Notices
of the American Mathematical Society

December 2014

Volume 61, Number 11

$$1$$
$$+ \frac{q}{(1-q)^2}$$
$$+ \frac{q^4}{(1-q)^2(1-q^2)^2}$$
$$+ \frac{q^9}{(1-q)^2(1-q^2)^2(1-q^3)^2}$$
$$+ \frac{q^{16}}{(1-q)^2(1-q^2)^2(1-q^3)^2(1-q^4)^2}$$
$$+ \frac{q^{25}}{(1-q)^2(1-q^2)^2(1-q^3)^2(1-q^4)^2(1-q^5)^2}$$
$$+ \frac{q^{36}}{(1-q)^2(1-q^2)^2(1-q^3)^2(1-q^4)^2(1-q^5)^2(1-q^6)^2}$$
$$+ \frac{q^{49}}{(1-q)^2(1-q^2)^2(1-q^3)^2(1-q^4)^2(1-q^5)^2(1-q^6)^2(1-q^7)^2}$$
$$+ \frac{q^{64}}{(1-q)^2(1-q^2)^2(1-q^3)^2(1-q^4)^2(1-q^5)^2(1-q^6)^2(1-q^7)^2(1-q^8)^2}$$

$$1$$
$$+ \frac{q}{(1+q)^2}$$
$$+ \frac{q^4}{(1+q)^2(1+q^2)^2}$$
$$+ \frac{q^9}{(1+q)^2(1+q^2)^2(1+q^3)^2}$$
$$+ \frac{q^{16}}{(1+q)^2(1+q^2)^2(1+q^3)^2(1+q^4)^2}$$
$$+ \frac{q^{25}}{(1+q)^2(1+q^2)^2(1+q^3)^2(1+q^4)^2(1+q^5)^2}$$
$$+ \frac{q^{36}}{(1+q)^2(1+q^2)^2(1+q^3)^2(1+q^4)^2(1+q^5)^2(1+q^6)^2}$$
$$+ \frac{q^{49}}{(1+q)^2(1+q^2)^2(1+q^3)^2(1+q^4)^2(1+q^5)^2(1+q^6)^2(1+q^7)^2}$$
$$+ \frac{q^{64}}{(1+q)^2(1+q^2)^2(1+q^3)^2(1+q^4)^2(1+q^5)^2(1+q^6)^2(1+q^7)^2(1+q^8)^2}$$

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About the cover: Which is the good Theta, and which is the mock? (see page 1364)

2015 AMS Dinner Celebration

Attend the AMS Dinner for an evening of celebrating the spirit of connection and collaboration with the tastes and sounds of Texas! Reconnect with colleagues and friends while enjoying a delicious meal from gourmet food stations, listening to live music, and entering for your chance to win fun prizes at the raffle table.

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1322

We end the year with a panoply of fascinating articles. There is an exposition of the study of Ramanujan's mock theta function. Accompanying that is a review of a new film about Ramanujan. There is a study of Math Teachers' Circles and an examination of the Kan extension seminar. Finally, there is a remembrance of the distinguished complex geometer Shoshichi Kobayashi. —*Steven G. Krantz, Editor*

Features

Notices
of the American Mathematical Society

Departments

Do the Math

Elliptic Tales
Curves, Counting, and Number Theory
Avner Ash & Robert Gross

Elliptic Tales describes the latest developments in number theory by looking at one of the most exciting unsolved problems in contemporary mathematics—the Birch and Swinnerton-Dyer Conjecture. Avner Ash and Robert Gross guide readers through the mathematics they need to understand this captivating problem.

Paper $16.95
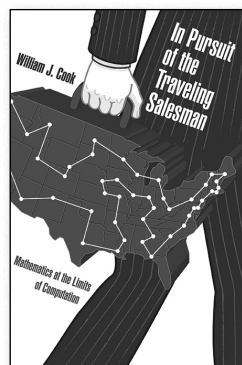
In Pursuit of the Traveling Salesman
Mathematics at the Limits of Computation
William J. Cook

In this book, William Cook takes readers on a mathematical excursion, picking up the salesman's trail in the 1800s when Irish mathematician W. R. Hamilton first defined the problem, and venturing to the furthest limits of today's state-of-the-art attempts to solve it. He also explores its many important applications, from genome sequencing and designing computer processors to arranging music and hunting for planets.

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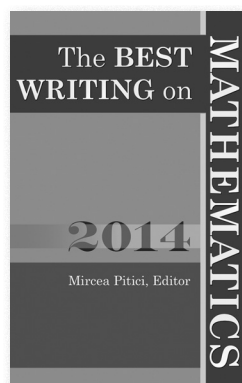
The Best Writing on Mathematics 2014
Edited by Mircea Pitici

This annual anthology brings together the year's finest mathematics writing from around the world. Featuring promising new voices alongside some of the foremost names in the field, *The Best Writing on Mathematics 2014* makes available to a wide audience many articles not easily found anywhere else.

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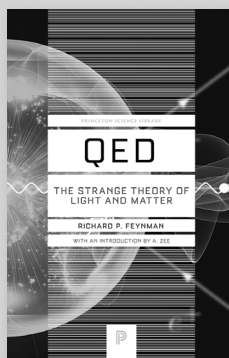
QED
The Strange Theory of Light and Matter
Richard P. Feynman
With an introduction by A. Zee

Using everyday language, spatial concepts, visualizations, and his renowned "Feynman diagrams" instead of advanced mathematics, Feynman clearly and humorously communicates both the substance and spirit of QED to the layperson.

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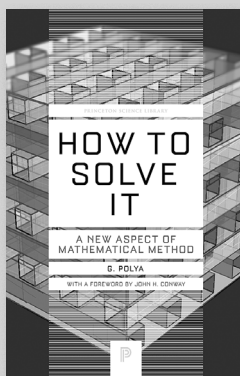
How to Solve It
A New Aspect of Mathematical Method
G. Polya
With a foreword by John H. Conway

A perennial bestseller by eminent mathematician G. Polya, *How to Solve It* will show anyone in any field how to think straight. In lucid and appealing prose, Polya reveals how the mathematical method of demonstrating a proof or finding an unknown can be of help in attacking any problem that can be "reasoned" out—from building a bridge to winning a game of anagrams.

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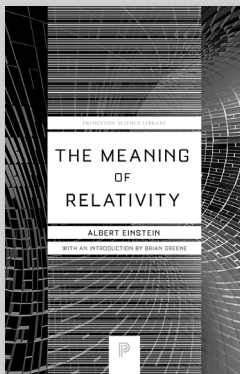
The Meaning of Relativity
Albert Einstein
With an introduction by Brian Greene

In 1921, Albert Einstein visited Princeton University where he delivered the Stafford Little Lectures for that year. These four lectures constituted an overview of his then-controversial theory of relativity. Princeton University Press made the lectures available under the title *The Meaning of Relativity*, the first book by Einstein to be produced by an American publisher.

Paper $19.95

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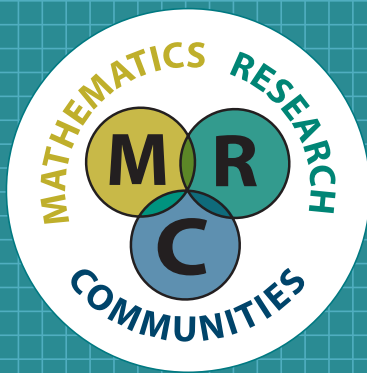
The American Mathematical Society *announces*

Mathematics Research Communities
Call for Applicants

The AMS invites mathematicians just beginning their research careers to become part of **Mathematics Research Communities**, a program to develop and sustain long-lasting cohorts for collaborative research projects in many areas of mathematics. Women and underrepresented minorities are especially encouraged to participate. The AMS will provide a structured program to engage and guide all participants as they start their careers. The program will include:

- One-week summer conference for each topic
- Special Sessions at the national meeting
- Discussion networks by research topic
- Longitudinal study of early-career mathematicians

The summer conferences of the Mathematics Research Communities will be held in the breathtaking mountain setting of the Snowbird Resort, Utah, where participants can enjoy the natural beauty and a collegial atmosphere. **The application deadline for summer 2015 is March 1, 2015.**

This program is supported by a grant from the National Science Foundation.

June 7-13, 2015
Commutative Algebra
Organizers:
Srikanth B. Iyengar *(University of Utah)*
Karl Schwede *(University of Utah)*
Liana Sega *(University of Missouri–Kansas City)*
Gregory G. Smith *(Queen's University)*
Wenliang Zhang *(University of Nebraska)*

June 14-20, 2015
Financial Mathematics
Organizers:
Maxim Bichuch *(Worcester Polytechnic Institute)*
Michael Carlisle *(Baruch College, CUNY)*
Olympia Hadjiliadis *(Brooklyn College, CUNY)*
Birgit Rudloff *(Princeton University)*
Stephan Sturm *(Worcester Polytechnic Institute)*

June 21-27, 2015
Differential Equations, Probability and Sea Ice
Organizers:
Daniel Feltham *(University of Reading)*
Kenneth M. Golden *(University of Utah)*
Mary Silber *(Northwestern University)*
Court Strong *(University of Utah)*
Deborah Sulsky *(University of New Mexico)*

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Opinion
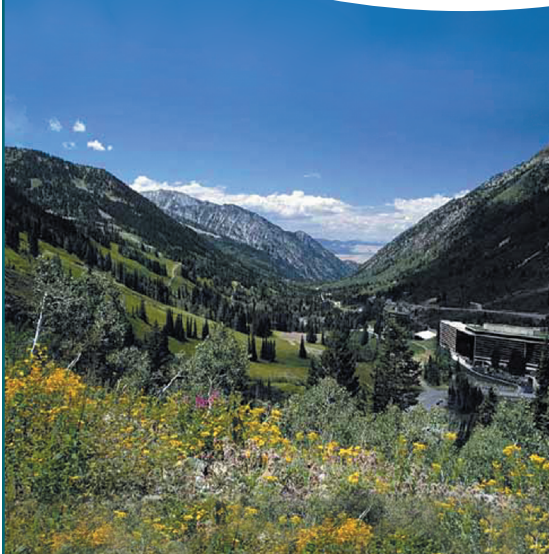
The Burden on Graduate School Recommenders

At this time of year, many of us will be assisting our undergraduate and master's students in applying to graduate school. We will also be helping our new PhDs apply for postdoctoral or tenure-track positions. While both application processes require letters of recommendation, they are otherwise quite different. Where the second requires us simply to upload the letter to MathJobs, the first often forces us to negotiate a wide variety of graduate school application systems with a plethora of extra questions and check boxes. This can be frustrating after one has spent time writing an informative, detailed letter covering all aspects of the applicant's qualifications. In some cases, the additional questions ask for evaluations of the applicant's originality, creativity, research potential, etc. If you are lucky, the answers to such questions use check boxes; if you are unlucky, entire paragraphs are demanded. We believe that we must push back against the unreasonable demand on our time from these extra recommendation forms, which likely provide only marginal value to graduate programs.

A simpler approach should be possible. Why do we trust our colleagues to recommend new PhDs or postdoctoral fellows with nothing but a letter, while for graduate applications we require that same information again, in a somewhat different format? In our experience, when we evaluate student applications, there is usually little if any extra information not in the letter. And the ratings provided are typically more inflated than they are in the letter. Of course: we all realize that providing an applicant with anything but the strongest endorsement to a question like "Do you support the student's application?" is a big strike against them. In a letter we can be more nuanced and offer more perspective.

What can be done? Different solutions are possible. Some require more effort than others, but may have a larger impact. For starters, all of us should examine the letter-of-recommendation process of our own departments. If you find the process annoying and too time consuming, chances are so will everyone else. If so, push for a change.

Recently, we have been inspired by a note Robert Strichartz wrote at the end of a letter of recommendation one year ago, which was read by the first author. Professor Strichartz has given us permission to reproduce the note here. Verbatim, it reads:

> If your application form asks for ratings of the student in various categories I will either deliberately leave them blank, or if your system does not allow the option of leaving them blank I will check the highest rating in all categories. In addition, the department administrative staff is designated to submit the application material for me. If your system requires other information in regards to my background, it may not be accurate. In both cases please disregard the ratings and faculty background information. I understand that this information is used in your evaluation process; however, I would like to suggest that you consider modifying your system to allow the option to skip ratings and background sections to make the process more efficient.

