the program of a meeting of the Society unless an abstract of the paper has been received in Providence prior to the deadline.

Special Sessions: The number of Special Sessions at an Annual Meeting is limited. Special Sessions at annual meetings are held under the supervision of the Program Committee for National Meetings and, for sectional meetings, under the supervision of each Section Program Committee. They are administered by the associate secretary in charge of that meeting with staff assistance from the Meetings and Conferences Department in Providence. (See the list of associate secretaries on page 112 of this issue.)

Each person selected to give an Invited Address is also invited to generate a Special Session, either by personally organizing one or by having it organized by others. Proposals to organize a Special Session are sometimes solicited either by a program committee or by the associate secretary. Other proposals should be submitted to the associate secretary in charge of that meeting (who is an ex officio member of the program committee) at the address listed on page 112. These proposals must be in the hands of the associate secretary at least seven months (for sectional meetings) or nine months (for national meetings) prior to the meeting at which the Special Session is to be held in order that the committee may consider all the proposals for Special Sessions simultaneously. Special Sessions must be announced in the *Notices* in a timely fashion so that any Society member who so wishes may submit an abstract for consideration for presentation in the Special Session.

Talks in Special Sessions are usually limited to twenty minutes; however, organizers who wish to allocate more time to individual speakers may do so within certain limits. A great many of the papers presented in Special Sessions at meetings of the Society are invited papers, but any member of the Society who wishes to do so may submit an abstract for consideration for presentation in a Special Session, provided it is submitted to the AMS prior to the special early deadline for consideration. Contributors should know that there is a limit to the size of a single Special Session, so sometimes all places are filled by invitation. An author *may* speak by invitation in more than one Special Session at the same meeting. Papers submitted for consideration for inclusion in Special Sessions but not accepted will receive consideration for a contributed paper session, unless specific instructions to the contrary are given.

The Society reserves the right of first refusal for the publication of proceedings of any Special Session. If published by the AMS, these proceedings appear in the book series *Contemporary Mathematics*. For more detailed information on organizing a Special Session, see `www.ams.org/meetings/specialsessionmanual.html`.

Contributed Papers: The Society also accepts abstracts for ten-minute contributed papers. These abstracts will be grouped by related *Mathematical Reviews* subject classifications into sessions to the extent possible. The title and author of each paper accepted and the time of presentation will be listed in the program of the meeting. Although an individual may present only one ten-minute contributed paper at a meeting, any combination of joint authorship may be accepted, provided no individual speaks more than once.

Other Sessions: In accordance with policy established by the AMS Committee on Meetings and Conferences, mathematicians interested in organizing a session (for either an annual or a sectional meeting) on employment opportunities inside or outside academia for young mathematicians should contact the associate secretary for the meeting with a proposal by the stated deadline. Also, potential organizers for poster sessions on a topic of choice should contact the associate secretary before the deadline.

Abstracts: Abstracts for all papers must be received by the meeting coordinator in Providence by the stated deadline. Unfortunately, late papers cannot be accommodated.

Submission Procedures: Visit the Meetings and Conferences homepage on the Web at `www.ams.org/meetings` and select "Submit an abstract".

Site Selection for Sectional Meetings

Sectional meeting sites are recommended by the associate secretary for the section and approved by the Secretariat. Recommendations are usually made eighteen to twenty-four months in advance. Host departments supply local information, ten to fifteen rooms with overhead projectors and a laptop projector for contributed paper sessions and Special Sessions, an auditorium with twin overhead projectors and a laptop projector for Invited Addresses, space for registration activities and an AMS book exhibit, and registration clerks. The Society partially reimburses for the rental of facilities and equipment and for staffing the registration desk. Most host departments volunteer; to do so, or for more information, contact the associate secretary for the section.

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.

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015

Saturday – Tuesday

Meeting #1106

Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of 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 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: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/national.html`.

Joint Invited Addresses

Jordan S. Ellenberg, University of WIsconsin - Madison, *Combinatorial designs, finite geometries, and beating the lottery* (AMS-MAA Invited Address).

Wen-Ching Winnie Li, Pennsylvania State University, *Modular Forms for Congruence and Noncongruence Subgroups* (AWM-AMS Noether Lecture).

Donald G. Saari, University of California, Irvine, *From Voting Paradoxes to the Search for "Dark Matter"* (MAA-AMS-SIAM Gerald and Judith Porter Public Lecture).

Richard A. Tapia, Rice University, *The Remarkable Journey of the Isoperimetric Problem: From Euler to Steiner to Weierstrass* (AMS-MAA Invited Address).

AMS Invited Addresses

Ian Agol, University of California, Berkeley, *Title to be announced*.

Henri Darmon, McGill University, *Elliptic curves and explicit class field theory*.

Irena Peeva, Cornell University, *Matrix factorizations and complete intersection rings*.

Susan Holmes, Stanford University, *Statistically relevant metrics for complex data*.

Michael J. Hopkins, Harvard University, *Algebraic topology: new and old directions* (AMS Colloquium Lectures, Lecture I).

Michael J. Hopkins, Harvard University, *Chern-Weil theory and abstract homotopy theory* (AMS Colloquium Lectures, Lecture III).

Michael J. Hopkins, Harvard University, *The Kervaire invariant problem* (AMS Colloquium Lectures, Lecture II).

Russell Lyons, Indiana University, Bloomington, *Random orderings and unique ergodicity of automorphism groups*.

Daniel A. Spielman, Yale University, *Graphs, vectors, and matrices* (AMS Josiah Willard Gibbs Lecture).

AMS Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `jointmathematicsmeetings.org/meetings/abstracts/abstract.pl?type=jmm`.

Some sessions are cosponsored with other organizations. These are noted within the parenthesis at the end of each listing, where applicable.

Accelerated Advances in Multiobjective Optimal Control Problems and Mathematical Programming Based on Generalized Invexity Frameworks, **N. J. Huang**, Sichuan University, **R. N. Mohapatra**, University of Central Florida, **Ram Verma**, Texas State University, and **Alexander Zaslavski**, Israel Institute of Technology.

Advances in Coding Theory, **Felice Manganiello** and **Gretchen L. Matthews**, Clemson University, and **Judy L. Walker**, University of Nebraska.

Algebraic Combinatorics and Representation Theory, **Zajj Daugherty**, Dartmouth College, and **Ben Salisbury**, Central Michigan University.

Algebraic and Geometric Methods in Applied Discrete Mathematics (a Mathematics Research Communities Session), **Heather Harrington**, University of Oxford, **Mohamed Omar**, Harvey Mudd College, and **Matthew Wright**, Institute for Mathematics and its Applications, University of Minnesota.

Applications of Dynamical Systems to Biological Models, **Yu Jin**, University of Nebraska-Lincoln, and **Xiang-Sheng Wang**, Southeast Missouri State University.

Beyond First-Order Model Theory, **John T. Baldwin**, University of Illinois at Chicago, **Xavier Caicedo**, Universidad de los Andes, **Rami Grossberg**, Carnegie Mellon University, **Jose Iovino**, University of Texas at San Antonio, and **Boris Zilber**, Oxford University (AMS-ASL).

Classification Problems in Operator Algebras, **Arnaud Brothier**, Vanderbilt University, **Ionut Chifan**, The University of Iowa, **Darren Creutz**, Vanderbilt University, **Remus Nicoara**, University of Tennessee, and **David Penneys**, University of Toronto.

Cluster Algebras (a Mathematics Research Communities session), **Andrew T. Carroll**, DePaul University, **Ian T. Le**, University of Chicago, and **Greg Muller**, University of Michigan.

Computing Intensive Modeling in Mathematical and Computational Biology, **Timothy D. Comar**, Benedictine University, **Olcay Akman**, Illinois State University, and **Daniel Hrozencik**, Chicago State University.

Continued Fractions, **James Mc Laughlin**, West Chester University, and **Nancy J. Wyshinski**, Trinity College.

Creating Coherence in K–12 Mathematics, **Brigitte Lahme**, Sonoma State University, **William McCallum** and **Cody Patterson**, University of Arizona, **Kristin Umland**, University of New Mexico, and **Ellen Whitesides**, University of Arizona.

Current Trends in Classical Dynamical Systems, **Lennard Bakker** and **Skyler Simmons**, Brigham Young University.

Difference Equations and Applications, **Steven Miller**, Williams College, and **Michael A. Radin**, Rochester Institute of Technology.

Differential Geometry and Statistics, **Susan Holmes**, Stanford University.

Enumerative Combinatorics, **Brian K. Miceli**, Trinity University, and **Jay Pantone** and **Vince Vatter**, University of Florida.

Ergodic Theory and Dynamical Systems, **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Factorization Theory and Its Applications, **Nicholas Baeth**, University of Central Missouri, **Scott Chapman**, Sam Houston State University, **Jim Coykendall**, Clemson University, and **Alfred Geroldinger**, Karl Franzens University.

Fixed Point Theory and Applications, **Clement Boateng Ampadu**.

Fractional, Stochastic, and Hybrid Dynamic Systems with Applications, **John R. Graef**, University of Tennessee at Chattanooga, **G. S. Ladde**, University of South Florida, and **A. S. Vatsala**, University of Louisiana at Lafayette.

Frames and Their Applications, **Radu Balan** and **Kasso Okoudjou**, University of Maryland, and **Rachel Ward**, University of Texas.

Geometries Defined by Differential Forms, **Sergey Grigorian**, University of Texas-Pan American, **Sema Salur**, University of Rochester, and **Albert J. Todd**, University of California, Riverside.

Geosystems Mathematics, **Willi Freeden**, University of Kaiserslautern, **Volker Michel**, University of Siegen, and **M. Zuhair Nashed**, University of Central Florida.

Graphs, Matrices, and Related Problems, **Cheryl Grood** and **Thomas Hunter**, Swarthmore College, and **Sharon McCathern**, Azusa Pacific University.

Groups, Algorithms, and Cryptography, **Bren Cavallo** and **Delaram Kahrobaei**, City University of New York Graduate Center.

Heavy-Tailed Distributions and Processes, **U. Tuncay Alparslan** and **John P. Nolan**, American University.

History of Mathematics, **Sloan Despeaux**, Western Carolina University, **Patti Hunter**, Westmont College, **Deborah Kent**, Drake University, and **Adrian Rice**, Randolph-Macon College (AMS-MAA).

Holomorphic Dynamics in One and Several Variables, **Tanya Firsova**, State University of New York at Stony Brook and Kansas State University, and **Thomas Sharland**, State University of New York at Stony Brook.

Hopf Algebras and Tensor Categories, **Susan Montgomery**, University of Southern California, **Siu-Hung Ng**, Louisiana State University and Iowa State University, and **Sarah Witherspoon**, Texas A&M University.

Inequalities and Quantitative Approximation, **Feng Dai**, University of Alberta, and **Mourad E. H. Ismail**, University of Central Florida.*Inverse Problems*, **Peter Muller**, Rensselaer Polytechnic Institute, and **Kaitlyn Voccola**, Colorado State University.

Knot Theory, **Tim Cochran** and **Shelly Harvey**, Rice University.