The inclusion of this note did not affect the standing of the applicant, which is of paramount importance. We have adopted this approach in our own letters this application season. Over the long term, it would be helpful to have a central system for letters of recommendation that would be used by all graduate programs in mathematical fields, something like MathJobs. Letters would be uploaded once for each applicant, after which the applicant decides which department receives which letters. The AMS, with its MathJobs experience, and its central position in the mathematical sciences, seems well placed to develop such a system. The rest of the application materials would not be entered into this online system but instead would be submitted by whatever means various departments currently use. Medical schools provide an example: 139 of the 141 accredited US medical schools receive letters of recommendation for more than 45,000 applicants through a website run by a professional society (`services.aamc.org/letterwriter/`).

The current systems for submitting letters of recommendation for graduate school applicants are unnecessarily burdensome to students' recommenders. Technology and coordination could ease the burden, as could simply more careful consideration to the amount and type of information that is truly needed. We should start by ensuring that the system at our home institutions is not one of the culprits. Beyond that, as recommenders we can follow Strichartz's idea of refusing to fill out additional forms, which might over time lead to departments changing their approach to a more reasonable one.

—Bernard Deconinck
University of Washington
`bernard@amath.washington.edu`

—Jan Medlock
Oregon State University
`jan.medlock@oregonstate.edu`

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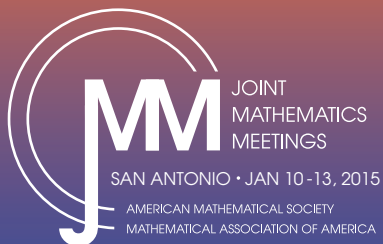
→ # THE 2015 AMS EMPLOYMENT CENTER

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January 10–13, 2015

Open hours:

Saturday, January 10, 8:00 a.m. – 5:30 p.m.
Sunday, January 11, 8:00 a.m. – 5:30 p.m.
Monday, January 12, 8:00 a.m. – 5:30 p.m.
Tuesday, January 13, 9:00 a.m. – noon

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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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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.

Almost a Century of Answering the Question: *What Is a Mock Theta Function?*

W. Duke

Quite a few famous and extraordinarily gifted mathematicians led lives that were tragically cut short. Ramanujan is certainly among them. While suffering from a fatal disease, he discovered what he called mock theta functions. Three months before his death in 1920 at the age of thirty-two, he described them in a letter to Hardy that *was written under difficulties and is in places very obscure* [30, p. 354]. One fascinating and also frustrating aspect of this story is that from the start the precise definition of a mock theta function has been elusive. Ramanujan did not give a formal definition but explained what properties a mock theta function should have and illustrated them through several examples. He also gave some of their properties without proof. Subsequent work stimulated by his letter (and his "lost" notebook discovered later) has been of two somewhat different types. The goal of the first type, beginning with Watson's cleverly titled address "The Final Problem…", has been to prove Ramanujan's claims on his terms and to give extensions of the same nature. Here the focus is not so much on the definition but rather on the examples. The mathematics is intricate and beautiful but leaves unclear a broader theoretical role for mock theta functions.

The second type, which is more recent, has clarified this role. We now understand that mock theta functions can be regarded as incomplete harmonic Maass forms and thus belong naturally to the theory of modular forms. This has led to new results about mock theta functions and, perhaps more interestingly, to a resurgence in the study of other kinds of harmonic Maass forms and their arithmetic properties. Mock theta functions are now seen as interesting examples of a much larger class of mock modular forms. These have applications to elliptic curves, singular moduli and their real quadratic analogues, Borcherds products, Eichler cohomology, and Galois representations, among others.

My main goal is to give a reasonably short (hence necessarily incomplete) introduction to this story that is accessible to a nonspecialist. At the same time I will occasionally make use of terms I have not defined and provide technical details for the benefit of those having more extensive background knowledge. A number of excellent expositions and survey articles have appeared on mock theta functions and their generalizations: [1], [9], [17], [18], [27], [28], [37]. In particular, this paper has quite a lot in common with Folsom's 2010 article [17] in the *Notices*. Here I give a complementary account along somewhat similar lines but with more detail and also outline further developments. Any serious discussion of Ramanujan's mathematics must contain identities between complex formulas. However, there are also conceptual aspects, and my aim is to give a treatment that illuminates both.

Ramanujan's Letter

The mathematical part of Ramanujan's letter is reproduced in [1]. Ramanujan motivated his mock theta functions by first describing briefly two "genuine" theta functions. The first example is the q-series for the partition function $p(n)$:

$$(1) \qquad g(q) = \sum_{n \geq 0} p(n) q^n = \prod_{m \geq 1} (1 - q^m)^{-1}.$$

A q-series is simply a power series in powers of q whose coefficients usually count something of combinatorial interest. Here $p(n)$ counts the number of ways of expressing n as a sum of positive integers, repetition allowed and not counting order. For example, $p(6) = 11$, since

$$
\begin{aligned}
6 &= 5 + 1 = 4 + 2 = 4 + 1 + 1 = 3 + 3 \\
&= 3 + 2 + 1 = 3 + 1 + 1 + 1 = 2 + 2 + 2 \\
&= 2 + 2 + 1 + 1 = 2 + 1 + 1 + 1 + 1 \\
&= 1 + 1 + 1 + 1 + 1 + 1.
\end{aligned}
$$
(2)

Ramanujan's second example of a genuine theta function is the q-series
(3)
$$
h(q) = \sum_{n \geq 0} \hat{p}(n) q^n = \prod_{m \geq 1} \frac{1}{(1 - q^{5m-1})(1 - q^{5m-4})},
$$

where now $\hat{p}(n)$ equals the number of partitions into parts of the forms $5m - 1$ and $5m - 4$.

A mock theta function, as conceived by Ramanujan, is a special kind of q-series that mimics two properties of $g(q)$ and $h(q)$. The first is that they can be expressed in Eulerian form:

(4)
$$
g(q) = 1 + \sum_{n \geq 1} \frac{q^{n^2}}{(1 - q)^2 (1 - q^2)^2 \cdots (1 - q^n)^2},
$$

(5)
$$
h(q) = 1 + \sum_{n \geq 1} \frac{q^{n^2}}{(1 - q)(1 - q^2) \cdots (1 - q^n)}.
$$

Here "Eulerian form" refers to the basic shape of the series in (4) and (5); such series have coefficients that count restricted partitions of various types. For example, (5) is one of the Rogers-Ramanujan identities and expresses the fact that $\hat{p}(n)$ equals the number of partitions of n into parts having minimal difference two.

The second property is that the q-series converge for $|q| < 1$ and have the unit circle as a natural boundary but are amenable to the circle method.[1] The circle method was actually invented by Hardy and Ramanujan in one of their most important collaborations [19] to obtain a remarkably accurate formula for $p(n)$. Their idea was to apply Cauchy's integral formula to $g(q)$.

As a model example, consider the number of partitions $p_3(n)$ of n into parts ≤ 3. For instance, it is easily checked from (2) that $p_3(6) = 7$. Now $p_3(n)$ has the generating function

$$
g_3(q) = \sum_{n \geq 0} p_3(n) q^n = \frac{1}{(1 - q)(1 - q^2)(1 - q^3)},
$$

and Cauchy's formula gives for $c < 1$ that

$$
p_3(n) = \frac{1}{2\pi i} \int_{|q|=c} q^{-n-1} g_3(q) \, dq.
$$

---

[1] *This is not exactly how Ramanujan put it, but it captures the idea.*

Next we push the contour over the singularities of g. By letting $c \to \infty$ we pick up residues from the poles to get the exact formula
(6)
$$
p_3(n) = \frac{1}{12}(n+3)^2 + (\tfrac{1}{2} \cos \tfrac{1}{2} \pi n)^2 - (\tfrac{2}{3} \sin \tfrac{1}{3} \pi n)^2.
$$
It follows that $p_3(n)$ is the integer nearest to $\frac{1}{12}(n+3)^2$.

The function $g(q)$ in (1) is much harder to use in this way, since it has the unit circle as a natural boundary but near roots of unity it can be well approximated. Thus Hardy and Ramanujan could not simply push the contour over the singularities but had the brilliant idea of moving it toward the unit circle in a cunning way (the circle method) and approximating the influence of the singularities. This process is greatly facilitated by modular properties of $g(q)$, which yield a precise approximation of $g(q)$ near each root of unity. The most influential singularity is at $q = 1$ and for this we use the modular inversion formula

(7)
$$
q^{1/24} g(q) = \sqrt{y} \, (q')^{1/24} g(q'),
$$

when $q = e^{-2\pi y}$ and $q' = e^{-\frac{2\pi}{y}}$. Now (7) easily gives

(8)
$$
\sqrt{y} \exp \tfrac{\pi}{12} \left(\tfrac{1}{y} - y \right)
$$

as the first-order approximation to $g(e^{-2\pi y})$ as $y \to 0$. This leads to the asymptotic formula

(9)
$$
p(n) \sim \frac{1}{4n\sqrt{3}} \exp \left(\pi \sqrt{\tfrac{2n}{3}} \right)
$$

as $n \to \infty$. Making full use of the modular properties of $g(q)$, Hardy and Ramanujan extended this idea to obtain an infinite sum with the property that $p(n)$ is the integer closest to the sum of the first $\sqrt{n}$ terms for sufficiently large n. Rademacher [30] (and independently Selberg) later refined their method to get a variation that is exact:
(10)
$$
p(n) = \frac{1}{\sqrt{6}\pi} \sum_{k \geq 1} k S_k(n) \frac{d}{dn} \left(\lambda(n)^{-1} \sinh \left(\frac{\sqrt{2}\pi\lambda(n)}{\sqrt{3}k} \right) \right)
$$

where $\lambda(n) = (n - \tfrac{1}{24})^{1/2}$. Also, after Selberg,

(11)
$$
S_k(n) = \sum (-1)^\ell \cos \frac{6\ell-1}{6k} \pi,
$$

the sum being over ℓ modulo $2k$ with $\frac{3\ell^2-\ell}{2} \equiv -n$ (mod k). In a sense, (10) is like (6) only much more difficult to derive. Selberg gives in [33] an interesting account of (10) and speculates about why Hardy and Ramanujan didn't give this refinement themselves. In any case, the fact that a purely arithmetic counting function can be computed by such a formula is astonishing and must have motivated Ramanujan to look for similar q-series. In particular, the function $h(q)$ also has modular properties that yield good approximations at roots of unity and is amenable to the circle method.

Ramanujan's first example of a mock theta function is the Eulerian series

(12)
$$f(q) = 1 + \sum_{n \geq 1} a(n) q^n$$
$$= 1 + \sum_{n \geq 1} \frac{q^{n^2}}{(1+q)^2 (1+q^2)^2 \cdots (1+q^n)^2},$$

which appears deceptively similar to $g(q)$ and $h(q)$. The coefficient $a(n)$ counts the number of partitions of n with even rank minus the number with odd rank, where the rank of a partition is its largest part minus the number of its parts. Ramanujan gives information about the behavior of $f(q)$ near each root of unity that is similar yet also different enough from that for genuine theta functions that he concludes that it is *inconceivable that a single ϑ-function could be found to cut out the singularities of $f(q)$*. Nevertheless, he was able to give an asymptotic formula for the coefficient $a(n)$ that comes from the circle method and whose leading term is given by

(13)
$$a(n) \sim \frac{(-1)^{n-1}}{2\sqrt{n-\frac{1}{24}}} \exp\left(\pi\sqrt{\frac{n}{6} - \frac{1}{144}}\right)$$

as $n \to \infty$.

Ramanujan gave some seventeen examples of mock theta functions and stated for them numerous identities and asymptotic properties. Andrews found more examples in Ramanujan's "lost" notebook, which he argues was written near the end of his life. Andrews [1], Gordon [18], Selberg [31] and Watson [35], among others, proved Ramanujan's claims and greatly expanded their extent, giving transformation formulas connecting them and combinatorial interpretations of their coefficients. Of particular interest are identities for certain "fifth order" mock theta functions found in the lost notebook, called by Andrews and Garvan [2] the *Mock Theta Conjectures*. The proof of these and others for mock theta functions of seventh order were given by Hickerson [21], [22]. See [1] for a wide-ranging survey and references on such problems (i.e., of the first type) about mock theta functions.

Ramanujan emphasized that a mock theta function should not have the same singularities at roots of unity as a genuine theta function. Exactly what he meant by a genuine theta function was never made clear, although various plausible explanations have been given. It seems to me that this issue is a bit of a red herring. After all, the really interesting problem is to explain structurally what unites these examples. In other words, it is more fruitful to regard $f(q)$ as a generalization of $g(q)$ and $h(q)$ and determine how it generalizes them.

For example, one of Ramanujan's results from the lost notebook (see [1, p. 287]), later rediscovered

by Watson [35], is that $f(q)$ is related under a modular transformation to another mock theta function:

$$\omega(q) = \sum_{n \geq 0} \frac{q^{2n(n+1)}}{(1-q)^2 (1-q^3)^2 \cdots (1-q^{2n+1})^2}.$$

Thus if $q = e^{-2\pi y}$ and $q_1 = e^{-\frac{\pi}{2y}}$, then

$$q^{-1/24} f(q) = 2y^{-1/2} q_1^{4/3} \omega(q_1^2) + 4(3y)^{1/2}$$
$$\times \int_0^\infty e^{-3\pi y x^2} \frac{\sinh 2\pi y x}{\sinh 3\pi y x} \, dx.$$

This suggestive formula hints that the mock theta function $f(q)$ secretly wants to be modular.

Mock Theta Functions Today

Modular forms can be defined in many different ways depending on one's point of view. For our purposes here they are smooth complex-valued functions F defined on the upper half-plane $\mathcal{H}$ that transform in a certain way under a finite-index subgroup Γ of SL$(2, \mathbb{Z})$, where $\gamma \in \Gamma$ acts on $\mathcal{H}$ by linear fractional maps $z \mapsto \gamma z = \frac{az+b}{cz+d}$. We say that F has weight $k \in \mathbb{Q}$ for Γ, if for all $\gamma = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \in \Gamma$,

(14)
$$F(\gamma z) = \chi(\gamma)(cz+d)^k F(z),$$

where $|\chi(\gamma)| = 1$ depends only on γ and the branch of log chosen to define $(cz+d)^k$. In addition, we suppose that $F(z)$ satisfies a growth condition, conveniently given by requiring that the invariant function $\text{Im}(z)^{k/2} |F(z)|$ is bounded in $\mathcal{H}$ by a constant times $\exp(C(\text{Im}(z) + \text{Im}(z)^{-1}))$ for some constant $C \geq 0$.

The generating function for the partition function gives rise to a modular form,

(15)
$$G(z) = q^{1/24} g(q) = q^{-1/24} \prod_{m \geq 1} (1 - q^m)^{-1},$$

where we set for $z \in \mathcal{H}$,

$$q = e(z) = \exp(2\pi i z).$$

Dedekind showed that $G(z)^{-1} = \eta(z)$ has weight $1/2$ for SL$(2, \mathbb{Z})$, this being Dedekind's famous eta function, so $G(z)$ has weight $-1/2$ for SL$(2, \mathbb{Z})$. The behavior of g near roots of unity is determined by that of $G(z)$ near rational points, and this can be deduced from the transformation formula. In particular, (7) follows from the transformation formula with $\gamma z = -1/z$. The Rademacher formula uses explicit knowledge of the $\chi(\gamma)$ in the transformation formula for all $\gamma \in \text{SL}(2, \mathbb{Z})$, which was found by Dedekind in terms of the Dedekind sum and is a 24th root of unity.

Similarly, the Rogers-Ramanujan function

$$H(z) = q^{-1/60} \prod_{m \geq 1} (1 - q^{5m-1})^{-1} (1 - q^{5m-4})^{-1}$$

is a modular form of weight 0 for $\Gamma(5)$. Here $\Gamma(N)$, the principal congruence subgroup of level $N \in \mathbb{Z}^+$, comprises $\gamma \in \text{SL}(2, \mathbb{Z})$ with $\gamma \equiv \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \pmod{N}$.

The functions G and H are holomorphic in $\mathcal{H}$ and are related to the g and h of (4) and (5) simply by multiplication by a fractional power of q. In order to give the modular form definition of mock theta functions, we must consider Maass forms. There is a weight k version of the Laplace operator defined through

$$\Delta_k F = -y^2(\partial_x^2 + \partial_y^2) + iky(\partial_x + i\partial_y).$$

If F has weight k for Γ, then so does $\Delta_k F$. This follows most easily from the decomposition $\Delta_k = \xi_{2-k} \circ \xi_k$, where

$$(16) \qquad \xi_k F(z) = 2iy^k \overline{\partial_{\bar{z}} F(z)},$$

since it is easily checked that $\xi_k F$ has weight $2 - k$ when F has weight k.

A Maass form of weight k for Γ is a modular form F of weight k for Γ that is an eigenfunction of Δ_k:

$$(17) \qquad \Delta_k F = \lambda F.$$

In case $\lambda = 0$ we say that F is harmonic of weight k. If F is holomorphic it is also harmonic of weight k for any k by (16), so the class of harmonic Maass forms of weight k includes the holomorphic forms.

Around 2000 Zwegers [39], [40] made a breakthrough in our understanding of Ramanujan's mock theta functions. It follows from his work that, after multiplication by a power of q and the addition of a certain nonholomorphic function, a mock theta function is a harmonic Maass form of weight $1/2$. For the example $f(q)$ from (12),

$$F(z) = q^{-\frac{1}{24}} f(q) + g^*(z)$$

is a harmonic Maass form of weight $1/2$ for $\Gamma(2)$ when

$$g^*(z) = \sum_{n \in 1+6\mathbb{Z}} \operatorname{sgn}(n)\, \beta(\tfrac{n^2 y}{6})\, q^{-n^2/24}.$$

Here $\beta(x)$ is defined for $x > 0$ in terms of the complementary error function and the standard incomplete gamma function by

$$(18) \quad \beta(x) = \operatorname{erfc}(\sqrt{\pi x}) = \frac{1}{\sqrt{\pi}} \Gamma(\tfrac{1}{2}, \pi x),$$

$$\text{where} \quad \Gamma(s, x) = \int_x^\infty t^s e^{-t}\, \frac{dt}{t}.$$

Now $g^*(z)$ satisfies the equation

$$(19) \qquad \xi_{1/2}\, g^*(z) = \frac{\sqrt{6}}{3} \sum_{n \in 1+6\mathbb{Z}} n\, q^{n^2/24},$$

and the right-hand side of (19) is a unary theta function (a cusp form) of weight $3/2$, called by Zagier a shadow of f. An explicit determination of the transformation formula of F allowed Bringmann and Ono [5] to prove an exact formula of Rademacher-type for the coefficients of Ramanujan's mock theta function $f(q)$. This formula, which refines Ramanujan's first-order asymptotic (13), had been conjectured by Andrews and Dragonette (see [5] for references). Combined with Rademacher's formula it gives exact formulas for the number of partitions with even (resp. odd) ranks.

This is but one of numerous recent results about mock theta functions stimulated, at least in part, by the work of Zwegers. See [27] and [37] for a lot more. In fact, a connection between Maass forms and mock theta functions was already found in 1988 by Cohen [10], but his results are much more closely connected with the theory of quantum modular forms [38] than with the main theme of this paper.

Modular Forms as q-series and L-functions

Today we understand that mock theta functions provide but one class of examples of harmonic Maass forms. Before discussing some others, I will give a whirlwind overview of some aspects of the theory of modular forms as q-series and their associated L-functions. This should help to place these examples in a broader context. Standard references for this section are the books [24] and [25]. An older but still valuable article on the Fourier coefficients of modular forms is [32]. The reader may also consult [26] by Iwaniec and Sarnak for an extensive overview of further developments.

Modular forms as q-series really began with Jacobi and his theta functions. Thus for $m \in \mathbb{Z}^+$ the function

$$(20) \qquad \vartheta(z)^m = \left(\sum_{n \in \mathbb{Z}} q^{n^2}\right)^m = \sum_{n \geq 0} r_m(n) q^n$$

is a modular form of weight $m/2$, where $r_m(n)$ is the number of representations of n as the sum of m squares. Ramanujan took the connection to another level, remarkably through an example known to Jacobi, namely,

$$(21)$$
$$\Delta(z) = \eta(z)^{24} = q \prod_{m \geq 1} (1 - q^m)^{24} = \sum_{n \geq 1} \tau(n) q^n,$$

which is a modular form of weight 12 for $\mathrm{SL}(2, \mathbb{Z})$. This modular form is a cusp form, which in this situation means simply that the constant term in the q-series (21) vanishes. Alternatively, $\Delta(z)$ being a cusp form is equivalent to having $\operatorname{Im}(z)^6 |\Delta(z)|$ be bounded on $\mathcal{H}$. Ramanujan made two conjectures about the Fourier coefficients $\tau(n)$, which are obviously integers. Both had a profound influence on the development of the theory of modular forms.

The first conjecture implies that $\tau(n)$ is a multiplicative arithmetic function and can be succinctly stated by saying that its associated L-series has an Euler product:

$$L(s) = \sum_{n \geq 1} \tau(n) n^{-s} = \prod_p (1 - \tau(p) p^{-s} + p^{11-2s})^{-1},$$

where p runs over the primes. This was soon proved by Mordell and served as the starting point for Hecke's theory of Hecke operators and L-functions associated to holomorphic cusp forms. In this example $L(s)$ is entire in s and satisfies a functional equation like that of the Riemann zeta function.

The second conjecture, known as **the** Ramanujan conjecture, states that for a prime p,

(22) $$|\tau(p)| \le 2p^{\frac{11}{2}}.$$

As Hardy showed, Cauchy's formula immediately gives the bound $|\tau(n)| \ll n^6$. Note that $\tau(n)$ is small in comparison with the size of the partition function $p(n)$, whose asymptotic formula was given in (9). This is explained by the fact that the asymptotic formula for $p(n)$ gets exponential terms from the singularities of its generating function $G(z)$, which was given in (15). The first nontrivial assault on (22) was made by Kloosterman, who applied the circle method and reduced the estimation of $\tau(n)$ (and the coefficients of other cusp forms) to that of Kloosterman sums. In their simplest form these are the exponential sums

$$K(n, m; c) = \sum e\left(\frac{nx + mx^{-1}}{c}\right)$$

where $c > 0$ and the sum is over $x \pmod{c}$ with $(x, c) = 1$ and $x^{-1}x \equiv 1 \pmod{c}$. Such sums show up in the circle method in a way similar to that of the sums $S_k(n)$ in (11) in the Rademacher/Selberg formula for $p(n)$. Weil's sharp estimate for Kloosterman sums, a consequence of the Riemann hypothesis for curves, yielded the exponent $23/4 + \epsilon$ in (22). The full conjecture is deeper and was finally established by Deligne.

Maass extended Hecke's theory to Maass cusp forms and their L-functions. Selberg developed the spectral theory of Maass forms and gave applications through his trace formula. Consideration of nonholomorphic forms was an essential generalization that opened the way for both specific applications and broad generalizations to automorphic representations of Lie groups and also, through their associated L-functions, to the Langlands program. One of the many motivations behind the Langlands program is to prove the analogue of the Ramanujan conjecture for the coefficients of a Maass cusp form, which is still open. Supporting data was computed to great accuracy by Hejhal [20] in the 1980s (see [3] for recent work). For example, numerically the smallest eigenvalue λ from (17) of a nonzero even Maass cusp form F of weight $k = 0$ for $SL(2, \mathbb{Z})$ is $\lambda = 190.13154\ldots$, and the coefficients of its associated L-function

$$L(s) = \prod_p (1 - \alpha(p)p^{-s} + p^{-2s})^{-1}$$
$$= 1 + (1.54930\ldots)2^{-s} + (0.24689\ldots)3^{-s} + \cdots$$

are conjectured to satisfy $|a(p)| \le 2$ for all primes p. In general, the coefficients of Maass forms are quite mysterious and present many unsolved problems.