Limits of Discrete Structures, **Peter Diao**, **Dominique Guillot**, **Apoorva Khare**, and **Bala Rajaratnam**, Stanford University.

Math Teachers Circles and the K–20 Continuum, **Brian Conrey**, American Institute of Mathematics, **Michael Nakamaye** and **Kristin Umland**, University of New Mexico, and **Diana White**, University of Colorado at Denver.

Mathematics in Natural Resource Modeling, **Shandelle M. Henson**, Andrews University, and **Catherine A. Roberts**, College of the Holy Cross.

Mathematics in Poland: Interbellum, World War II, and Immediate Post-War Developments, **Mohammad Javaheri** and **Emelie A. Kenney**, Siena College.

Model Theory and Applications, **David Marker**, University of Illinois at Chicago, **Sergei Starchenko**, University of Notre Dame, and **Carol Wood**, Wesleyan University.

Network Science (a Mathematics Research Communities Session), **Bailey Fosdick**, Colorado State University, **Franklin Kenter**, Rice University, **Christine Klymko**, Lawrence Livermore National Laboratory, and **Johan Ugander**, Microsoft Research.

Noncommutative Function Theory, **Paul S. Muhly**, University of Iowa, and **Gelu F. Popescu**, University of Texas at San Antonio.

Operator Algebras and Their Applications: A Tribute to Richard V. Kadison, **Robert S. Doran** and **Efton Park**, Texas Christian University.

Partitions, q-Series, and Modular Forms, **Atul Dixit**, Tulane University, **Tim Huber**, University of Texas-Pan American, **Amita Malik**, University of Illinois, and **Ae Ja Yee**, Pennsylvania State University.

Positivity and Matrix Inequalities, **Dominique Guillot**, **Apoorva Khare**, and **Bala Rajaratnam**, Stanford University.

Probability and Applications, **Rick Kenyon**, Brown University, and **Russell Lyons**, Indiana University.

Progress in Multivariable Operator Theory, **Ron Douglas**, Texas A&M University, and **Constanze Liaw**, Baylor University.

Quantum Information and Fusion Categories (a Mathematics Research Communities Session), **Paul Bruillard**, Pacific Northwest National Laboratory, **Henry J. Tucker**, University of Southern California, and **Amanda Young**, University of California, Davis.

Quantum Markov Chains, Quantum Walks, and Related Topics, **Chaobin Liu**, Bowie State University, **Takuya Machida**, University of California, Berkeley, **Salvador E. Venegas-Andraca**, Tecnologicó de Monterrey, Campus Estado de México, and **Nelson Petulante**, Bowie State University.

Recent Advances in Discrete and Intuitive Geometry, **Andras Bezdek**, Auburn University, **Ted Bisztriczky**, University of Calgary, and **Wlodek Kuperberg**, Auburn University.*Recent Advances in the Analysis and Applications of Modern Splitting Methods*, **Abdul Q. M. Khaliq**, Middle Tennessee State University, **Qin Sheng**, Baylor University, and **Bruce Wade**, University of Wisconsin-Milwaukee.

Recent Developments in Algebraic Number Theory, **Wen-Ching Winnie Li**, Pennsylvania State University, **Tong Liu**, Purdue University, and **Ling Long**, Iowa State University and Louisiana State University (AMS-AWM).

Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, **Darren A. Narayan**, Rochester Institute of Technology, **Tamas Forgacs**, California State University Fresno, and **Jobby Jacob**, **Carl V. Lutzer**, and **Tamas Wiandt**, Rochester Institute of Technology (AMS-MAA-SIAM).

Ricci Curvature for Homogeneous Spaces and Related Topics, **Megan Kerr**, Wellesley College, and **Tracy Payne**, Idaho State University.

Selmer Groups, **Mirela Ciperiani**, University of Texas, and **Henri Darmon**, McGill University.

Set-Valued Optimization and Variational Problems with Applications, **Akhtar A. Khan**, Rochester Institute of Technology, **Mau Nam Nguyen**, Portland State University, **Miguel Sama**, Universidad Nacional de Educacion a Distancia, Madrid, and **Christiane Tammer**, Martin Luther University of Halle-Wittenberg.

Studies in Interconnections among Parameters in Graph Theory, Combinatorics, and Discrete Geometry, **Cong X. Kang** and **Eunjeong Yi**, Texas A&M University at Galveston.

Successes and Challenges in Teaching Mathematics, **Ellina Grigorieva**, Texas Woman's University, and **Natali Hritonenko**, Prairie View A&M University.

Syzygies, **Giulio Caviglia**, Purdue University, **Jason McCullough**, Rider University, and **Irena Peeva**, Cornell University.

The Scottish Book, **Krystyna Kuperberg**, Auburn University, **R. Daniel Mauldin**, University of North Texas, and **Jan Mycielski**, University of Colorado.

Theory and Application of Reaction Diffusion Models, **Jerome Goddard II**, Auburn University Montgomery, and **Ratnasingham Shivaji**, University of North Carolina Greensboro.

Topological Measures of Complexity: Inverse Limits, Entropy, and Structure of Attractors, **Loribeth M. Alvin**, University of Denver, **Jan P. Boroński**, National Supercomputing Centre IT4Innovations, Ostrava, **James Keesling**, University of Florida, **Olga Lukina**, University of Illinois at Chicago, and **P. Oprocha**, AGH University of Science and Technology, Krakow.

What's New in Group Theory?, **Arturo Magidin**, University of Louisiana at Lafayette, and **Elizabeth Wilcox**, Oswego State University.

Washington, D.C.

Georgetown University

March 7–8, 2015

Saturday - Sunday

Meeting #1107

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: March 2015
Issue of *Abstracts*: Volume 36, Issue 2

Deadlines

For organizers: Expired
For abstracts: January 20, 2015

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Frederico Rodriguez Hertz, Pennsylvania State University, *Title to be announced.*

Nancy Hingston, The College of New Jersey, *Title to be announced.*

Simon Tavaré, Cambridge University, *Title to be announced* (Einstein Public Lecture in Mathematics).

Yitang Zhang, University of New Hampshire, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Algebra and Representation Theory (Code: SS 13A), **Ela Celikbas** and **Olgur Celikbas**, University of Connecticut, and **Frank Moore**, Wake Forest University.

Algebraic Structures Motivated by and Applied to Knot Theory (Code: SS 18A), **Jozef H. Przytycki**, George Washington University, and **Radmilla Sazdanovic**, North Carolina State University.

Asymptotic Problems for Stochastic Processes and PDEs (Code: SS 19A), **Sandra Cerrai**, **Dmitry Dolgopyat**, **Mark Freidlin**, and **Leonid Koralov**, University of Maryland.

Bases and Frames in Hilbert Spaces and Applications (Code: SS 26A), **Laura De Carli**, Florida International University.

Characterizing Uncertainty for Modeling Physical Processes (Code: SS 21A), **Ali Arab**, Georgetown University.

Closure Operations in Commutative Algebra (Code: SS 28A), **Neil Epstein**, George Mason University, and **Lance Edward Miller**, University of Arkansas.

Computable Structure Theory (Code: SS 8A), **Rumen Dimitrov**, Western Illinois University, **Valentina Harizanov**, George Washington University, and **Russell Miller**, Queens College and Graduate Center, City University of New York.

Conceptual Mathematical Models in Climate Science (Code: SS 5A), **Hans Engler** and **Hans Kaper**, Georgetown University.

Convexity and Combinatorics (Code: SS 9A), **Jim Lawrence** and **Valeriu Soltan**, George Mason University.

Crossing Numbers of Graphs (Code: SS 3A), **Paul Kainen**, Georgetown University.

Data Assimilation: Recent Progress in Theory, Methods and Applications (Code: SS 23A), **Evelyn M. Lunasin** and **Reza Malek-Madani**, United States Naval Academy.

Difference Equations and Applications (Code: SS 32A), **Michael Radin**, Rochester Institute of Technology, and **Steven J. Miller**, Williams College.

Dynamical Systems Models of Physiological Processes (Code: SS 27A), **Paula Grajdeanu**, Shenandoah University, and **Talitha Washington** and **Abdul-Aziz Yakubu**, Howard University.

Geometric Structures on Low-Dimensional Manifolds and their Invariants (Code: SS 24A), **Cagatay Kutluhan**, University at Buffalo, and **Thomas E. Mark** and **Bulent Tosun**, University of Virginia.

History and Philosophy of Mathematics (Code: SS 15A), **V. Frederick Rickey**, West Point Military Academy, and **James J. Tattersall**, Providence College.

Inverse Problems for Non-destructive Testing (Code: SS 22A), **Nicolas Valdivia**, Naval Research Laboratory.

Iterated Integrals and Applications (Code: SS 12A), **Ivan Horozov**, Washington University in St. Louis.

Mathematical Fluid Dynamics and Turbulence (Code: SS 17A), **Zachary Bradshaw**, University of British Columbia, **Aseel Farhat**, Indiana University, and **Michele Coti Zelati**, University of Maryland.

Nonlinear Dispersive and Wave Equations with Applications to Fluids (Code: SS 14A), **Pierre Germain** and **Zaher Hani**, New York University, and **Benoit Pausader**, Princeton University.

Nonlinear Partial Differential Equations in Sciences and Engineering (Code: SS 16A), **Lorena Bociu**, North Carolina State University, **Ciprian Gal**, Florida International University, and **Daniel Toundykov**, University of Nebraska.

Number Theory in Ergodic Theory and Dynamical Systems (Code: SS 29A), **Joe Herning**, Northern Virginia Community College, **Erblin Mehmetaj**, George Washington University and Georgetown University, **E. Arthur Robinson Jr.**, George Washington University, and **Tyler White**, Northern Virginia Community College.

Operator Theory on Analytic Function Spaces (Code: SS 11A), **Robert F. Allen**, University of Wisconsin, La Cross, and **Flavia Colonna**, George Mason University.

Optimization Theory, Algorithms and Applications (Code: SS 20A), **Olga Brezhneva**, Miami University, Oxford, OH, and **Igor Griva**, George Mason University.

Patterns in Permutations and Words (Code: SS 30A), **Alexander Burstein**, Howard University.

Qualitative Behavior of Solutions of Partial Differential Equations (Code: SS 7A), **Junping Shi**, College of William and Mary, and **Jiuyi Zhu**, John Hopkins University.

Quantum Algebras, Representations, and Categorifications (Code: SS 2A), **Sean Clark** and **Weiqiang Wang**, University of Virginia.

Singularities: Algebraic and Analytic Aspects (Code: SS 31A), **Claudia Miller**, Syracuse University, and **Sophia Vassiliadou**, Georgetown University.

Somos Sequences and Nonlinear Recurrences (Code: SS 10A), **Andrew Vogt**, Georgetown University.

Spatial Evolutionary Models and Biological Invasions (Code: SS 6A), **Judith Miller**, Georgetown University, and **Yuan Lou**, Ohio State University.

Stochastic Analysis and Stochastic PDEs (Code: SS 25A), **Sandra Cerrai**, University of Maryland, and **Frederi Viens**, Purdue University.