Harmonic Maass Forms

It is especially interesting therefore that mock theta functions can be completed to become harmonic Maass forms. Of course harmonic Maass forms are quite special (with eigenvalue $\lambda = 0$), and this is one reason behind their having more accessible arithmetic properties. It is sometimes convenient to use terminology due to Zagier and call a q-series a mock modular form of weight k if it can be completed as before to a harmonic Maass form F. Such a mock modular form has as a shadow a nonzero constant multiple of $\xi_k F$, which is a holomorphic form of weight $2 - k$. Roughly speaking, a harmonic Maass form of weight k has a "holomorphic part," which is a mock modular form, and a shadow (normalized in some way), which is a holomorphic form of weight $2 - k$.

An early example of a mock modular form of weight 3/2 was found in [23] and is given by the Eisenstein series

(23)
$$E_{3/2}(z) = -\frac{1}{12} + \sum_{n \ge 1} H(n)q^n$$
$$= -\frac{1}{12} + \frac{1}{3}q^3 + \frac{1}{2}q^4 + q^7 + \cdots,$$

where $H(n)$ are the Hurwitz class numbers, which count (with weights) the number of classes of binary quadratic forms of discriminant $-n$. Although it was not stated in this form, it was shown there that the Jacobi theta function $\vartheta(z)$ from (20) is a shadow of $E_{3/2}(z)$.

A natural problem is to try to understand the coefficients of a mock modular form having as a shadow a given holomorphic modular form. For example, Bruinier and Ono [7] applied this idea to cusp forms of weight 3/2 whose Shimura lifts are cusp forms of weight 2 associated to certain elliptic curves. They found mock modular forms of weight 1/2 that are not classical mock theta functions but whose coefficients contain information about the L-series of the curves. Related to this are interesting questions about the algebraicity of the coefficients of harmonic Maass forms (see [29], [8], and their references).

Another catalyst for recent interest in harmonic Maass forms was the work of Borcherds on monstrous moonshine, which as a byproduct created new interest in modular forms with singularities (see e.g., [4], [6]). In particular, this has led to various applications and generalizations of the Borcherds product (see [28] for some further references). In [12], mock modular forms of weight 1/2 for $SL(2, \mathbb{Z})$ are constructed whose coefficients are cycle integrals of the modular j-function. They

have as shadows certain *meromorphic* modular forms of weight 3/2 studied by Zagier [36] with coefficients that are traces of singular moduli. Associated to these mock modular forms are real quadratic analogues of Borcherds products. In addition, a real quadratic analogue of (23) is constructed. See also [11], [13].

There are interesting examples of mock modular forms in integral weights as well. An example is the Eisenstein series

$$E_2(z) = 1 - 24 \sum_{n \geq 1} \sigma(n) q^n$$
$$= 1 - 24\,q - 72\,q^2 - 96\,q^3 - \cdots,$$

where $\sigma(n) = \sum_{d \mid n} d$ is the sum of divisors function. It follows from an early result of Hecke that $E_2(z)$ is mock modular of weight 2 for the full modular group with the constant function 1 as a shadow. Other mock modular forms of weight 2 whose shadows are weakly holomorphic modular functions are studied in [14]. Another kind of example is given by an Eichler integral of a holomorphic modular form of weight $k \in 2\mathbb{Z}^+$, which may be considered to be mock modular of weight $2 - k$ (see [37]).

Mock modular forms in the self-dual case of weight 1 with coefficients that can be expressed in terms of logs of algebraic numbers from certain Hilbert class fields are studied in [15], [16], and [34]. These forms have shadows whose L-functions are Artin L-functions associated to dihedral Galois representations. This phenomenon appears, at least numerically, to hold for exotic representations as well [15]. It is closely connected with Stark's conjectures on special values of derivatives of L-functions.

Finally, it should be noted that harmonic Maass forms with singularities do not respect Hecke operators like those without singularities. Therefore they do not fit directly into the usual automorphic representation picture. It is possible that a shadow of such a form is a Hecke eigenform and hence has an associated L-function. This gives an indirect connection, but one that is still not very well understood in general. While we now have a better understanding of what a mock theta function is and have examples of other kinds of harmonic Maass forms with arithmetic properties, we are still far from an answer to the question: *what broader role do general harmonic Maass forms play in arithmetic?*

Acknowledgments

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Remembering Shoshichi Kobayashi

Gary R. Jensen, Coordinating Editor

hoshichi Kobayashi was born January 4, 1932, in Kofu City, Japan. He grew up amidst the colossal devastation of World War II. After completing a BS degree in 1953 at the University of Tokyo, he spent the academic year 1953–1954 on a French scholarship at the University of Paris and the University of Strasbourg. From there he went to the University of Washington in Seattle, where he received a Ph.D. in 1956 for the thesis "Theory of connections," (*Annali di Mat.* (1957), 119–194), written under the direction of Carl B. Allendoerfer. There followed two years as a member of the Institute for Advanced Study in Princeton and then two years as a research associate at MIT. In 1960 he became an assistant professor at the University of British Columbia, which he left in 1962 to go to the University of California at Berkeley, where he remained for the rest of his life.

Shoshichi published 134 papers, widely admired not only for their mathematical content but for the elegance of his writing. Among his thirteen books, *Hyperbolic Manifolds and Holomorphic Mappings* and the Kobayashi metric in complex manifolds created a field, while *Foundations of Differential Geometry, I and II*, coauthored with Nomizu, are known by virtually every differential geometry student of the past fifty years. In their articles below, Shoshichi's student, Toshiki Mabuchi at Osaka University and former Professor Takushiro Ochiai at the University of Tokyo summarize

Shoshichi Kobayashi

many of Shoshichi's mathematical achievements. Several of his students relate their experiences of working under Professor Kobayashi's supervision. Some Berkeley colleagues write of their personal experiences with Shoshichi.

His brother, Hisashi, recounts some details of Shoshichi's early education. Shoshichi's wife and daughters tell a fascinating story of his childhood, his studies abroad, and major life experiences preceding his move to Berkeley.

He died August 29, 2012, of heart failure on a flight from Tokyo to San Francisco.

Toshiki Mabuchi

Many of Professor Kobayashi's books are known as standard references in differential geometry, complex geometry, and other related areas. Especially, *Foundations of Differential Geometry, Vols. I and II*,

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coauthored by Nomizu, are very popular with mathematicians as well as with physicists. He and Nomizu received the 2007 MSJ Publication Prize from the Mathematical Society of Japan for this work. His books *Hyperbolic Manifolds and Holomorphic Mappings* (1970) and *Transformation Groups in Differential Geometry* (1972) also influenced many mathematicians. His mathematical achievements range across differential geometry, Lie algebras, transformation groups, and complex analysis. The most important ones are:

1. the Kobayashi intrinsic pseudo-distance,
2. the Kobayashi hyperbolicity and measure hyperbolicity,
3. projectively invariant distances for affine and projective distances,
4. the study of compact complex manifolds with positive Ricci curvature,
5. filtered Lie algebras and geometric structures, and
6. Kobayashi-Hitchin correspondence for vector bundles.

In (1) and (2) we see his outstanding creativity. Kobayashi's distance decreasing property for holomorphic mappings plays a very important role in (1), while the generalized Schwarz lemma is crucially used in (2). His works now give us a fundamental tool in the study of holomorphic mappings between complex manifolds. For instance, Picard's small theorem follows easily from (2). Recently, the above results were being generalized by him to almost complex manifolds.

On the other hand, (4) has led succeeding mathematicians to Frankel's Conjecture and Hartshorne's Conjecture. Among them, his joint work with T. Ochiai, "Characterization of complex projective spaces and hyperquadrics," J. Math. Kyoto U. **13** (1972), 31–47, was effectively used in Siu-Yau's proof of Frankel's Conjecture. It should also be noted that the method of reduction modulo p in Mori's proof of Hartshorne's Conjecture became a clue to the Mori theory on the minimal model program of projective algebraic manifolds.

The Kobayashi-Hitchin correspondence for vector bundles in (6) states that a holomorphic vector bundle E over a compact Kähler manifold is stable in the sense of Mumford-Takemoto if and only if E admits a Hermitian-Einstein metric. Kobayashi and Lübke proved the "if" part, while the "only if" part, conjectured by Kobayashi and Hitchin, was proved finally by Donaldson and Uhlenbeck-Yau.

Since 1995 Professor Kobayashi regularly attended our annual workshop on complex geometry at Sugadaira, Japan.

Takushiro Ochiai [1]

The life and academic achievements of Shoshichi Kobayashi give a definition of what a great mathematician should be. He left us numerous manuscripts of high originality, comparable to great musical compositions. His books, taken as a whole, harmonize splendidly into a great symphony. Though aware of my inability to reach the height of his talent, I dare to write this article to bring attention to the fine personal character and remarkable academic achievements of Shoshichi Kobayashi, outstanding mathematician, mentor, and colleague.

Kobayashi published papers in academic journals every year without fail, starting from his virgin paper in 1954 until his last days. Among a total of 134 papers, there are 85 single-author papers and 49 collaborative works. A unique feature of his single-author publications is their brevity. There are 34 papers of less than five pages, 28 papers of less than ten pages, and 15 papers of less than 28 pages. Every one of them is deep and rich in content with transparent and easily comprehensible explanations, as is evidenced by his invention of the concepts of the *Kobayashi distance*, hyperbolic complex manifolds, and the Hermitian-Einstein vector bundles. Inspired by Chern's result, which further improved on the generalization of the classical Schwarz's lemma by L. Ahlfors ("The holomorphic maps between Hermitian manifolds" by S. S. Chern), Kobayashi became interested in Schwarz's lemma and read all the related papers one by one. He especially admired Carathéodory's point of view and devoted himself to and took advantage of the holomorphic maps, which he admitted led him to the discovery of the Kobayashi distance.

Expanding all his papers, paying attention to the historic background and development, Kobayashi subsequently published thirteen self-contained books, every one of which is easily comprehensible by graduate students. Professor Kobayashi once said to me: "When I write books, I prepare one or two years for the first manuscript and make certain to give lectures based on it for one or two years in order to deepen the contents before finally completing the final manuscript."

To convey to the public his philosophy of mathematics, or rather of differential geometry, I include here passages from his essays in Japanese as published in well-known magazines on mathematical

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[1] *This is a translation into English of some part of my article "Kobayashi-sensei wo shinonde," which appeared in* Sūgaku Seminar*, 2013.*

First row: T. Ochiai, S. Kobayashi, S.-T. Yau; Second row: H. Mori, S.-S. Chern. Tokyo, 1977.

sciences which deeply reflect his mathematical achievements. The transparency, beauty, and open-mindedness of his viewpoints, which he sharpened well to the limit, express my personal and eternal yearning.

"Differential geometry is one viewpoint over mathematics, and a method, in itself. When various fields in mathematics reach the point of being well understood, the phenomenon called 'algebraization' occurs. I think it is possible to see different fields of mathematics from a differential geometric viewpoint as well as from an algebraic viewpoint. The raison d'etre of differential geometry is to offer a new viewpoint and powerful methods rather than being considered like a theory of numbers. Moreover, the concepts and methods understood from a geometric point of view are so natural (different from artificially created nonsense) that development beyond anticipation later occurs in many cases. Differential geometry can produce limitless developments by carrying its methods into all the fields of mathematics. It is especially important, then, to know how to make use of the differential geometric method to make connections in fields such as the theory of functions (one or several complex variables), algebraic geometry, topology, a differential equation theory." (*Suuri Kagaku*, August 1965)

"Wonderful theorems in mathematics are proven with breakthroughs of originality which cause everyone to understand them. A mathematician gets the greatest feeling of happiness when he finds such a new idea. A problem, which is solved merely by understanding and following a routine process, is a petty problem, and a theorem whose proof does not use any idea which comes involuntarily, is really tedious. It seems that any problem which does not open a new field, or any result which has no application in any other field of mathematics, disappears after a while. An eternal life is given only to a beautiful result." (*Sūgaku Seminar*, December 1965)

"Some percentage of the work in mathematics consists of the creation of suitable notation. Suitable notation makes calculations easy to handle, makes formulas look beautiful and easy to memorize, and makes theorems apparent at a glance. Suitable notation is important not only from a passive role to make descriptions beautiful and easy, but also from an active role, even to suggesting what should be done next. We cannot explain in one word what kind of notation is suitable or what kind of theorem is good. It is a mathematical sense that will take it in somehow." (*Sūgaku Seminar*, September 1967)

"When you study subjects in mathematics which are not restricted to calculus, I would like to urge you to study the history of its development together by all means. Since modern mathematics requires too much stringency, lectures as well as textbooks rarely touch historical background. However, I think that one can understand the subject more deeply by getting to know the history and 'why this concept was produced.' I want people who become school teachers to study the history of mathematics by all means." (*Suuri Kagaku*, February 2001)

Through my acquaintance with Professor Kobayashi for many years, I am convinced that his passion for mathematics was motivated by his love for human beings and for scholarship. I am extremely fortunate to have collaborated with Professor Kobayashi on some of his mathematical work.

Joe Wolf

I met Shoshichi Kobayashi when we both arrived at Berkeley in September of 1962. We got to know each other quite well for two reasons. First, the differential geometry group at Berkeley, just then forming under Professor Chern's guidance, was very cohesive, both socially and mathematically. Second, we shared an office where we had many informal conversations about differential geometry, mathematics in general, and academic life. I always learned some interesting mathematics when Sho and I talked. Years before, I had read Nomizu's short paperback *Lie Groups and Differential Geometry*, and I was thrilled to learn that Shoshichi had just completed his monumental work on differential geometry with Nomizu. At various times during the 1960s the geometry group at Berkeley included S.-S. Chern, Sho Kobayashi, Phil Griffiths, Jim Simons, Alfred Gray, Peter Gilkey, Jeff Cheeger, Blaine Lawson, Nolan Wallach, Manfredo do Carmo, Wu-Yi Hsiang, Hung-Hsi Wu, me, and many others. It was

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very collaborative and did not draw distinctions between big shots, young academics, and graduate students. And there were many famous and influential visitors attracted by Chern, including Gene Calabi and Fritz Hirzebruch. So it was a kind of mathematical heaven. During this time Shoshichi constructed his pseudo-metric, with the associated notion of Kobayashi hyperbolicity, and also his reproducing kernel methods for irreducibility of unitary representations.

When the building that currently houses the math department (Evans Hall) was built, math was to have floors seven, eight, nine, and ten. Sho and I went into the building to choose our offices before the elevators were installed. We walked up the stairs together, and at some point I realized that he was speeding up. I couldn't keep pace, but he had to stop at the seventh floor and I managed to get to the eighth. So his new office was on the seventh floor and mine was on the eighth. Later, when Sho was math department chair, the chancellor's office informed him that we were losing our space on the seventh floor. With Sho in charge we came out of these "space wars" pretty well, retaining most of the seventh floor.

It is hard to realize that Sho is no longer with us. It was a great privilege to have been a friend and colleague of Shoshichi Kobayashi.

Hung-Hsi Wu

I first met Sho in 1962 at one of the AMS Summer Institutes in Santa Barbara. I had just finished my first year as a graduate student at MIT, and he told me he was on his way to Berkeley. We ended up being colleagues for forty-seven years when I myself got to Berkeley in 1965. Although as colleagues we could not help but run into each other often, I think it was in the ten or so years from 1980 to 1990 that I had extended contact with him every week when he drove me home after each differential geometry seminar late in the day on Friday. We had to walk a bit before we could get to his car and that gave us even more of a chance to chat and gossip. I am afraid the intellectual quality of the conversations was not particularly high, but the entertainment value was off the charts. It was most enjoyable. However, the one thing that has stuck in my mind about Sho all these years is probably the fortuitous confluence of events surrounding the discovery of the Kobayashi metric in 1966.

In the summer of 1966, Professor Chern and I attended the AMS Summer Institute on entire functions in La Jolla, and Professor Chern gave a

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M. Berger, S. Kobayashi, W. Klingenberg, K. Yano, S.-S. Chern, 1970s.

lecture on his new result on the volume decreasing property for holomorphic mappings from (basically) the unit ball in $\mathbf{C}^n$ into an Einstein manifold of the same dimension with negative curvature in a suitable sense. This is a generalization of the famous Ahlfors-Schwarz lemma on the unit disc, and it is to Professor Chern's credit that he recognized it as the special case of a general theorem about holomorphic mappings on complex manifolds. At the time, the idea of putting the subject of holomorphic functions in a geometric setting was very much on his mind. In the following fall, he gave a similar talk in one of the first lectures of the Friday geometry seminar, but this time he had a manuscript ready. The main ingredient of his proof is basically a Weitzenböck formula for the volume form; his observation was that negative curvature (in one form or another) of the target manifold limits the behavior of holomorphic mappings. This is the beginning of what Phillip Griffiths later called *hyperbolic complex analysis*. Of course both Sho and I were in the audience, and within two or three weeks Sho came up with a generalization using more elementary methods.

At the time I was fascinated with Bloch's theorem (in one complex variable) and was trying to understand why there would be a univalent disc for holomorphic functions into the unit disc. Professor Chern's paper contains a reference to a paper of Grauert-Reckziegel which can also be said to be an application of the Ahlfors-Schwarz lemma. Upon reading it, I got the idea that Bloch's theorem was a consequence of the phenomenon of normal families and, as a result, I could prove a qualitative generalization for Bloch's theorem for holomorphic mappings between complex manifolds. I wrote up my findings and, as it was the tradition then among the geometers at Berkeley, put copies of my manuscript in my geometry colleagues' mailboxes.

Nomizu and Kobayashi, 1954.

In a few days, Sho came up with the manuscript of his announcement that all complex manifolds carry an intrinsic metric, the metric that now bears his name. Sho recognized that with the availability of the Ahlfors-Schwarz lemma, the construction of the Carathéodory metric could be "dualized" to define the Kobayashi metric. His paper took the focus completely out of the holomorphic mappings themselves and put it rightfully on the Kobayashi metric of the target complex manifold in question. This insight sheds light on numerous classical results (such as the little and big Picard theorems) and inaugurates a new era in complex manifolds.

Robert Greene

Berkeley in the 1960s was an earthly paradise for people interested in real and complex geometry. When I arrived in early 1965 as a new graduate student, Professor Chern was the unquestioned leader of the geometry group, and indeed of the field itself, and Kobayashi occupied a special place as an organizer and presenter of the field as a whole. He was, after all, the author with K. Nomizu of The Book, *Foundations of Differential Geometry*, which was to function for many years as the veritable bible of the subject. It was a summit all the new students in geometry were determined to climb. When Volume II appeared in 1969, the whole became a definitive work indeed, a position which the passage of time has not dimmed as far as the field up to that point is concerned.

After qualifying examinations, I began work with Hung-Hsi Wu as my dissertation advisor, a happy association that turned later into a long-term collaboration. Almost as soon as Wu had accepted me as a student, he went on sabbatical in England for a term, so he asked Kobayashi to take me under

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his wing. The proposal was that I should read Helgason's *Differential Geometry and Symmetric Spaces* under Kobayashi's guidance. Kobayashi was the soul of politeness in dealing with my obvious disaffection from the book I was supposed to be going through. And in spite of this somewhat rocky start—I think Kobayashi never quite entirely forgave me for not liking Helgason's book—we became friends.

Impressive though Kobayashi and Nomizu's great survey book was and is, it was another of Kobayashi's books, *Hyperbolic Manifolds and Holomorphic Mappings*, that demonstrated best the elegance with which he could present a subject from its beginnings. When his "little red book," as we young people thought of it, appeared it had a big influence on us, flowing along as it did like a crystal stream. It was seductive, and indeed it did convince people that hyperbolic manifolds had a good bit more vitality as an independent subject than it in fact did in the long run, vital though the Kobayashi metric became and remains as a tool. The hyperbolic idea swept through Berkeley like a California wildfire in the hills. I did not work on hyperbolic manifolds directly at that time, but later in the mid-1970s Wu and I developed a refinement of the strictly negative curvature criterion, so I did get into the hyperbolic act eventually. And the general circle of ideas did influence me in the direction of thinking about complex manifolds. In this somewhat indirect way, Kobayashi shaped my mathematical life, since complex geometry has remained my principal mathematical interest.

Gary R. Jensen

For me, Shoshichi Kobayashi was the ideal thesis advisor and mentor. Without his help and guidance at many stages, I would never have become a professor of mathematics. Here is the story.

After four semesters of course work at Berkeley, I could imagine only Professor Kobayashi as someone I might talk to. When I asked him to be my advisor, his response was cautious but not cold. After all, I had taken no courses in differential geometry other than the required curves and surfaces course. He suggested that I spend the summer reading his new book, written with Nomizu, *Foundations of Differential Geometry, Vol. I*. Thus began my lifelong love of differential geometry.

At the beginning of the fall semester he agreed to be my advisor. He handed me a list of problems he and James Eells had edited for the proceedings of a recent conference in Kyoto, Japan, with an indication of two or three problems that might interest me. A week later we agreed that I look at the problem proposed by Eells and Sampson: Does

any simply connected, compact Riemannian space of nonnegative curvature admit a Ricci parallel metric? During that academic year I read papers and got nowhere. When I finally told Professor Kobayashi that I felt I was making no progress, in fact, that I really had no idea of how to begin trying to solve this problem, his reply was simple and profoundly helpful. "Why don't you just look at the dimension four homogeneous case first," he said. It is embarrassing to remember that for a year this idea had not occurred to me. Along with this advice he suggested a paper by S. Ishihara on four-dimensional homogeneous spaces. At last, a paper I understood and saw how to apply to my problem.

Graduate school at Berkeley in the mid-sixties was wonderful. In our meeting at the beginning of the fall 1967 semester, Professor Kobayashi quietly mentioned that this would be my last year. "But I don't have enough results for a thesis," I reminded him. Yes, he agreed, but he stated again that this would be my last year. I got the message and it was a powerful motivator. In our weekly meetings I started presenting partial results, bits and pieces that at first seemed to hit a wall, but soon began yielding to the assault. By the end of December I had found all homogeneous Einstein spaces of dimension four.

Meanwhile, Professor Kobayashi had raised the issue of a job for next year. Strangely enough, I was very vague on this point, no doubt due to my subconscious desire to remain a graduate student for the rest of my life. He introduced me to some mathematicians from a university in the East, and I told them I would like to join their department. Weeks passed with no communication from that department. I didn't give it much thought, but one day Professor Kobayashi asked me, with some anxiety, whether I had heard anything. Hearing the answer and hearing that I had not applied for anything else, he took me by the arm and escorted me to the library's collection of notebooks of available jobs. Together we picked out a few. He told me to write a letter of application to each and to find two more people to write letters of recommendation for me. It still frightens me to think what might have become of me if he had not intervened so effectively at that time to make sure that I had applied for jobs. In early March I interviewed at Carnegie-Mellon and accepted their offer.

In June my family and I headed out for Pittsburgh with a copy of the manuscript of *Foundations of Differential Geometry, Vol. II*, in the trunk of the car. After reading it I struggled to find new research problems. I wrote to Professor Kobayashi that I needed more contact with differential geometers. I asked him if a postdoctoral fellowship somewhere might be possible. In early March a call came from Washington University in St. Louis asking me if I would be interested in coming there to interview for a one-year postdoc position connected to a special year in symmetric spaces. Professor Kobayashi had suggested my name to them for this position.

At the end of my postdoc year, I accepted a tenure-track offer from Washington University. Professor Kobayashi's mentoring continued. He was instrumental in arranging a visiting research position for me at Berkeley during the summer of 1971. In one conversation that summer he directed my attention to his 1963 *Tôhoku Math. J.* paper "Topology of positively pinched Kaehler manifolds," which formed the basis of my best-known paper of the 1970s, "Einstein metrics on principal fibre bundles," a paper that probably tipped the tenure decision in my favor.