Topology in Biology (Code: SS 4A), **Paul Kainen**, Georgetown University.

Within-Host Disease Modeling (Code: SS 1A), **Stanca Ciupe**, Virginia Polytechnic Institute, and **Sivan Leviyang**, Georgetown University.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice. Special discounted rates were negotiated with the hotels listed below. Rates quoted do not include the District of Columbia hotel tax (14.5%). Participants must state that they are with the **American Mathematical Society (AMS) Meeting at Georgetown University** to receive the discounted rate. The AMS is not responsible for rate changes or for the quality of the accommodations. **Hotels have varying cancellation and early checkout penalties; be sure to ask for details.**

Georgetown University Hotel and Conference Center, 3800 Reservoir Road, Washington, DC 20057; 202-687-3200 or 888-902-1606 (toll free); `www.acc-guhotelandconferencecenter.com/` Rates are US$139 per night for single/double occupancy. Amenities include complimentary daily newspaper; 24 hour guest parking with in and out priviliages available for US$25 inclusive of tax, per night; and wireless Internet available in guest rooms for a fee of US$9.95 per day. This property is located approximately .80 miles drive from the campus or a 19 minute walking distance. Cancellation and early check-out policies vary and penalties exist at this property; be sure

to check when you make your reservation. The deadline for reservations at this rate is **February 6, 2015**.

Melrose Georgetown Hotel 2430 Pennsylvania Avenue NW, Washington, DC 20037; 202-955-6400; www.melrose-hoteldc.com/. Rates are US$179 per night for a single or double occupancy deluxe room. Amenities include complimentary access to fitness center; complimentary tea and coffee service in lobby daily each morning; business center on-site; parking available for US$48 inclusive of tax per day; *Jardenea* restaurant and lounge located on property, serving breakfast, lunch and dinner; 24 hour room service; and wired and wireless Internet available in guest rooms for a fee, ranging between US$4.95 and US$9.95. This property is located approximately 1.28 miles driving distance and 33 minutes walking distance from the campus. Cancellation and early check-out policies vary and penalties exist at this property; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 6, 2015**.

The Fairfax at Embassy Row, 2100 Massachusetts Avenue NW, Washington, DC 20008; 202-293-2100; www.fairfaxhoteldc.com/. Rates are US$149 per night for a single or double occupancy room. Amenities include two restaurants located on property *The Capitol Room* and the *Fairfax Grille and Lounge*, serving breakfast, lunch and dinner; room service is available; complimentary access to fitness center; business center on-site; valet parking available for US$45 + tax per day; and wired and wireless Internet available in guest rooms for a fee of US$12.95. This property is located approximately 1.28 miles driving distance and 33 minutes walking distance from the campus. Cancellation and early check-out policies vary and penalties exist at this property; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 6, 2015**.

Washington Marriott Georgetown, 1221 22nd Street NW, Washington, D.C., 20037; 202-872-1500; 800-393-3053 (toll free); www.marriott.com/hotels/travel/waswe-washington-marriott-georgetown/. Rates are US$169 per night for single/double occupancy in a room with one king or two double beds. Amenities include two restaurants on property the *Atrium* serving breakfast, lunch, and dinner and the *Court Lounge* serving lunch,dinner, and cocktails; room service is available; indoor pool; on-site fitness room; full service business center; complimentary wireless Internet in all public spaces; wired and wireless Internet available in in guest rooms for a fee (US$12.95-US$16.95); and parking available on-site for self-park US$36/ valet park US$40 per day. This property is located approximately 1.74 miles driving distance and 33 minutes walking distance from the campus. Cancellation and early check-out policies vary; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 13, 2015**.

Renaissance Washington, DC Dupont Circle 1143 New Hampshire Avenue NW, Washington DC, 20037; 202-775-0800; 888-803-1298 (toll free); www.marriott.com/hotels/travel/wasrw-renaissance-washington-dc-dupont-circle-hotel/. Rates are US$159 per night for single/double occupancy. Amenities include fitness center; *M Brasserie and Bar* restaurant on property serving breakfast, lunch, and dinner; *Illy caffe, an Italian Coffee House*, on-site serving coffee, breakfast, and lunch; room service is available; complimentary wireless Internet in all public spaces; wired and wireless Internet available in in guest rooms for a fee (US$12.95-US$16.95); and valet parking available on-site for US$49 per day. This property is located approximately 1.75 miles driving distance, or 40 minutes walking distance from the campus. Cancellation and early check-out policies vary; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 13, 2015**.

Courtyard Washington, D.C./ Foggy Bottom, 515 20th Street NW, Washington, DC 20052; 202-296-5700; www.marriott.com/hotels/travel/wasfb-courtyard-washington-dc-foggy-bott.com/. Rates are US$199 per night for single occupancy for a standard room. Amenities include a restaurant on-property *Eat.Drink.Connect.* serving breakfast and dinner; indoor pool; on-site fitness room; complimentary wired and wireless Internet in guest rooms; and parking available on-site for self-park or valet park for US$36 per day. This property is located approximately 2.08 miles driving distance and 50 minutes walking distance from the campus. Cancellation and early check-out policies vary; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 13, 2015**.

Crystal Gateway Marriott, 1700 Jefferson Davis Highway, Arlington, VA, 22202; 703-920-3230; www.marriott.com/hotels/travel/wasgw-crystal-gateway-marriott/. Rates are US$169 per night for single/double occupancy in a room with one king or two double beds. Amenities include three restaurants on property including the *Atrium* serving dinner, *Restaurant Mez* serving breakfast and lunch, and *Einstein Bros Bagels* serving breakfast and lunch; room service is available; indoor pool; on-site fitness room; full service business center; complimentary wireless Internet in all public spaces; wired and wireless Internet available in in guest rooms for a fee (US$12.95-US$16.95); and parking available on-site for self-park US$27/ valet park US$32 per day. This property is located approximately 4.32 miles driving distance and 44 minutes by public transportation from the campus. Cancellation and early check-out policies vary; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 13, 2015**.

Food Services

On Campus: Please note that the meeting is taking place during the University's spring break recess. Campus dining options may be limited and are subject to change, please watch the web and review the printed program onsite for more complete details .

For those wishing to stay on campus *Epicurean and Company* offers a buffet, pizza, sandwiches, and sushi. It is located at the Georgetown University Hospital at located at 3800 Reservoir Road, N.W.

Leavey Center houses many retail dining options. *Cosi* and *Starbucks* are located in the North Gallery of Leavey. The South Gallery is home to the *Faculty Club*, while Center Hall in Leavey Center offers *Uncommon Grounds*, *Vital Vittles, Elevation Burger,* and *Subway*. Additional information

on these and other dining options on-campus can be found at studentliving.georgetown.edu/dining/. Hours of operation for these locations may be different than those posted on the Web, as a result of the spring recess.

Off Campus: There are many dining choices for casual dining and "grab and go" options convenient to campus. Restaurants can be located on M. St. which is approximately a 10-15 minute walk from campus. More options can also be found on Wisconsin Ave which is also approximatley a 10 - 15 minute walk from campus.

Information on the more than 140 restaurants located in the Georgetown area can be found at www.georgetowndc.com/.

Registration and Meeting Information

Advance Registration: Advance registration for this meeting will open on **January 19, 2015**. Advance registration fees will be US$56 for AMS members, US$78 for nonmembers, and US$5 for students, unemployed mathematicians, and emeritus members.

Onsite Information and Registration: The registration desk and the AMS book exhibit will be located in the South Gallery in the Leavey Center. Special Sessions will be held in the Reiss Science Center, the Bunn Intercultural Center (ICC), White-Gravenor Hall (WGH), Healy Hall, and Regents Hall. Invited Addresses and the Einstein Lecture will take place in the Lohrfink Auditorium in the Rafik B. Hariri Building. For further information on building locations, a campus map is available at http://maps.georgetown.edu/

The registration desk will be open on Saturday, March 7, 7:30 a.m.-4:00 p.m. and Sunday, March 8, 8:00 a.m.-12:00 p.m. Fees are US$56 for AMS members, US$78 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on-site via cash, check, or credit card.

Special Needs: It is the goal of the AMS to ensure that its conferences are accessible to all, regardless of disability. The AMS will strive, unless it is not practicable, to choose venues that are fully accessible to the physically handicapped.

If special needs accommodations are necessary in order for you to participate in an AMS Sectional Meeting, please communicate your needs in advance to the AMS Meetings Department by:

- Registering early for the meeting

- Checking the appropriate box on the registration form, and

- Sending an email request to the AMS Meetings Department at mmsb@ams.org or meet@ams.org.

AMS Einstein Public Lecture in Mathematics

The Einstein Public Lecture will be given by **Simon Tavaré,** Cambridge University. The title of his talk is *Cancer by the Numbers*. The lecture will be given on Saturday, March 7, at 5:00 p.m., in the Lohrfink Auditorium in the Rafik B. Hariri Building.

A reception in conjunction with this lecture and hosted by the Department of Mathematics and the AMS will take place in the conference center in the Leavey Center. The AMS thanks our hosts for their gracious hospitality.

Other Activities

Book Sales: Stop by the on-site AMS bookstore to review our newest publications and take advantage of exhibit discounts! AMS members receive 40% off list price. Nonmembers receive a 25% discount. Not a member? Ask about the benefits of AMS membership. Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you wish to discuss with the AMS, please stop by the book exhibit.

Local Information and Maps

This meeting will take place on the main campus of George Washington University. An interactive campus map can be found at maps.georgetown.edu/. Information about the Georgetown Department of Mathematics and Statistics can be found at mathstat.georgetown.edu/. Please watch the website available at www.ams.org/meetings/sectional/sectional.html for additional information on this meeting. Please visit the Georgetown University website at www.georgetown.edu/ for additional information on the campus.

Wi-fi will be available for meeting participants via a guest network at the University. Details about accessing this network will be available on-site at the registration desk.

Parking

Street parking in the Georgetown area is severely limited and most parking requires a permit. A limited number of metered spaces are available on Reservoir Road, 37th Street, and Prospect Street. Parking may be available on campus in the Southwest Garage, accessible via the Canal Road entrance. Please note, when turning into Georgetown University from Canal Street, turn right into the second parking garage, this is the Southwest Garage. If you arrive at a stop sign you have gone too far. Information on parking at Georgetown can be found at otm.georgetown.edu/index.cfm?fuse=directions.

Travel

Georgetown University's Main Campus is located at 3700 O St., N.W., Washington D.C., centrally located in the D.C. Metropolitan area, nearby to the White House, Congress, the Supreme Court, and many other D.C. landmarks.

By Air: Reagan Washington National Airport (DCA) in suburban Virginia is the closest and most convenient airport to the University. From the airport, you can use the Metrorail train to the Rosslyn or take a taxi directly to the Georgetown University Main Campus. This ride should span approximately 30 minutes. To access the Metrorail Station from Terminal B and C use the pedestrian bridges that lead directly to the station; to access the station from Terminal A board any "Airport Shuttle" bus from outside the terminal and travel to the station. Metrorail passes may be purchased in machines located at the station and

fares range between US$2.30 and US$2.90 one way. Taxicab stands are located near the Arrivals (Baggage Claim) exits of each terminal and no advanced reservations are required. Taxi fares can be estimated at US$15 one way to campus. There is also a US$3.00 airport fee payable in addition to the taxi fare.