Myung H. Kwack

I am very fortunate to have had Professor Shoshichi Kobayashi as my teacher, mentor, and advisor. He was instrumental in my work as a mathematician, and I am grateful for his support and encouragement throughout my career.

My father left Korea to study in the US in 1954 right after the Korean War. He left the rest of his family of four: a wife and three children. After seven years of separation, he brought his family to the US I had just finished high school and a semester of college in Seoul, Korea, and I found myself enrolled in San Francisco State College unable to communicate in a foreign culture. I found that I enjoyed studying calculus textbooks. I transferred to Berkeley, getting a BA degree in mathematics in 1965, and then entered into the graduate program at Berkeley. I still felt socially uncomfortable, as my language skills were not much improved. In addition, only one or two girls were in mathematics courses. It was a pleasant surprise that I passed the qualifying examination in 1967. I met Professor Kobayashi and somehow felt comfortable with him and had enough courage to ask him to be my thesis advisor.

With his usual warmth and understanding nature, Professor Kobayashi was able to make me feel at ease during visits to his office to learn and ask questions about mathematics. He introduced me to the concepts of hyperbolic manifolds. He suggested the problem of extending the classical Big Picard Theorem to hyperbolic manifolds and gave me many articles dealing with related problems. Many times I rushed to his office having "solved" the problem and started writing

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Muneo Hayashi, circa 1948.

my "solution" on the blackboard until I could no longer continue, having come to a gap or an error in my "proof." Professor Kobayashi always had time and patience to listen to my wrong "proof" and never suggested that I should try to check my "solutions." Instead, he encouraged me as I sat discouraged after discovering my error. Without his encouragement I would not have been able to find a proof of a generalization of the Big Picard Theorem and experience the deep pleasure of discovering a mathematical theorem which has come to be known in hyperbolic geometry as Kwack's Theorem.

Professor Kobayashi understood not only the difficulty of doing mathematical research but also the challenges faced by a young girl from a foreign country at the time when girls were not encouraged to study. Professor Wu at Berkeley once said that Professor Kobayashi had the most female thesis students, making him the envy of the faculty of the Department of Mathematics at Berkeley.

Professor and Mrs. Kobayashi came to visit Howard University while I was there when Professor Kobayashi gave a week of lectures. He continued to support and encourage me to do mathematical research by sending many articles, his as well as many related ones, especially whenever I mentioned any interest in some problems. Furthermore, whenever I come to the Bay Area to visit my parents, he and his wife would take me to lunch and any gatherings of mathematicians he was attending.

I will be grateful to Professor Kobayashi for the rest of my life for enabling me to become a mathematician.

Eriko Shinozaki

I first met Professor Kobayashi twenty years ago, during my junior year of college, when he was a visiting professor at International Christian University in Tokyo, Japan. I had always wanted to study mathematics at university and had started as a math major at ICU. I began to doubt this decision, however, because out of all the math courses offered at ICU at that time none felt comfortable.

High school was where I always felt confident when studying mathematics and always knew what I was doing. I had to choose between geometry, algebra, and analysis after the fall of my junior year, but at that time I never considered geometry as my area of study. I was even thinking about changing to a chemistry major. I took Professor Kobayashi's class, since it was a required subject, not knowing that it would totally change my life. Thus, in my third year of mathematics studies, I thanked God for giving me this opportunity to meet Professor Kobayashi. I knew he would soon be leaving after the second term (ICU's academic year is divided into three terms), so I fully focused on geometry, solving everything I could, and visited his office almost every day.

After the end of the term exams, for the first time since high school, I finally achieved a grade at ICU with which I was familiar. When I got my exams back from Professor Kobayashi, he asked me if I was willing to continue in differential geometry. To tell the truth, all I wanted to do was ask him how I could possibly study differential geometry, due to the fact that there was no differential geometry teacher at ICU!

Subsequently, he kindly advised me to continue my differential geometry studies under Ms. Makiko Tanaka (currently a professor at Tokyo Science University), who was at the time helping us, the ICU students, with our calculus recitations. Fortunately for me, she was also a differential geometry major studying under Professor Kobayashi's colleague, Professor Nagano at Sophia University. Professor Kobayashi also offered to let me continue my differential geometry studies under his guidance, as well as advise me on my senior thesis, which was to be submitted the following year.

During most of my senior year he was at Tokyo University evaluating its mathematical curricula, enabling me to meet with him often on the Hongo campus. I even met him on the day he was returning to Berkeley. We worked on the thesis, then walked to Ueno station together and took the train to Narita as we continued our mathematical discussions on the train, shaking hands and saying good-bye at the airport.

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Since that time, for almost twenty years, I continued to meet with Professor Kobayashi each time he visited Japan for meetings, seminars, university evaluations, and special lectures. What we worked on together changed over the years. During my senior year Professor Kobayashi helped me choose a thesis on the topic of conjugate connections, helped me find a theorem and then sent it to the *Tokyo Journal of Mathematics* under the title "Conjugate connections and moduli spaces of connections." However, since I decided to work full-time as a mathematics teacher in a Japanese high school rather than pursue graduate studies (finding a job was very competitive in Japan in 1995), it became difficult for me to continue with my research.

One day Dr. Kobayashi asked me if he could give my topic to another of his graduate students and asked me to help him translate and type, using LaTeX, his book *Differential Geometry of Curves and Surfaces* into English instead. I thanked him very much for allowing me the opportunity to continue working in the field of mathematics with him and appreciated his confidence in my translation and understanding of his work. Unfortunately, we weren't able to complete the translation together, but I plan to continue working on it with Professor Makiko Tanaka.

Hisashi Kobayashi [2]

I realize how different was the world around Shoshichi, the first son of our family, from that around me, the third son, although we were raised by the same parents. I knew pretty much about his career, but I was not well aware of what Shoshichi felt or thought in his youth.

He published several essays in a Japanese journal, *Mathematical Seminar*, and elsewhere, but I read them for the first time only after he had passed away. Shoshichi was a quiet person like our mother and did not say much even to us, his younger brothers, about his memories and stories of younger days. I wish I had read these essays while he was alive; then I could have asked more details. Since my childhood, Shoshichi has been my role model, teacher, and the person I respected most among those I have personally known. He has been my hero, so to speak.

Soon after his birth our parents moved to Tokyo and opened a futon (Japanese bed) store in Koenji,

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[2] *This is an excerpt of the speech "Rediscover my brother Shoshichi," presented at the memorial reception held May 25, 2013, at the University of Tokyo. The complete speech is at* http://www.shoshichikobayashi.com.

January 18, 1950. L to R back: Shoshichi (18), Toshinori (15). L to R front: Mother Yoshie (41), Kazuo (2), Father Kyuzo (45), Hisashi (11).

Suginami-ku. By the time I grew to the age when I could remember things, our parents moved the store to Kyodo, Setagaya-ku, Tokyo. Apparently Shoshichi liked mathematics since his childhood, but he had some difficulty with a homework assignment given when he was a fifth- or sixth-grader, in which the student was asked to compute the volume of the cone that can be created from a fan shape. He recalls this incident in his essay "Deeply impressed by a beautiful theorem" in the May 1973 issue of *Mathematics Seminar*.

In April 1944 Shoshichi entered Chitose Middle School in Tokyo. This school emphasized military training, but discussions with the older students began his thinking of going on to high school. It was a big surprise for me to find that it was not until he entered middle school that he developed the idea of going to a high school, despite the fact that he was talented enough to be inspired by the Pythagorean Theorem.

In the spring of 1945 when he became a second-year student of the middle school, our family evacuated from Tokyo and moved to Minamisaku, Nagano-Ken, and the war ended soon after. Thanks to the kind people of Hiraga Village, the family stayed there until the fall of 1948. When Shoshichi became a fourth-year student of Nozawa Middle School [3] there, the mathematics teacher was Mr. Muneo Hayashi. His encounter with Mr. Hayashi turned out to be a giant step to nurture the mathematician Shoshichi. He writes about that period in another essay, "The mathematician I luckily encountered: Muneo Hayashi, math teacher in middle school."

It seems that Mr. Hayashi's encouragement allowed Shoshichi to gain confidence to apply to

[3] *Shoshichi's classmate Noboru Naito wrote in detail of this school and Mr. Hayashi in "Newsletter No. 2, August 2013" at the* http://www.shoshichikobayashi.com.

Shoshichi, age 3.

Ichikoh (high school), and our parents came to realize that their first son was talented enough to advance to Ichikoh and then Todai (University of Tokyo). Shoshichi must have been the pride and emotional mainstay of our parents, who had lost everything in the war.

In 1948 Shoshichi succeeded in entering Ichikoh in his fourth year at middle school (skipping the fifth year), and the following year he entered the University of Tokyo under the new education system just introduced. In 1951 he advanced to the mathematics department, the Division of Sciences, and studied with the late Professor Kentaro Yano (1912–1993), who encouraged Shoshichi to strive to win the French Government's Scholarship. I was in a junior high school at that time, and I remember well that Shoshichi attended French classes at Athénée Français and Institut Français du Japon on his way home after a day of studying at Todai.

He was told that the examination for the French Government Scholarship was stiff and advised to make a first trial when he was a senior at Todai. To his and Professor Yano's surprise, he made it in his first attempt.

After a year of study in France, he moved to the University of Washington in Seattle, where he got his Ph.D. in less than two years. I was wondering all these years why he did not go to Princeton or Harvard, whereas he advised me to go to Princeton later. He explains his situation at that time in another essay, "My teachers, my friends and my mathematics: the period when I studied in the United States" in *Mathematics Seminar*, July 1982.

In recapitulating Shoshichi's life from his childhood until his marriage, I believe that his encounters with his seniors at Chitose Middle School motivated Shoshichi to think about going to a high school. Mr. Muneo Hayashi at Nozawa Middle School discovered Shoshichi's talent in mathematics and took time personally to nurture it. Professor Kentaro Yano encouraged him to study in France. Dr. Katsumi Nomizu egged Shoshichi on to study in the US Professor Allendoerfer hired him as an assistant. Shoshichi's friends and all of these wonderful encounters served as the sources of energy that drove Shoshichi to work as a mathematician for over fifty-five years. He led a fruitful life, blessed with a wonderful spouse and family.

Mei and Yukiko Kobayashi

Shoshichi Kobayashi was born January 4, 1932, during the Japanese New Year's holiday celebrations in the seventh year of the reign of the Emperor Showa.[4] Shoshichi was the eldest of five sons born to his parents, Yoshie and Kyuzo.

Several months after the arrival of Shoshichi, the family moved to Tokyo, where business opportunities were more promising. Within a few years, Kyuzo had saved enough to open his own futon store.

When the war ended, Shoshichi's math teacher, Mr. Muneo Hayashi, advised his parents to allow their son to apply for Ichiko (number one high school) in Tokyo. Shoshichi passed the entrance exam in his fourth year at middle school.

At the end of his first year in Ichiko, Shoshichi took the entrance exam for admission to the University of Tokyo. He passed it on his first try and entered the university after only one year at Ichiko.

At the University of Tokyo (Tokyo-daigaku or Todai) Shoshichi found that he was among the top students in mathematics. At the end of his sophomore year he declared his major to be mathematics and registered for a program to receive high school teaching certification. At this time he was unaware that people could make a living "just doing mathematics." The situation soon changed.

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[4]*The name Shochichi is an abbreviation for Showa-shichinen (seventh year of reign of Emperor Showa, 1932). Showa is the postmortem name of Hirohito.*

When Shoshichi started looking for a major advisor, his assigned undergraduate advisor told him about a charismatic young professor named Kentaro Yano, who would be returning from the Institute for Advanced Study at Princeton the following academic year. Just hearing about someone returning from Princeton seemed exotic and exciting to Shoshichi. Sure enough, Professor Yano lived up to and exceeded all expectations. Advisor and advisee made quite an odd but inseparable pair. Yano was a vivacious chain smoker who enjoyed drinking and clubbing, while Shoshichi was a quiet bookish type, a nonsmoker who drank modestly and only during social occasions. Words cannot express the admiration, love, and respect that Shoshichi had for his thesis advisor. Their kinship lasted until Yano's death during the year-end holiday season in 1993. Under Yano's guidance Shoshichi was bitten by the research bug.