Dulles International Airport (IAD) is more distant in the Virginia suburbs, and is located approximately 25 miles west of campus. You may use a taxi or use the Washington Flyer shuttles to get into the city. If using a taxi, request to be brought to Georgetown University at 37th and O Streets, N.W., Washington, D.C., a one way trip may cost approximately US$60. The exclusive taxicab service serving the airport is Washington Flyer Taxi. No reservations are necessary for leaving the airport, follow the signs for ground transportation to the lower level of the main terminal. To arrange for a reservation to return to the airport call 703-572-8294 at least 8 hours prior to the desired pick-up time to place a reservation. Washington Flyer Coach Service travels nonstop to the Wiehle-Reston East Metro Station (Metro Silver Line), approximately every 15 - 20 minutes for US$5. Tickets for the Dulles International Airport Silver Line Express can be purchased at the ticket counter located inside the vestibule of Door 4 on the Arrivals Level of the Main Terminal. Passengers boarding at Wiehle-Reston East Metro Station can purchase a ticket when they arrive at Washington Dulles International Airport.

Baltimore-Washington International Airport (BWI), in Maryland, is the most distant area airport, located approximately 40 miles north of campus. To get to the campus ground transportation options include taxi service, Super Shuttle, and the Amtrak train into Washington, D.C. Taxi service may cost as much as US$95 or more. Super Shuttle reservations can be made via the web at www.supershuttle.com/en/BWIAirport. Super Shuttle counters are located at the lower level baggage claims 1 through 10. To utilize Amtrak service into Washington D.C. from the airport, take a complimentary shuttle from the terminal to BWI Marshall Rail Station. Board the Amtrak train from BWI to Washington's Union Station. The estimated fare can range between US$15 to US$59 one way. To contact Amtrak Passenger Services at Union Station, please call 202-906-3260. To contact the Union Station ticket office, call 202-906-3104.

By Train: The Washington region is served by Amtrak, reservations can be made at www.amtrak.com. If traveling by rail, you will arrive at Union Station, not far from the Capitol. Inside Union Station, you can board Metrorail for a short subway ride to the Dupont Circle or Roslyn metro stop.

By Bus: The Washington region is served by Greyhound Lines, reservations can be made at www.greyhound.com. Megabus also travels to the DC area; reservations can be made at us.megabus.com/. Boltbus also provides service to the DC area; reservations can be made at https://www.boltbus.com/. You will arrive at Union Station, not far from the Capitol. Inside Union Station, you can board Metrorail for a short subway ride to the Dupont Circle or Roslyn metro stop.

By Car: From Baltimore and points north, follow I-95 South and exit onto 495 West (Capital Beltway). Continue on 495 to George Washington Memorial Parkway. Follow the parkway toward Washington, D.C., and exit onto Key Bridge. Cross Key Bridge and turn left onto M Street. Go through one light and turn right into Georgetown University. Follow signs to visitor parking.

From Richmond and points south, follow I-95 North to 395 to Route 27 (Washington Boulevard.) Once on Route 27, carefully watch for signs that lead you through Rosslyn to the Key Bridge. Follow the signs and cross Key Bridge, then turn left onto M Street. Go through one light and turn right into Georgetown University. Follow signs to visitor parking.

From Pittsburgh and points west, follow the Pennsylvania Turnpike East to Exit 12 (Breezewood.) Follow I-70 South to Frederick, where 270 South begins and continue on 270 South toward Washington, D.C. When 270 South intersects with 495 (Capital Beltway), keep right and follow 495 toward Northern Virginia. Continue on 495 to George Washington Memorial Parkway. Follow the parkway toward Washington and exit onto Key Bridge. Cross Key Bridge and turn left onto M Street. Go through one light and turn right into Georgetown University. Follow signs to visitor parking.

Car Rental: Hertz is the official car rental company for the meeting. To make a reservation accessing our special meeting rates online at www.hertz.com, click on the box "I have a discount", and type in our convention number (CV): 04N30005. You can also call Hertz directly at 800-654-2240 (U.S. and Canada) or 1-405-749-4434 (other countries). At the time of reservation, the meeting rates will be automatically compared to other Hertz rates and you will be quoted the best comparable rate available.

For directions to campus, inquire at your rental car counter for directions to the Key Bridge in Rosslyn. Once you get to the Key Bridge, cross Key Bridge and turn left onto M Street. Go through one light. Turn right into Georgetown University. Follow signs to visitor parking.

Local Transportation

Taxi Service: Licensed, metered taxis are available throughout Washington, D.C., close-in suburbs, and the airports.

Bus and Subway Service: The Metro bus and rail system serves Washington D.C. and surrounding areas. Metrobus fare for regular routes can range from US$1.75 to US$4.00 using cash. Senior/Disabled fare can range from US.85¢ to US$2.00 on express routes. You must have exact change, drivers do not carry cash. Metrobus route G2 stops at the Healy Gate (37th and O Streets, N.W.). The G2 bus connects to the Metro subway at the Dupont Circle Metro station (near 20th and Q Streets, N.W.)

Metrorail regular fares vary by time of day and by day of week and by length of journey. Additional information on fares can be found at www.wmata.com/fares/. The Metro offers a SmarTrip® card to purchase multiple fares. It is a permanent, rechargeable farecard which can be purchased online or at any Metrorail station. Fares can also be purchased individually as a standard paper Farecard however, there is a US$1 surcharge levied. Each rider needs his or her own farecard or pass to ride Metrorail. A pass or farecard cannot be shared with another person.

If travelling to Georgetown by the Metro: the Metro subway stations closest to Georgetown University are Dupont Circle station (at 20th & Q Streets, N.W.) and Rosslyn station (located across the Key Bridge in Rosslyn, Va., with entrances at North Moore Street & Wilson Blvd., and on Fort Myer Drive between 19th Street & Wilson Blvd.).

Another public transportation option in the D.C. area is the D.C. Circulator. Information on the Circulator can be located at http://www.dccirculator.com/. The Circulator operates five routes throughout the city's neighborhoods, with buses running approximately every 10 minutes, at a cost of $1 per ride. The two most relevant routes to campus are Dupont Circle-Georgetown-Rosslyn and Georgetown-Union Station.

Weather

The average high temperature for March is approximately 56 degrees Fahrenheit and the average low is approximately 38 degrees Fahrenheit. Rain is common in for this time of year. Visitors should be prepared for inclement weather and check weather forecasts in advance of their arrival.

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 sites.nationalacademies.org/pga/biso/visas/ and travel.state.gov/visa/visa_1750.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to mac@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

Social Networking

Attendees and speakers are encouraged to tweet about the meeting using the hashtags #AMSmtg and #AMSHOYA.

East Lansing, Michigan

Michigan State University

March 14–15, 2015

Saturday – Sunday

Meeting #1108

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: January 2015
Program first available on AMS website: January 29, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 2

Deadlines

For organizers: Expired
For abstracts: January 20, 2015

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Philippe Di Francesco, University of Illinois at Urbana-Champaign, *Integrable combinatorics*.

Alexander Furman, University of Illinois at Chicago, *Hidden symmetries of some groups*.

Vera Mikyoung Hur, University of Illinois at Urbana-Champaign, *Breaking the waves*.

Mihnea Popa, Northwestern University, *Recent Results on Holomorphic one-forms*.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Algebraic Combinatorics (Code: SS 19A), **Carolina Benedetti**, **Peter Magyar**, and **Bruce Sagan**, Michigan State University.

Approximation Theory in Signal Processing and Computer Science (Code: SS 5A), **Mark Iwen**, Michigan State University, **Rayan Saab**, University of California San Diego, and **Aditya Viswanathan**, Michigan State University.

Arithmetic of Hyperelliptic Curves (Code: SS 3A), **Tony Shaska**, Oakland University.

Calculus of Variations, Nonlinear Partial Differential Equations, and Applications (Code: SS 31A), **Moxun Tang** and **Baisheng Yan**, Michigan State University, and **Zhengfang Zhou**, MIchigan State University.

Combinatorics, Geometry, and Representation Theory of Homogeneous Spaces (Code: SS 36A), **Mahir Bilen Can** and **Michael Joyce**, Tulane University, and **Miriam Logan**, Bowdoin College.

Complex Analysis in Several Variables and its Applications (Code: SS 11A), **Debraj Chakrabarti**, Central Michigan University, and **Yunus Zeytuncu**, University of Michigan at Dearborn.

Conformal Geometry and Statistical Physics (Code: SS 20A), **Ilia Binder**, University of Toronto, and **Dapeng Zhan**, Michigan State University.

Discrete Stochastic Models (Code: SS 29A), **Michael Damron**, Indiana University, and **David Sivakoff**, The Ohio State University.

Extremal Graph Theory: Hypergraphs, Directed Graphs, and Other Generalizations (Code: SS 25A), **Louis DeBiasio**, Miami University, and **Theodore Molla**, University of Illinois at Urbana-Champaign.

Floer Homology, Gauge Theory, and Symplectic Geometry (Code: SS 37A), **David Duncan**, **Matt Hedden**, and **Tom Parker**, Michigan State University.

Fractals and Tilings (Code: SS 10A), **Sze-Man Ngai**, Georgia Southern University, **Erin Pearse**, California Polytechnic State University, **Yang Wang**, Hong Kong University of Science and Technology, and **Yimin Xiao**, Michigan State University.

Fractional Calculus and Nonlocal Operators (Code: SS 1A), **Mark M. Meerschaert** and **Russell Schwab**, Michigan State University.

Frames, Wavelets and Their Applications (Code: SS 16A), **Palle Jorgensen**, University of Iowa, **Darrin Speegle**, St. Louis University, and **Yang Wang**, Hong Kong University of Science and Technology.

Geometry and Invariants of 3-Manifolds (Code: SS 22A), **Oliver Dasbach**, Louisiana State University, and **Effie Kalfagianni**, Michigan State University.

Geometry of Manifolds, Singular Spaces, and Groups (Code: SS 18A), **Benjamin Schmidt**, Michigan State University, and **Meera Mainkar**, Central Michigan University.

Groups and Representations (Code: SS 9A), **Amanda Schaeffer Fry**, Metropolitan State University of Denver, **Jonathan Hall**, Michigan State University, and **Hung Nguyen**, University of Akron.

Harmonic Analysis and Applications (Code: SS 27A), **Jarod Hart**, Wayne State University, **Nguyen Lam**, University of Pittsburgh, and **Guozhen Lu**, Wayne State University.

Harmonic Analysis and Partial Differential Equations (Code: SS 26A), **Michael Goldberg**, University of Cincinnati, and **William Green**, Rose-Hulman Institute of Technology.

High-Frequency Problems (Code: SS 14A), **Shlomo Levental** and **Mark Schroder**, Michigan State University.

Homotopy Continuation Methods and Their Applications to Science and Engineering (Code: SS 6A), **Tianran Chen**, Michigan State University, and **Dhagash Mehta**, North Carolina State University.

Integrable Combinatorics (Code: SS 28A), **Philippe Di Francesco**, University of Illinois at Urbana-Champaign, and **Rinat Kedem**, University of Illinois at Urbana-Champaign.

Interactions between Geometry, Group Theory, and Number Theory (Code: SS 24A), **Benjamin Linowitz**, University of Michigan, and **D. B. Reynolds**, Purdue University.

Inverse Problems and Imaging (Code: SS 21A), **Yulia Hristova**, University of Michigan-Dearborn, and **Linh Nguyen**, University of Idaho.

Knot Theory and Floer-Type Invariants (Code: SS 34A), **Christopher Cornwell**, Université du Québec à Montréal, and **Faramarz Vafaee**, Caltech.

Mathematics in Industry and Industrial Problems with Mathematics Application (Code: SS 30A), **Peiru Wu**, Michigan State University.

Modeling, Numerics, and Analysis of Electro-Diffusion Phenomena (Code: SS 17A), **Peter W. Bates**, Michigan State University, **Weishi Liu**, University of Kansas, and **Mingji Zhang**, MIchigan State University.

New Developments in Actuarial Mathematics (Code: SS 15A), **Emiliano A. Valdez**, Michigan State University.

New Developments in Stochastic Analysis, Stochastic Control and Related Fields (Code: SS 7A), **Chao Zhu**, University of Wisconsin-Milwaukee.

Nonlinear Waves: Dynamics and Stability (Code: SS 23A), **Keith Promislow** and **Qiliang Wu**, Michigan State University.

Phase Retrieval in Theory and Practice (Code: SS 8A), **Matthew Fickus**, Air Force Institute of Technology, **Mark Iwen**, Michigan State University, and **Dustin Mixon**, Air Force Institute of Technology.

Random Fields and Long Range Dependence (Code: SS 2A), **Mark M. Meerschaert** and **Yimin Xiao**, Michigan State University.

Random Matrices and Compressed Sensing (Code: SS 40A), **Yang Liu**, Michigan State University.

Recent Advances in Finite Element and Discontinuous Galerkin Methods for Partial Differential Equations (Code: SS 33A), **Aycil Cesmelioglu** and **Anna Maria Spagnuolo**, Oakland University.

Recent Advances in the Geometry of Submanifolds, Dedicated to the Memory of Franki Dillen (1963-2013) (Code: SS 12A), **Alfonso Carriazo Rubio**, University of Sevilla, **Yun Myung Oh**, Andrews University, **Bogdan D. Suceavă**, California State University, Fullerton, and **Joeri Van der Veken**, KU Leuven.

Recent Advances in the Mathematics of Credit Risk and Quantitative Finance (Code: SS 32A), **Albert Cohen**, Michigan State University, and **Nick Costanzino**, University of Toronto.

Smooth Dynamical Systems and Ergodic Theory (Code: SS 35A), **Nicolai Haydn**, University of Southern California, and **Huyi Hu** and **Sheldon Newhouse**, Michigan State University.

Spectral Theory, Disorder, and Quantum Many Body Physics (Code: SS 38A), **Peter D. Hislop**, University of Kentucky, and **Jeffrey Schenker**, Michigan State University.

Stochastic Partial Differential Equations and Applications (Code: SS 4A), **Leszek Gawarecki**, Kettering University, and **Vidyadhar Mandrekar**, Michigan State University.

Survey of Biomathematics (Code: SS 13A), **Hannah Callender**, University of Portland, **Peter Hinow**, University of Wisconsin, Milwaukee, and **Deena Schmidt**, Case Western Reserve University.

Topics in Noncommutative Algebra and Algebraic Geometry (Code: SS 39A), **Jason Bell**, University of Waterloo, **Rajesh S. Kulkarni**, Michigan State University, and **Daniel Rogalski**, UC San Diego.

Session for Contributed Talks

There also will be a session for 10-minute contributed talks. Please see the abstracts submission form at `http://www.ams.org/cgi-bin/abstracts/abstract.pl`. The deadline for all submissions is January 20, 2015.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice. Special discounted rates were negotiated with the hotels listed below. Rates quoted do not include hotel tax. Participants must state that they are with the **American Mathematical Society (AMS) Meeting at Michigan State University** to receive the discounted rates. The AMS is not responsible for rate changes or for the quality of the accommodations. **Hotels have varying cancellation and early checkout penalties; be sure to ask for details.**

Kellogg Hotel and Conference Center, 219 S Harrison Rd, East Lansing, MI 48824, 800-875-5090; www.kelloggcenter.com/. Located on the MSU campus. Rates are US$95 plus a US$5 hotel fee per night for single/double occupancy. Please note additional state and local taxes apply. Amenities include Wi-Fi, fitness center, laundry and dry cleaning services, Capital City Airport shuttle service and covered parking for hotel guests. Check in time is 4:00 p.m. and check out time is 12:00 p.m. The deadline for reservations at this rate is February 10, 2015. Please use Group Code: AMS031315.

Candlewood Suites Hotel, at the Henry Center of MSU, 3545 Forest Rd Lansing, MI 48910, 877-226-3539; `www.ihg.com/candlewood/hotels/us/en/lansing/lanmu/hoteldetail`. Rates are US$95 per night for studio suites. Please note that the hotel tax is 13%. Amenities include Wi-Fi, fitness center, laundry and dry cleaning services and complimentary parking. Check in time is 3:00 p.m. and check out time is 12:00 p.m. **The deadline for reservations at this rate is February 12, 2015. Please use Group Code: AMS.**

East Lansing Area Hotels/Inns, Please visit `www.ctlr.msu.edu/COTravel/Hotels_MSULocal.aspx` for a listing of area hotel and inn recommendations. Discounted rates have only been negotiated with the Kellogg Hotel and Conference Center and Candlewood Suites Hotel.

Food Services

On Campus: **Residential Dining:** Choose the convenience of dining in one of our 10 residence dining halls. Each neighborhood offers vegetarian options, comfort food, grill items, salads, desserts, international cuisine, pizza and sandwiches, breakfast items and more!

Sparty's, Sparty's Café has Spartan Spirit Coffee, hot and cold specialty drinks, convenience items and made-to-order food. Sparty's Express has Spartan Spirit Coffee and convenience items for when you're on the go. Sparty's Refresh has Spartan Spirit Coffee, hot and cold specialty drinks and convenience items. No matter where you are on campus there's, a Sparty's near you!

Dooley's Pub, 442 Water St., Eau Claire, WI 54703; 715-834-2388. Offering traditional Irish pub food. Open Monday-Sunday 11:00 a.m.-close.

Retail Dining, In addition to residence halls and Sparty's, you can take advantage of a number of other campus dining options when you choose to eat at MSU.

Off Campus: There is a wide variety of restaurants and fast food close to campus.

Registration and Meeting Information

Advance Registration: Advance registration for this meeting will open on **January 19, 2015**. Fees will be US$56 for AMS members, US$78 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. More details to be posted then.

Onsite Information and Registration: Registration, the book exhibit, Special Sessions, and the Invited Address will be located in Well Hall, 619 Red Cedar Road East Lansing, MI 48824. You can find the campus map here: `maps.msu.edu/`.

The registration desk will be open on Saturday, March 14, 7:30 a.m.-4:30 p.m. and Sunday, March 15, 8:00 a.m.-12:00 p.m. Fees will be US$56 for AMS members, US$78 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees will be payable onsite via cash, check, or credit card.

Special Needs: It is the goal of the AMS to ensure that its conferences are accessible to all, regardless of disability. AMS shall strive, unless it is not practicable, to choose venues that are fully accessible to the physically handicapped.

If special needs accommodations are necessary in order for you to participate in an AMS Sectional Meeting, please communicate your needs in advance to the AMS Meetings Department by:

- Registering early for the meeting
- Checking the appropriate box on the registration form
- Sending an email request to the AMS Meetings Department at `mmsb@ams.org` or `meet@ams.org`.

Other Activities

Book Sales: Stop by the on-site AMS bookstore to review our newest publications and take advantage of exhibit discounts! AMS members receive 40% off list price. Nonmembers receive a 25 percent discount. Not a member? Ask about the benefits of AMS membership. Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you

wish to discuss with the AMS, please stop by the book exhibit.

Local Information and Maps

This conference will take place in Wells Hall on Michigan State University's campus. Wells Hall is located at 619 Red Cedar Road, East Lansing, MI 48824. Campus maps may be found at maps.msu.edu/. Information about the the Department of Mathematics may be found at math.msu.edu/. Please visit the university's website at www.msu.edu for additional information on the campus.

Parking

Visitor Pay Lots (Lots 39, 62W, 63W, 79, 100 and Wharton Ramp 3) will be FREE the week of Spring Break, March 9-15, 2015 at Michigan State University. Lot 39, the International Center Lot, would be the closest option to Wells Hall. Please note permits will be required outside of Visitor Pay Lots.

Questions about parking on campus at Michigan State University can be addressed to the MSU Police Parking Office at 517-355-8440.

Travel

Airports: East Lansing is served by Lansing's Capital City Airport (LAN). The nearest major airport is Detroit's Metropolitan Airport (DTW). The Michigan Flyer (luxury coach bus service) provides ground transportation from DTW to East Lansing. The Flint Airport (FNT) is located about 40 miles from MSU and would require a rental car for transportation.

Train: Amtrak services the East Lansing area with varying routes. The East Lansing Train Station is located just west of campus.

Driving to MSU

From Traverse City or Points North via I-75: Proceed south on I-75 to US-127 near Grayling. Proceed south on US-127 to East Lansing. Take the Trowbridge Road exit. Follow Trowbridge Road east to Michigan State University.

From Detroit or Points East via I-96: Proceed west on I-96 to northbound US-127; follow US-127 north to East Lansing. Take the Trowbridge Road exit. Follow Trowbridge Road east to Michigan State University.

From Grand Rapids or Points West via I-96: Proceed east on I-96 to eastbound I-69. Proceed east on I-69 to southbound US-127. Take US-127 south to East Lansing. Take the Trowbridge Road exit. Follow Trowbridge Road east to Michigan State University.

From Flint or Points East via I-69: Proceed southwest on I-69 to southbound US-127. Take US-127 south to East Lansing. Take the Trowbridge Road exit. Follow Trowbridge Road east to Michigan State University.

From Kalamazoo or Points South via I-69: Proceed east on I-94 to northbound I-69. Take I-69 north to Lansing. Take I-496 east to the Trowbridge Road exit. Follow Trowbridge Road east to Michigan State University.

From Jackson or Points South via US-127: Proceed north on US-127 to East Lansing. Take the Trowbridge Road exit and continue east to Michigan State University.