Soon it became clear that postgraduation studies in France would be better than remaining in Tokyo. Shoshichi enrolled in night classes at Athénée Français to learn French to prepare for the exam for a fellowship to study abroad. The effort paid off handsomely. Shoshichi won a fully funded fellowship to study at the Universities of Strasbourg and Paris for one year (1953–54). He was elated by the news.

The fellowship required recipients to pay for their boat fare and transportation to Paris. This cost Shoshichi's parents nearly a fifth of what they had paid for a house three years before. Costs for room, board, and tuition in France plus a small stipend would be covered by the French government. The fare for the return trip at the conclusion of the year was also included in the package.

On what was the hottest summer day in Tokyo recorded at that time, Shoshichi boarded a French passenger ship with other fellowship recipients and waved to his relatives who had travelled to the port of Yokohama to wish him well during his year abroad. No one imagined that Shoshichi's departure would be permanent. He would return for his first brief visit to Japan in 1965 as a husband, father, and visiting professor from the University of California at Berkeley, courtesy of a Sloan Fellowship.

The journey to France was quite an adventure. Shortly after the ship passed through the Suez Canal, Shoshichi began running a dangerously high fever and was admitted to the hospital quarters onboard. He was only semiconscious when the ship arrived in France. The first months of his

The family at Yokohama to wish Shoshichi bon voyage to France, August 20, 1953.

postgraduate experience were spent in a French hospital recovering from typhoid.[5]

The French mathematical community was very friendly. Shoshichi attended seminars organized by famous professors.[6] He discovered that he might be able to make a living "just doing mathematics." One day in Paris he met Katsumi Nomizu, a young Japanese mathematician who had just finished his Ph.D. under Chern at the University of Chicago. Nomizu suggested that Shoshichi return to Japan via the United States. He mentioned two great mathematicians from whom Shoshichi could learn the art of mathematics: Chern at Chicago and Allendoerfer at the University of Washington. Shoshichi sent a personal statement together with reprints of his recent publications to these two universities. A few weeks later he received an acceptance letter from the University of Washington stating that all expenses would be covered upon arrival. From Chicago he received a thick envelope of application forms. His decision was not difficult. The French authorities agreed to cover his boat fare to the United States in lieu of travel costs back to his parents' home in Japan.

Shoshichi was overwhelmed by the generosity and kindness of the members of the university community in Seattle. On his first day at the university, the department chair, Professor Carl Barnett Allendoerfer, made time to greet Shoshichi and inform him of special arrangements to have his stipend paid in advance at the beginning of each month for just the first year. The administration had heard from more senior foreign students of the difficulties in securing a loan after arriving with little money. Shoshichi took an immediate liking

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[5] See Shoshichi's account of his first five weeks in France in his article "My memory of Professor Henri Cartan" in the Notices of the AMS **57, no. 8,** 954–955

[6] The seminars of Henri Cartan, Andre Lichnerowicz, Marcel Berger, and others in Paris. He worked with Charles Ehresmann in Strasbourg.

Wedding of Yukiko and Shoshichi.

to the professor. Over the course of a few months he found Allendoerfer to be a great statesman and scholar and was very happy when Allendoerfer agreed to be his doctoral thesis advisor.

Later that year Shoshichi was best man at the wedding of his friend Akira Ishimaru. The bride's maid of honor was Yukiko Ashizawa, who was also from Tokyo but from a different section of the city. She was on leave from her duties as a teacher at Rikkyo Elementary School in Tokyo. Had it not been for the war, it is doubtful that Shoshichi and Yukiko's paths would have crossed in Tokyo. They were formally engaged before he left for the Institute for Advanced Study in Princeton for his first postdoc in 1956, one year after his arrival in the United States. Shoshichi returned to Seattle the following spring for Yukiko's graduation and for their wedding on May 11, 1957.

After the wedding the couple drove to the University of Chicago, which had indisputably become a leading international center of geometric research under the leadership of Shiing-Shen Chern. Shoshichi was excited over the prospect of meeting Chern in person. Although Shoshichi had heard many stories of the great mathematician while in Paris, he was even more impressed by

Chern's kindness. Shoshichi enjoyed the open and productive collaborative atmosphere as a summer research associate sponsored by Chern.

In the fall the Kobayashis returned to Princeton to complete his second and final year at the institute. Eleven months following their marriage, the couple welcomed their first child, Sumire. In the fall of 1958 Shoshichi and Yukiko packed up for another move, this time to MIT, where Shoshichi would be a postdoctoral research associate. Just as they settled in and learned that they would soon be parents to a second child, Shoshichi received a tenure-track offer from the University of California at Berkeley. Chern would be moving to Berkeley, and he was working to establish a world-class center for mathematical research. He asked whether Shoshichi would be interested in joining the faculty. There could be no greater privilege.

Since United States visa regulations at the time required applicants to leave the country during administrative processing for a green card, Shoshichi accepted a very generous offer from the University of British Columbia in Vancouver, Canada. In 1962 Shoshichi and his family received visa clearance, and he joined the faculty at Berkeley. A year later Volume I of *The Foundations of Differential Geometry* was completed and published. In 1966 Shoshichi became a full professor at Berkeley. He remained on the faculty at Berkeley after his retirement, first as professor in graduate studies and then as professor emeritus.

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Math Teachers' Circles: Partnerships between Mathematicians and Teachers

B. Donaldson, M. Nakamaye, K. Umland, and D. White

Mathematicians depend on primary and secondary teachers to educate young students and inspire their mathematical minds. Teachers in turn benefit from mathematical experiences led by mathematicians that kindle their creative energy and broaden their intellectual horizons. Mathematics departments, as part of their mission, provide mathematical training for current and future teachers. Many mathematics faculty have a natural desire to share their excitement for mathematical inquiry in ways that can reach beyond their own classrooms and affect K–12 education. Unfortunately, mathematicians who are looking for opportunities to interact with teachers in a productive, collaborative spirit do not always know where to find them.

Math Teachers' Circles (MTCs) are a unique form of professional development that tap into this instinct that mathematicians have to share their love of mathematics with others. In contrast to other important forms of professional development for mathematics teachers that require specialized educational knowledge, MTCs leverage mathematicians' disciplinary knowledge and skill. That is, as mathematicians facilitate an MTC session, they ask probing questions, model mathematical thinking, and encourage mathematical conjecturing, exploration, communication, and discovery. This is similar in many ways to other activities that mathematicians regularly engage in, such as training Ph.D. students, guiding research experiences for undergraduates, or leading a capstone experience for mathematics majors. This makes MTCs an accessible entry point for mathematicians interested in working with teachers.

In this article we describe the history of MTCs, the MTC model, a sample session, and what we know about the impact of MTCs on teachers, mathematicians, and the K–20 mathematical community.

The Rise of MTCs

The idea for Math Teachers' Circles originated from a middle school mathematics teacher, Mary Fay-Zenk, at the time a teacher at Cupertino Middle School in Cupertino, CA. Intrigued by the mathematics at the San Jose (CA) Math Circle for students, Fay-Zenk thought that teachers should have their own outlet for mathematical exploration. She and a small group of other teachers and mathematicians, including Tom Davis (co-founder

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of Silicon Graphics), Wade Ellis (emeritus from West Valley College), Tatiana Shubin (San Jose State University), Sam Vandervelde (now at St. Lawrence University), and Joshua Zucker (now at the American Institute of Mathematics), developed this idea over the course of about a year. They secured sponsorship for a summer workshop at the American Institute of Mathematics (AIM) in 2006, thereby launching the first MTC. It continues to thrive, with some participants having attended throughout the eight years since its inception.

In 2007 AIM began to organize annual summer training workshops, entitled "How to Run a Math Teachers' Circle," to support the spread of the model. The fifteen workshops held to date have resulted in the formation of almost seventy new MTCs in thirty-seven states. As each MTC typically involves between 15 and 20 teachers during a normal year, most at the middle school level, collectively these MTCs reach 1,000 to 1,500 teachers per year. The MTC Network (`http://www.mathteacherscircle.org`) links together MTCs around the U.S., providing ongoing support in the form of materials from successful math sessions, discussion groups, and a semi-annual newsletter. The program has garnered support from the National Science Foundation (NSF), National Security Agency, American Mathematical Society (AMS), Mathematical Association of America (MAA), Math for America, Educational Advancement Foundation, and private donors. In its recent Mathematical Education of Teachers II (MET2) document [C], the Conference Board of the Mathematical Sciences (CBMS) recommended the MTC model among a handful of professional development models for middle and high school teachers.

The MTC Model

Math Teachers' Circles focus on highly interactive sessions in which teachers work with mathematicians on rich mathematical problems. Typically, a new MTC group begins with an intensive summer workshop for between fifteen and twenty-five middle school teachers who immerse themselves in mathematics full-time for a week guided by three or four mathematicians. During subsequent academic years, the group continues to meet approximately once a month, with summer workshops held as necessary to involve new teachers. Needs of local teachers drive the logistics of how the model is implemented at different sites, but all MTCs focus on problem solving in the context of significant mathematical content, draw on the content expertise of mathematicians, and have high levels of interactivity among participants and session leaders.

Two primary goals of the MTC model are to encourage teachers to develop as mathematicians by engaging them in the process of doing mathematics and to create an ongoing professional K–20 mathematics community. The core model does not explicitly address enhancing instruction, although many MTC groups choose to include formal discussions of pedagogy as well as informal time to discuss classroom ideas and concerns. Thus, MTCs are not intended as a comprehensive form of teacher professional development. Rather, they fall on the mathematical end of the spectrum, and they complement other forms of professional development that are more focused on direct classroom applications. As a result, it is natural to pair MTCs with other kinds of professional development, such as classroom coaching, lesson study, or Professional Learning Communities.

The problems that form the basis of MTC activities are mathematically rich and have multiple entry points or methods of attack, thereby encouraging collaboration and communication among group members with varying skill levels and backgrounds. Since participants do not know the method of solution in advance, the problems require creativity and perseverance. To draw participants in, session leaders try to choose problems that are immediately appealing in some way. The work that participants do to solve the problems leads them to methods and techniques that are broadly applicable in other mathematical endeavors, such as considering a special case or a more general case or drawing a picture or thinking abstractly or one of the many other techniques familiar to good problem solvers. The pursuit of the solution also reveals specific mathematical content. Those readers familiar with the Common Core State Standards for Mathematical Practice will recognize that this focus of the MTC model on doing interesting mathematics presents an opportunity to help teachers develop a deeper understanding of how the mathematical practices interact with mathematical content.

The initial leadership team for each MTC generally consists of two mathematicians, two middle school math teachers, and an additional organizer with expertise such as well-developed connections to the local teaching community or grant-writing experience. These leaders are genuine partners in planning and developing their MTC to meet the needs of the local mathematical and teaching community, with each person bringing his or her distinct skills to the table. In a typical case, the mathematicians provide leadership in choosing rich material and facilitating the teachers' work during the sessions, the teachers help design the program so that it is an appealing and meaningful experience for their colleagues, and the additional
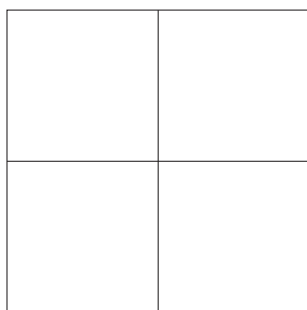
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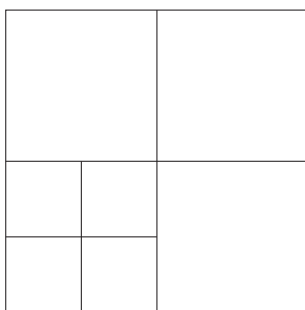
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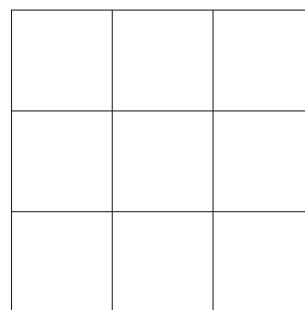
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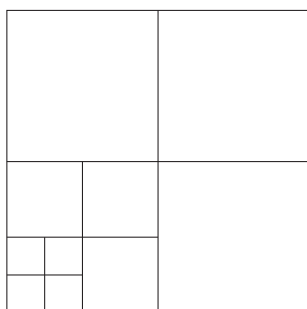
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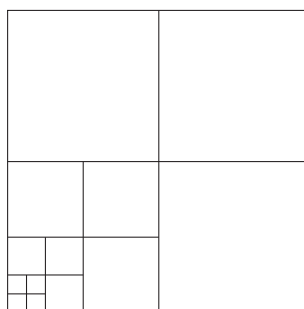
Thirteen Squares

organizer helps connect the team with resources for recruiting participants and raising funding. They all work collaboratively on developing a vision for their MTC, planning workshops and meetings, and fostering a positive atmosphere for all involved.