Local Transportation

Taxi Service

Big Daddy Taxi: 517-367-7474
Capitol Transport: 517-482-1444
Country Club Taxi: 517-323-9070

Bus Service

The Michigan Flyer: Makes stops in Ann Arbor and Jackson, in addition to the Detroit Airport, if you are traveling to MSU from either of those cities; www.michiganflyer.com/

CATA: Buses can be used to travel around the greater Lansing area; www.cata.org/

Weather

During the month of March, the average high temperature is in the mid-40s, the average low temperature is in mid-20s and the average precipitation is around 2 inches.

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 sites.nationalacademies.org/pga/biso/visas/ and travel.state.gov/visa/visa_1750.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to aba@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.

Social Networking

Attendees and speakers are encouraged to tweet about the meeting using the hashtag #AMSmtg.

Huntsville, Alabama

University of Alabama in Huntsville

March 27–29, 2015

Friday – Sunday

Meeting #1109

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: January 2015
Program first available on AMS website: February 11, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 2

Deadlines

For organizers: Expired
For abstracts: February 4, 2015

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Eva Bayer-Fluckiger, EPFL, *On the Euclidean Division.*

M. Gregory Forest, University of North Carolina at Chapel Hill, *Mathematics of living fluids.*

Dan Margalit, Georgia Institute of Technology, *Geometry, algebra, and dynamics of surfaces.*

Paul Pollack, University of Georgia, *Big doings with small gaps.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at www.ams.org/cgi-bin/abstracts/abstract.pl.

Advances in the Theory and Applications of Dynamical Systems (Code: SS 6A), **Shangbing Ai** and **Wenzhang Huang**, University of Alabama in Huntsville.

Analysis on Nonlinear Integral and Partial Differential Equations (Code: SS 14A), **Tadele Mengesha** and **Tuoc Phan**, University of Tennessee.

Analytic Methods in Elementary Number Theory (Code: SS 9A), **Paul Pollack**, University of Georgia.

Fractal Geometry and Ergodic Theory (Code: SS 1A), **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Geometric Group Theory and Topology (Code: SS 15A), **Tara Brendle**, University of Glasgow, **Christopher Leininger**, University of Illinois at Urbana-Champaign, and **Dan Margalit**, Georgia Institute of Technology.

Graph Theory (Code: SS 11A), **Chris Stephens**, **Dong Ye**, and **Xiaoya Zha**, Middle Tennessee State University.

Mathematical Modeling in Ecology and Epidemiology (Code: SS 16A), **Andrew Nevai** and **Zhisheng Shuai**, University of Central Florida.

New Developments in Population Dynamics and Epidemiology (Code: SS 4A), **Jia Li**, University of Alabama in Huntsville, **Maia Martcheva**, University of Florida, and **Necibe Tuncer**, Florida Atlantic University.

Nonlinear Operator Theory and Partial Differential Equations (Code: SS 7A), **Craig Cowan**, University of Manitoba, and **Claudio Morales**, University of Alabama in Huntsville.

Quadratic Forms in Arithmetic and Geometry (Code: SS 12A), **Asher Auel**, Yale University, **Jorge Morales**, Louisiana State University, and **Anne Quéguiner-Mathieu**, Université Paris 13.

Recent Advances in Numerical Methods for Nonlinear Partial Differential Equations (Code: SS 10A), **S. S. Ravindran**, University of Alabama in Huntsville.

Recent Progress in Differential Equations (Code: SS 8A), **Mathew Gluck**, University of Alabama in Huntsville.

Recent Trends in Mathematical Biology (Code: SS 3A), **Wandi Ding** and **Zachariah Sinkala**, Middle Tennessee State University.

Stochastic Analysis and Applications (Code: SS 13A), **Parisa Fatheddin**, University of Alabama in Huntsville.

Stochastic Processes and Related Topics (Code: SS 2A), **Paul Jung**, University of Alabama at Birmingham, **Erkan Nane**, Auburn University, and **Dongsheng Wu**, University of Alabama in Huntsville.

Topology and Topological Methods in Dynamical Systems (Code: SS 5A), **John Mayer** and **Lex Oversteegen**, University of Alabama at Birmingham.

Session for Contributed Talks

There also will be a session for 10-minute contributed talks. Please see the abstracts submission form at www.ams.org/cgi-bin/abstracts/abstract.pl. The deadline for all submissions is February 4, 2015.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice. Special discounted rates were negotiated with the hotels listed below. Rates quoted do not include a room tax of 13 percent plus a US$1 city surcharge. **Participants should mention 'AMS Meeting'** to receive the discounted rates. The AMS is not responsible for rate changes or for the quality of the accommodations. **Hotels have varying cancellation and early checkout penalties; be sure to ask for details.**

Bevill Conference Center and Hotel (on campus), 550 Sparkman Drive, Huntsville, AL, 35816, 256-721-9428, www.uah.edu/bevill-center. Rates are US$79 single/double. Rooms have microwaves and mini-refrigerators. There is a complimentary continental breakfast. Complimentary passes to the University Fitness Center are available, and there is free parking. Deadline for reservations is March 20, 2015.

Courtyard by Marriott Huntsville (1.3 miles to campus), 4804 University Drive NW, Huntsville, AL, 35816, 256-837-1400. www.marriott.com/hotels/hotel-photos/hsvch-courtyard-huntsville. Rates are US$84 single/

double. Rooms have microwaves and mini-refrigerators, complimentary wired and wireless internet, and there is complimentary parking. There is a restaurant, *The Bistro*, open for breakfast and dinner. Local restaurant dinner delivery is available. Amenities include a fitness room and seasonal outdoor pool. Deadline for reservations is March 6, 2015.

Fairfield Inn Huntsville (3.2 miles from campus), 1385 Enterprise Way, Huntsville, AL 35806, 256-971-0921, www.marriott.com/hotels/travel/hsvfi-fairfield-inn-huntsville. Rates are US$89 single/double. Many rooms have microwaves and mini-refrigerators. Complimentary continental breakfast. Local restaurant dinner delivery. Complimentary wifi is available and free parking is offered. **Deadline for reservations is March 3, 2015.**

Hilton Garden Inn Huntsville/Space Center (1 mile from campus), 4801 Governor's House Drive, Huntsville, AL, 35805, 256-430-1778. hiltongardeninn3.hilton.com/en/hotels/alabama/hilton-garden-inn-huntsville-space-center-HSVSCGI/accommodations/index.html. Rates are US$99 single/double. Rooms have microwaves and mini-refrigerators. There is free high-speed internet access and complimentary parking. A full service restaurant, *The Great American Grill*, is open for breakfast and dinner. Amenities include a fitness center and outdoor pool. Deadline for reservations is February 28, 2015.

Huntsville Marriott at the Space Center (2.3 miles from campus), 5 Tranquility Base, Huntsville, AL 35805, 256-830-2222, www.marriott.com/hotels/travel/hsval-huntsville-marriott. Rates are US$99 single/double. The Marriott has high-speed wireless for US$9.95 per day and complimentary wireless in the lobby and public areas. There is free parking. A complimentary airport shuttle is available upon request; please reserve in advance. A full-service restaurant, *Porter's Steakhouse*, is open for breakfast and dinner. Local restaurant dinner delivery is also available. Amenities include a fitness center and an indoor pool. Deadline for reservations is March 6, 2015.

Dining Information

A google map with restaurant information has been created by the Department of Mathematical Sciences at https://www.google.com/maps/d/viewer?mid=zLp6IFv3IdeI.kiVMDs1r9-HE. Nearby restaurants include the following:

American

Beauregards, 511 Jordan Lane NW, 256-837-2433. Burgers, Pub Food, Sandwiches/Subs. (1.13 miles)

Burger King, 308 Jordan Lane NW, 256-533-0630. Burgers, Fast Food. (1.33 miles)

Frizzles, 210 Jordan Lane NW, 256-518-2211, Fast Food. (1.38 miles)

KFC, 1003 Jordan Lane NW, 256-837-9770. American, Fast Food. (1.66 miles)

Landry's Seafood, 5101 Governors House Drive, 256-864-0000. Seafood, Steakhouse, American. (0.88 miles)

McDonald's, 4002 University Drive NW, 256-837-3970. Burgers, American. (1.56 miles)

New Orleans Lunchbox, 4000 Holmes Avenue, 256-830-0081. American, Cajun/Creole, Barbecue. (1.07 miles)

Quiznos, 4314 University Drive NW, 256-539-4475/ Sandwiches/Subs. (1.15 miles)

Schlotzsky's Deli, 4319 University Drive NW, 256-830-6400. Sandwiches/Subs. (1.2 miles)

Stanlieo's Sub Villas, 605 Jordan Lane NW, 256-837-7220, Sandwiches/Subs, Hot Dogs/Sausages. (1.15 miles)

Subway, 414 Jordan Lane NW, 256-536-5353. Sandwiches/Subs, Fast Food. (1.21 miles)

Tim's Cajun Kitchen, 114 Jordan Lane NW, 256-533-7589. Southern/Soul, Cajun/Creole, Seafood. (1.47 miles)

Tenders, 527 Wynn Drive NW, 256-721-3395, American, (1.14 miles)

Waffle House, 3995 University Drive NW, 256-837-9781.Breakfast/Brunch, Coffee, Diner. (1.66 miles)

Wintzell's Oyster House, 5100 Sanderson Street SW, 256-726-0511, Seafood. (1.1 miles)

Asian

New China Buffet, 207 Jordan Ln NW, 256-830-8156. Buffet, Chinese, Sushi. (1.39 miles)

Garam Korean Restaurant, 600 Jordan Ln NW Ste 1, 256-519-2374. Korean, Asian. (1.12 miles)

I Love Korea, 404 Jordan Lane NW, 256-489-7766. Asian, Korean. (1.28 miles)

Viet Cuisine, 405 Jordan Lane NW, 256-890-0104. Vietnamese. (1.27 miles)

Indian

Sitar, 420 Jordan Lane NW, 256-536-3360. Indian, Buffet, Vegetarian. (1.17 miles)

Mexican

La Alameda Mexican, 311 Jordan Lane NW, 256-539-6244, Mexican, Buffet. (1.31 miles)

Taco Bell, 4315 University Drive NW, 256-716-1112. Mexican. (1.18 miles)

Italian/Mediterranean

Domino's Pizza, 4506 University Drive, NW, 256-830-2662. Pizza. (1.38 miles)

Jamo's Cafe, 413 Jordan Lane NW, 256-837-7880. Middle Eastern, Mediterranean, Vegetarian. (1.21miles)

See the final program for a list of additional dining options within driving distance.

Registration and Meeting Information

Advance Registration

Advance registration for this meeting will open on January 19, 2015. Advance registration fees will be US$56 for AMS members, US$78 for nonmembers, and US$5 for students, unemployed mathematicians, and emeritus members.

Onsite Information and Registration

The Registration Desk and the AMS Book Exhibit will be located in the Shelby Center Lobby. Sessions will be held in the Shelby Center and the Business Adminstration Building. A campus map can be viewed at www.uah.edu/map. The Registration Desk will be open on Friday, March 27, 12:00 p.m.–4:30 p.m. and Saturday, March 28, 7:30 a.m.–4:00 p.m. Fees onsite will be US$56 for AMS Members,

US$78 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on-site via cash, check, or credit card.

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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 wish to discuss with the AMS, please stop by the book exhibit.

Local Information and Maps

This meeting will take place on the campus of the University of Alabama at Huntsville. A campus map can be viewed at http://www.uah.edu/map. Information about the University of Alabama Department of Mathematical Sciences can be found on their website at www.uah.edu/science/departments/math/. Please watch the website at www.ams.org/meetings/sectional/sectional.html for additional information on this meeting. Please visit the University of Alabama website at www.uah.edu for additional information about the campus.

Parking

The nearby Intermodal Parking Facility on John Wright Drive is is available to participants, and there is some additional parking adjacent to Shelby Center. Please check the meeting website at www.ams.org/meetings/sectional/sectional.html for updates.

Travel

The meeting will be held at the University of Alabama, Huntsville, 301 Sparkman Dr NW, Huntsville, AL 35805.

By Air: The closest airport to the university is Huntsville International Airport, Carl T. Jones Field (HSV), 1000 Glenn Hearn Boulevard, Huntsville, AL 35824, www.flyhuntsville.com. The distance from Huntsville International Airport to the campus at the University of Alabama is approximately 11 miles.

The next closest airport is Nashville International Airport (BNA), One Terminal Drive, Nashville, TN, 37214, www.flynashville.com, Nashville International Airport is approximately 115 miles from Huntsville. However, there is a shuttle, see below, from the Nashville International Airport to Huntsville.

Taxis: Taxi service is available from the Huntsville airport for approximately US$25-$30 to the hotels listed and the University. For more information, see the ground transportation page at the Huntsville International Airport website at www.flyhuntsville.com/hsv/airport-information/ground-transportation/#.VFN-8hYgyvw. Taxis are readily available at the airport, however, for your convenience, the following companies are listed:

Huntsville Cab Company	256-536-1313
A-1 United Deluxe Cab	256-536-3600
A Plus Cab Company	256-534-5000
Trans City Cab	256-536-1113

Shuttles

From Huntsville International Airport: Executive Connection, 256-772-0186, www.execconnecthsv.com. One way transportation from the airport to Bevill Center is currently US$27. It is US$23 to the Hilton Garden Inn and US$25 to the Courtyard by Marriott. There is no round-trip discount.

From Nashville International Airport: Madison County Shuttle, 256-287-5155, madisoncountyshuttle.com/main_page.html, approximately US$78 round trip; US$44 one way.

Car Rental: Rental cars are available through a number of agencies at the airport. Please visit the airport website for information on rental car companies in Huntsville.

Driving Directions

From Huntsville International Airport: Start out going east on Glenn Hearn Boulevard. Take Glenn Hearn Boulevard SW toward I-565 Huntsville/Decatur. Merge onto I-565 E/Huntsville Decatur Hwy E toward Huntsville. Take I-565 to Exit 15 (Madison Pike/Sparkman Drive/Bob Wallace Avenue). Keep left to take the ramp toward Sparkman Drive/Botanical Garden. Turn left at the 2nd traffic light onto Sparkman Drive. Continue about a mile to Holmes Avenue and turn right. Continue about a mile (you will pass Charger Union on your right), and at the traffic light, turn right onto John Wright Drive. The Intermodal Parking Facility will be immediately on your right.

From the North (including Nashville): Take I-65 South to Exit 351 (US 72 East). US 72 becomes University Drive. After crossing Wynn Drive, go through one more traffic light and then take the next right (Exit sign) onto Sparkman Drive. At the bottom of the ramp, turn right onto Sparkman. Go about ½ mile to Holmes Avenue and turn left OR:

Take I-65 South to Exit 340 (I-565 East). Take Exit 15 at the US Space & Rocket Center. Turn left at the 2nd traffic light onto Sparkman Drive. Continue about a mile to Holmes Avenue and turn right.

At this point on Holmes Avenue, the directions become the same: Continue about a mile (you will pass Charger Union on your right) and at the traffic light, turn right onto John Wright Drive. The Intermodal Parking Facility will be immediately on your right.

From the Northeast (including Chattanooga):

Take US 72 West from Chattanooga. Entering Huntsville, US 72 splits into I-565. Take I-565 to Exit 15 (Sparkman Drive) and turn right off the exit. Continue about a mile to Holmes Avenue and turn right. Continue about a mile (you will pass Charger Union on your right) and at the traffic light, turn right onto John Wright Drive. The Intermodal Parking Facility will be immediately on your right.

From the South (including Birmingham):

Travel North on I-65. Take Exit 340 onto I-565 East to Huntsville. Take Exit 15 at the US Space & Rocket Center. Turn left at the 2nd traffic light onto Sparkman Drive. Continue about a mile to Holmes Avenue and turn RIGHT. Continue about a mile (you will pass Charger Union on your right) and at the traffic light, turn right onto John Wright Drive. The Intermodal Parking Facility will be immediately on your right.

From the East (including Atlanta):

Travel I-20 West to Birmingham, then I-65 North. Take Exit 340 onto I-565 East to Huntsville. Take Exit 15 at the US Space & Rocket Center. Turn left at the 2nd traffic light onto Sparkman Drive. Continue about a mile to Holmes Avenue and turn right. Continue about a mile (you will pass Charger Union on your right) and at the traffic light, turn right onto John Wright Drive. The Intermodal Parking Facility will be immediately on your right.

From the West (including Memphis)

Take US 72 East through Athens. Entering Huntsville, US 72 becomes University Drive. After crossing Wynn Drive, go through one more traffic light and then take the next right (Exit sign) onto Sparkman Drive. At the bottom of the ramp, turn right onto Sparkman. Continue about ½ mile to Holmes Avenue and turn left. **OR**:

Take US 72 ALT through Decatur. US 72 ALT becomes I-565. Take I-565 East to Huntsville. Take Exit 15 at the US Space & Rocket Center. Turn left at the 2nd traffic light onto Sparkman Drive. Continue about a mile to Holmes Avenue and turn right.

At this point on Holmes Avenue the directions become the same: Continue about a mile (you will pass Charger Union on your right) and at the traffic light, turn right onto John Wright Drive. The Intermodal Parking Facility will be immediately on your right.

Public Transportation: Please see the City of Huntsville's local site at `www.huntsville.org/visitors/transportation/public-transportation/`.

Weather

The month of March in Huntsville is characterized by rising daily high temperatures, with daily highs increasing from 59 degrees F to 68 degrees F over the course of the month, occasionally temperatures rise as high as 80 degrees or as fall as low as 49 degrees. Huntsville in general has a warm, humid climate. Visitors should check weather forecasts in advance of their arrival.

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 `sites.nationalacademies.org/pga/biso/visas/` and `travel.state.gov/visa/visa_1750.html`. If you need a preliminary conference invitation in order to secure a visa, please send your request to `dls@ams.org`.

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Social Networking

Attendees and speakers are encouraged to tweet about the meeting using the hashtag #AMSmtg.

Las Vegas, Nevada

University of Nevada, Las Vegas

April 18–19, 2015
Saturday – Sunday

Meeting #1110
Western Section

Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2015
Program first available on AMS website: March 5, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 2

Deadlines

For organizers: Expired
For abstracts: February 24, 2015

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Joel Hass, University of California, Davis, *Title to be announced.*

Ko Honda, University of California, Los Angeles, *Title to be announced.*

Brendon Rhoades, University of California, San Diego, *Title to be announced.*

Bianca Viray, Brown University, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Algebraic Structures in Knot Theory (Code: SS 7A), **Sam Nelson**, Claremont McKenna College, and **Radmila Sazdanović**, North Carolina State University.

Algebraic and Enumerative Combinatorics (Code: SS 8A), **Drew Armstrong**, University of Miami, and **Brendon Rhoades**, University of California, San Diego.

Algebro-Geometric Methods in Graph Theory (Code: SS 24A), **Mohamed Omar**, Harvey Mudd College, and **Matthew T. Stamps**, KTH.

Cloaking and Metamaterials (Code: SS 9A), **Jichun Li**, University of Nevada, Las Vegas, and **Fernando Guevera Vasquez**, University of Utah.

Contact Geometry and Low-Dimensional Topology (Code: SS 25A), **Ko Honda** and **Erkao Bao**, University of California, Los Angeles, and **Lenhard Ng**, Duke University.

Data Analysis and Physical Processes (Code: SS 4A), **Hanna Makaruk**, Los Alamos National Laboratory, and **Eric Machorro**, National Security Technologies.

Developments of Numerical Methods and Computations for Fluid Flow Problems (Code: SS 11A), **Monika Neda**, University of Nevada, Las Vegas.

Evolution Problems at the Interface of Waves and Fluids (Code: SS 12A), **I. Bejenaru**, University of California, San Diego, and **B. Pausader** and **V. Vicol**, Princeton University.

Extremal and Structural Graph Theory (Code: SS 10A), **Bernard Lidický** and **Derrick Stolee**, Iowa State University.

Geometric Inequalities and Nonlinear Partial Differential Equations (Code: SS 19A), **Guozhen Lu**, Wayne State University, **Nguyen Lam**, University of Pittsburgh, and **Bernhard Ruf**, Università di Milano.

History of Mathematics (Code: SS 23A), **Satish C. Bhatnagar**, University of Nevada, Las Vegas.

Inverse Problems and Related Mathematical Methods in Physics (Code: SS 1A), **Hanna Makaruk**, Los Alamos National Laboratory, and **Robert Owczarek**, University of New Mexico, Albuquerque.

Knots and 3-Manifolds (Code: SS 14A), **Abby Thompson** and **Anastasiia Tsvietkova**, University of California-Davis.

Mathematical and Numerical Aspects of Modeling Flows Through Porous Media (Code: SS 16A), **Aleksey S. Telyakovskiy** and **Stephen W. Wheatcraft**, University of Nevada, Reno.

Modeling and Numerical Studies for Coupled System of PDEs Arising From Interdisciplinary Problems (Code: SS 20A), **Pengtao Sun**, University of Nevada, Las Vegas.

New Developments in Noncommutative Algebra (Code: SS 22A), **Ellen Kirkman**, Wake Forest University, and **James Zhang**, University of Washington, Seattle.

Nonlinear Conservation Laws and Applications (Code: SS 6A), **Matthias Youngs**, Indiana University-Purdue University Columbus, **Cheng Yu**, University of Texas at Austin, and **Kun Zhao**, Tulane University.

Nonlinear Elliptic and Parabolic PDEs (Code: SS 17A), **Igor Kukavica**, University of Southern California, **Walter Rusin**, Oklahoma State University, and **Fei Wang**, University of Southern California.

Nonlinear PDEs and Variational Methods (Code: SS 5A), **David Costa**, **Zhonghai Ding**, and **Hossein Tehrani**, University of Nevada, Las Vegas.

Recent Advances in Finite Element Analysis and Applications (Code: SS 13A), **Jichun Li**, University of Las Vegas, and **Susanne Brenner**, Louisiana State University.

Recent Advances in Finite Element Analysis and Applications (Code: SS 21A), **Jichun Li**, University of Nevada, Las Vegas, and **Susanne Brenner**, Louisiana State University.

Set Theory (Code: SS 15A), **Derrick Dubose** and **Douglas Burke**, University of Nevada, Las Vegas.

Special Session on Arithmetic Geometry (Code: SS 18A), **Katherine E. Stange**, University of Colorado, Boulder, and **Bianca Viray**, University of Washington.

Stochastic Analysis and Rough Paths (Code: SS 2A), **Fabrice Baudoin**, Purdue University, **David Nualart**, University of Kansas, and **Cheng Ouyang**, University of Illinois at Chicago.

Topics in Graph Theory: Structural and Extremal Problems (Code: SS 3A), **Jie Ma**, Carnegie Mellon University, **Hehui Wu**, Simon Fraser University, and **Gexin Yu**, College of William & Mary.

Porto, Portugal

University of Porto

June 10–13, 2015

Wednesday – Saturday

Meeting #1111

First Joint International Meeting involving the American Mathematical Society (AMS), the European Mathematical Society (EMS), and the Sociedade de Portuguesa Matematica (SPM).

Associate secretary: Georgia Benkart

Announcement issue of *Notices*: To be announced
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: Expired
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses

Rui Loja Fernandes, University of Illinois at Urbana-Champaign, *Title to be announced.*

Irene Fonseca, Carnegie Mellon University, *Title to be announced.*

Annette Huber, Albert-Ludwigs-Universität, *Title to be announced.*

Mikhail Khovanov, Columbia University, *Title to be announced.*

André Neves, Imperial College London, *Title to be announced.*

Sylvia Serfaty, Université Pierre et Marie Curie Paris 6, *Title to be announced.*

Gigliola Staffilani, Massachusetts Institute of Technology, *Title to be announced.*

Marcelo Viana, Instituto de Matemática Pura e Aplicada, Brasil, *Title to be announced.*

Chicago, Illinois

Loyola University Chicago

October 3–4, 2015

Saturday – Sunday

Meeting #1112

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: June 2015
Program first available on AMS website: August 20, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 4

Deadlines

For organizers: March 10, 2015
For abstracts: August 11, 2015

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Julia Chuzhoy, Toyota Technological Institute at Chicago, *Title to be announced.*

Andrew Neitzke, The University of Texas at Austin, *Title to be announced.*

Sebastien Roch, University of Wisconsin-Madison, *Title to be announced.*

Peter Sarnak, Princeton University, *Title to be announced* (Erdős Memorial Lecture).

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Algebraic Methods Common to Association Schemes, Hopf Algebras, Tensor Categories, Finite Geometry, and Related Areas (Code: SS 1A), **Harvey Blau**, Northern Illinois University, **Sung Y. Song**, Iowa State University, and **Bangteng Xu**, Eastern Kentucky University.

Memphis, Tennessee

University of Memphis

October 17–18, 2015

Saturday – Sunday

Meeting #1113

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: August 2015
Program first available on AMS website: September 3, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 3

Deadlines

For organizers: March 17, 2015
For abstracts: August 25, 2015

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Mark van Hoeij, Florida State University, *Title to be announced.*

Vaughan Jones, Vanderbilt University, *Title to be announced.*

Mette Olufsen, North Carolina State University, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Advances in Operator Theory and Applications. (Code: SS 5A), **Fernanda Botelho**, University of Memphis.

Banach Spaces and Applications (Code: SS 4A), **Anna Kaminska**, **Peikee Lin**, and **Bentuo Zheng**, University of Memphis.

Computational Analysis (Code: SS 1A), **George Anastassiou**, University of Memphis.

Extremal Graph Theory (Code: SS 3A), **Ralph Faudree**, University of Memphis.

Fractal Geometry and Dynamical Systems (Code: SS 2A), **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Fullerton, California

California State University, Fullerton

October 24–25, 2015

Saturday – Sunday

Meeting #1114

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2015
Program first available on AMS website: September 10, 2015
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Volume 36, Issue 4

Deadlines

For organizers: March 27, 2015
For abstracts: September 1, 2015
The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Mina Aganagic, University of California, Berkeley, *Title to be announced.*

John Lott, University of California, Berkeley, *Title to be announced.*

Eyal Lubetzky, Microsoft Research, Redmond, *Title to be announced.*

Zhiwei Yun, Stanford University, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Geometric Analysis (Code: SS 1A), **John Lott**, University of California, Berkeley, and **Aaron Naber**, Northwestern University.

Mathematicians and Outreach Programs (Code: SS 2A), **Olga Radko**, University of California Los Angeles, and **Bodgan D. Suceava**, California State University, Fullerton.

New Brunswick, New Jersey

Rutgers University

November 14–15, 2015

Saturday – Sunday

Meeting #1115

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: September 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: November 2015
Issue of *Abstracts*: Volume 36, Issue 4

Deadlines

For organizers: April 14, 2015
For abstracts: September 22, 2015

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Lee Mosher, Rutgers University, *Title to be announced.*

Jill Pipher, Brown University, *Title to be announced.*

David Vogan, Massachusetts Institute of Technology, *Title to be announced.*

Wei Zhang, Columbia University, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at http://www.ams.org/cgi-bin/abstracts/abstract.pl.

Applications of CAT(0) Cube Complexes (Code: SS 1A), **Sean Cleary**, City College of New York and the City University of New York Graduate Center, and **Megan Owen**, Lehman College of the City University of New York.

Commutative Algebra (Code: SS 2A), **Laura Ghezzi**, New York City College of Technology, City University of New York, and **Jooyoun Hong**, Southern Connecticut State University.

Seattle, Washington

Washington State Convention 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 (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of 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 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 abstracts: To be announced

Athens, Georgia

University of Georgia

March 5–6, 2016

Saturday – Sunday
Southeastern Section
Associate secretary: Brian D. Boe
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 5, 2015
For abstracts: To be announced

Stony Brook, New York

State University of New York at Stony Brook

March 19–20, 2016

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: August 19, 2015
For abstracts: February 2, 2016

Salt Lake City, Utah

University of Utah

April 9–10, 2016

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 abstracts: To be announced

Fargo, North Dakota

North Dakota State University

April 16–17, 2016

Saturday – 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 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

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `http://www.ams.org/cgi-bin/abstracts/abstract.pl`.

Ergodic Theory and Dynamical Systems (Code: SS 5A), **Dogan Comez**, North Dakota State University, and **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Denver, Colorado

University of Denver

October 8–9, 2016

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: March 8, 2016
For abstracts: August 16, 2016

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: Brian D. Boe
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 abstracts: To be announced

Charleston, South Carolina

College of Charleston

March 10–12, 2017

Friday – Sunday
Southeastern Section
Associate secretary: Brian D. Boe
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: November 10, 2016
For abstracts: To be announced

Bloomington, Indiana

Indiana University

April 1–2, 2017

Saturday – 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 abstracts: To be announced

Pullman, Washington

Washington State University

April 22–23, 2017

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 abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 10–13, 2018

Wednesday – Saturday
Joint Mathematics Meetings, including the 124th Annual Meeting of the AMS, 101st Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2017
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2017
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center, Hilton Baltimore, and Baltimore Marriott Inner Harbor Hotel

January 16–19, 2019

Wednesday – Saturday
Joint Mathematics Meetings, including the 125th Annual Meeting of the AMS, 102nd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM)and the National Association of Mathematicians (NAM), and the winter meeting of the Association of 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 2018
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 2, 2018
For abstracts: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

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: **Brian D. Boe,** Department of Mathematics, University of Georgia, 220 D W Brooks Drive, Athens, GA 30602-7403, e-mail: brian@math.uga.edu; telephone: 706-542-2547.

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.

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:

2015

January 10–13	San Antonio, Texas Annual Meeting	p. 92
March 7–8	Washington, DC	p. 94
March 14–15	East Lansing, Michigan	p. 99
March 27–29	Huntsville, Alabama	p. 103
April 18–19	Las Vegas, Nevada	p. 106
June 10–13	Porto, Portugal	p. 107
October 3–4	Chicago, Illinois	p. 108
October 17–18	Memphis, Tennessee	p. 108
October 24–25	Fullerton, California	p. 109
November 14–15	New Brunswick, New Jersey	p. 109

2016

January 6–9	Seattle, Washington Annual Meeting	p. 109
March 5–6	Athens, Georgia	p. 110
March 19–20	Stony Brook, New York	p. 110
April 9–10	Salt Lake City, Utah	p. 110
April 16–17	Fargo, North Dakota	p. 110
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2017

January 4–7	Atlanta, Georgia Annual Meeting	p. 110
March 10–12	Charleston, South Carolina	p. 111
April 1–2	Bloomington, Indiana	p. 111
April 22–23	Pullman, Washington	p. 111

2018

January 10–13	San Diego, California Annual Meeting	p. 111

2019

January 16–19	Baltimore, Maryland Annual Meeting	p. 111

Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 91 in the January 2015 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarly coded material (such as accent marks in text) must be typeset in LaTeX. Visit 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 in Cooperation with the AMS: (See www.ams.org/meetings/ for the most up-to-date information on these conferences.)

February 12–16, 2015: 2015 Annual Meeting of AAAS, San Jose, California.

April 2–5, 2015: The Second International Conference on Mathematics and Statistics (AUS-ICMS '15). American University of Sharjah, United Arab Emirates.

July 13–31, 2015: 2015 Summer Research Institute on Algebraic Geometry, University of Utah, Salt Lake City, Utah.

AMERICAN MATHEMATICAL SOCIETY

CURRENT EVENTS BULLETIN

Monday, January 12, 2015, 1:00 PM to 5:00 PM

Room 205 Henry B. Gonzalez Convention Center
Joint Mathematics Meetings, San Antonio, TX

1:00 PM

Jared S. Weinstein, *Boston University*

Exploring the Galois group of the rational numbers: Recent breakthroughs.

There's a deep analogy between number fields and curves over finite fields. Learn about Peter Scholze's work establishing a new and more direct connection.

2:00 PM

Andrea R. Nahmod, *University of Massachusetts, Amherst*

The nonlinear Schrödinger equation on tori: Integrating harmonic analysis, geometry, and probability.

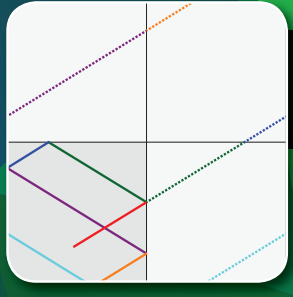
One of the most important and classical partial differential equations, in a broad modern context.

3:00 PM

Mina Aganagic, *University of California, Berkeley*

String theory and math: Why this marriage may last.

Is string theory physics? Is it math? Both? What's going on now? Hear a report from the front!



4:00 PM

Alex Wright, *Stanford University*

From rational billiards to dynamics on moduli spaces.

Dynamical systems in some old and some very modern settings. Come hear about one of the things for which Maryam Mirzakhani won the Fields Medal in 2014!

Organized by David Eisenbud,
Mathematical Sciences Research Institute

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