To provide a better understanding of what an MTC session entails and the kind of mathematical exploration and dialogue MTCs can support, we now turn our attention to an example of the type of problem that teachers and mathematicians collaborate on in a typical meeting.

An MTC Session: Dividing Squares

The session begins by showing teachers some pictures of a square divided into smaller squares, not necessarily of the same size. Teachers work for about fifteen minutes creating different divisions of a square and recording their results. After sharing, two natural questions about this division arise:

1. For which whole numbers n is it possible to subdivide a square into n smaller squares?
2. For which whole numbers n is it *not* possible to subdivide a square into n smaller squares?

For the first question, the examples teachers produce seem to indicate that when $n \geq 6$ there is a division into n squares. Teachers then identify, possibly with some guidance from the session leader, some nice relationships between their different pictures. For example, the pictures above

with four and seven squares are closely linked: these are the same except that one square has been further subdivided into four smaller squares. This is a process which can be repeated, and each time this is done, three new squares are added—since a single square is replaced with four smaller ones. Above are pictures showing two further divisions starting from the decomposition into seven squares.

Teachers observe that these divisions give $4, 7, 10, 13, 16, \ldots$ squares. This is an example of an arithmetic sequence generated by a geometric process. The same operation, applied to the "tic tac toe" division into nine squares, produces examples with $9, 12, 15, 18, \ldots$ squares. At this point, most of the missing numbers belong to another arithmetic sequence, namely $5, 8, 11, 14, \ldots$. Teachers can now apply this technique to a division into eight squares, as shown below:
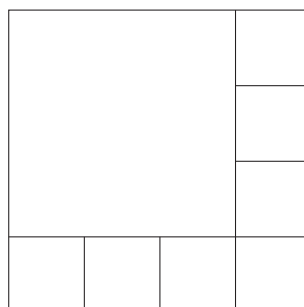
Putting all of these examples together gives divisions of the square into $4, 7, 8, 9, 10, 11, \ldots$ smaller squares. The original square itself, without division, is one square. In our experience, teachers come up with divisions into these numbers, up to about thirty, and also identify patterns which can be used to generate sequences. The session leader often needs to provide some guidance putting together the different ideas and constructions if a formal argument, as presented here, is a major goal of the session.

The only remaining possibilities are $2, 3, 5$, and 6 squares. Dealing with these special cases can require some prompting from the session leader, particularly the cases of 2 and 3, which appear very simple. A good argument to eliminate these is to note that, as soon as a division is made, each of the four corners of the initial square must belong to a *different* smaller square. The session leader must decide how much to stress this argument, as it does not always come naturally to teachers and is not the main focus of the problem. Five squares is also not possible, but the reason is more challenging to explain: the four squares containing the corners of the original square cannot be the same size in this case, but it is impossible for the complement of these four squares to be a square, since this complement is not a convex set. This is subtle and necessarily so because it establishes that *regardless of how we cut*, we will never arrive at exactly five smaller squares. Here too the session leader must decide how much rigor to pursue in the argument. Cutting into six squares is possible and is left to the reader. The conclusion of this first investigation answers questions 1 and 2: it is possible to cut the large square into any number of smaller squares with the exception of $2, 3$, and 5. This first part of the session can take anywhere from forty-five minutes to an hour and a half depending on the level of precision and thoroughness of the arguments.

One of the hallmarks of Math Teachers' Circle investigations is beginning with a simple, readily accessible question and then heading as far as the mind and imagination are willing to go. In this example, there are many further questions which can be asked about the process of subdividing a square into smaller squares. In the Albuquerque Math Teachers' Circle session described here, the leader posed the following question:

3. Is it possible to perform the division so that there is a *unique* square of smallest size?

The open-endedness makes this a challenging question, and intuitions for the answer vary. In the session described here, one of the teachers was able to successfully answer this question, but, in general, the session leader needs to decide whether to provide guidance or to leave teachers with an open question. This line of inquiry can be carried even further:

4. Is it possible to perform the division in such a way that no two squares have the same size?

Another direction of inquiry would go in the opposite direction: given a certain number of squares (of various sizes) is it possible to assemble them to form a single square? The question about squares can also naturally be adapted for different shapes. One very famous example of decomposing an equilateral triangle into smaller equilateral triangles is Sierpinski's triangle.

A substantial amount of research[1] has been done on the question of decomposing a rectangle into squares [D], [BSST], [G]. However, the teachers are not familiar with the details of that mathematics, and unless this happens to be directly in the research area of the mathematicians, they will not be familiar with it either. Thus, together they are participating in their own miniresearch experience as they explore this topic.

This problem illustrates several features of typical MTC problems. They are easy to state and require minimal background knowledge, allowing everyone to immediately engage in a search for an answer. The questions considered are often open ended, providing teachers an invaluable opportunity to experience problem solving as mathematicians. They also lead to rich and interesting investigations, leaving the door open for teachers to continue their mathematical explorations long after the MTC session has ended.

MTC Problems Can Lead Anywhere

One session of a Math Teachers' Circle in the San Francisco Bay Area led to sustained collaboration among mathematicians, teachers, and students. In this session, teachers were given a few minutes to make their best guess as to the size of 100! with the answer expressed in scientific notation. After discussion, the session continued with a goal of providing an estimate that is accurate to within a factor of 2. A good starting point for making these estimates is that $2^{10} = 1024$, which is pretty close to 10^3; from here it follows that 2 is about $10^{0.3}$. We can deduce from here that 5 is about $10^{0.7}$. Using these estimates and the fact that 80 and 81 are neighboring integers whose only prime factors are 2, 3, and 5, we can deduce that 3 is about $10^{0.48}$. These estimates for 2, 3, and 5 can be used directly to give estimates, as a power of 10, for many of the numbers between 1 and 100.

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[1] *The authors are grateful to Jim Madden for sharing the rich history of this problem with them.*

More work is then needed to fill in numbers with prime factors other than 2, 3, or 5.

Critical in this method was finding the numbers 80 and 81, which are adjacent integers with small prime factors. Intrigued, the session leader had two high school students from Morgan Hill, CA, Mark Holmstrom and Tara McLaughlin, investigate these special numbers further. This led to a method of constructing large neighbors out of sets of small neighbors. In the end, around 345,000 neighbors were identified with prime factors less than 200, the largest having twenty-three digits! Holmstrom and McLaughlin's project won first prize in the regional science fair and a trip to Pittsburgh for the Intel International Science and Engineering Fair, where they received an honorable mention from the AMS. The two students and the session leader wrote up these results, and they will be published in *Experimental Mathematics*.

On at least two other occasions, original mathematical research has stemmed from MTC sessions and been published. One of these cases [A] involved research developed by the mathematical facilitator and a collaborator. The other example, involving the geometry of the card game Set, recently appeared in an article [B] in the *College Mathematics Journal* of the Mathematical Association of America. It is coauthored by ten teachers and three facilitators!

Imagine the impact on these teachers' self-confidence and mathematical self-identities that comes from contributing in a bona fide way to genuine mathematical research!

Focus on Partnerships

Whereas the organization of each local MTC varies considerably, core principles persist across locales. One of the key principles involves cultivating cross-community partnerships. As noted earlier, the leadership team should consist of mathematicians, teachers, and administrators. Additionally, MTC sessions themselves often find a variety of partners coming together to engage in mathematics. Indeed, depending on the local chapter, MTCs can include not only the mathematician facilitators and middle school teachers but also some elementary or high school teachers, other mathematics or science faculty, and undergraduate or graduate students training to be teachers.

The CBMS MET2 document cited this vertical integration as follows: "A substantial benefit of [Math Teachers' Circles] is that they address the isolation of both teachers and practicing mathematicians: they establish communities of mathematical practice in which teachers and mathematicians can learn about each other's profession, culture, and work" [C].

Impact on Teachers

Ongoing research demonstrates the benefits of MTCs for teachers' confidence, knowledge, and teaching of mathematics. A team led by Diana White has recently reported [W] that teachers' mathematical knowledge for teaching (MKT) increases significantly over the course of a four- to five-day intensive summer MTC workshop. Previous research has found a positive correlation between teachers' MKT and student achievement scores [H]. Additionally, researchers from the University of Colorado at Colorado Springs have reported evidence from classroom observations that MTC participants significantly increase the use of inquiry-based teaching practices over a one-year period [M].

The coauthors of this article are members of a research team that is investigating the impact of MTCs with support from the NSF. Our research has three primary components: a further investigation into the effects of MTC participation on teachers' mathematical knowledge for teaching, a series of annual surveys aimed at learning more about the teachers who participate and their motivations for doing so, and the development of in-depth, multiyear case studies that include classroom video observations and interviews. The case study results are too preliminary to report here, but the surveys are providing an interesting picture of teachers' experience with MTCs. For example, on the 2012 survey, 75 percent of the 169 respondents said that MTC participation has affected their teaching. Examples ranged from specific topics that MTC sessions have helped them teach more effectively (e.g., "I've incorporated number theory ideas I learned with respect to comparing fractions") to broader changes in how they ask students to approach mathematics (e.g., "I give students fewer steps and ask them to tackle complex problems with less scaffolding of the problem itself. I also have been helping students reflect on what their problem-solving process is and how to optimize their problem-solving process"). Over half of the respondents told us that MTC participation has changed their view of mathematics. They cite that MTCs enable them to see deeper connections between mathematical topics, expose them to fields of mathematics that they were previously unfamiliar with, and help them envision doing mathematics as a more collaborative and enjoyable enterprise. Approximately half of the respondents also wrote that participating in MTCs has affected their other professional activities, for example, leading them to become more involved in collaborations, leadership, and student extracurricular mathematics activities.

Perhaps the most rewarding result we have seen, and the one that we believe will ultimately have the

biggest impact, is that participating teachers report beginning to see themselves as mathematicians. For example, here are a few quotations from middle school teacher participants:

- "You encouraged me as a mathematician. I have never actually seen myself as one before."
- "I've become much more of a recreational problem solver—I always have my problem notebook with me for down times."
- "MTC grows teachers who are also mathematicians."

Impact on Mathematicians

There has been considerably more research into the benefits of MTC participation for teachers, but we now turn our attention to how mathematicians benefit from MTCs. Beyond the opportunity to get involved in K–12 education while sharing one's love of mathematics, MTCs can be synergistic with other efforts, such as mentoring student research, as illustrated in the example above. MTCs can also provide an excellent avenue for contributing to one's departmental or institutional mission, especially at a state-supported institution or an institution with a large teacher-training program. For those involved in teacher training or professional development, MTCs can provide a way to maintain a professional connection with the local teaching community and to offer ongoing support to teachers who have participated in other university programs. One mathematician chose to become involved because "we have relationships with many teachers in our surrounding districts. Our teachers are eager for any help we can provide. The Math Teachers' Circle will provide a venue to address their needs." Another writes that "offering Math Teachers' Circles would be a perfect opportunity for our master's program to continue to support the teachers graduating from it, and providing leadership opportunities for them." Having an impact on the preparation of local K–12 students who will eventually attend the university is another potential long-term benefit. For example, another mathematician writes that the primary reason for becoming involved was "to form relationships with local schools while enhancing the instruction provided to future undergraduate students in our target recruitment populations."

Increasingly, MTCs are becoming a professionally recognized forum for mathematicians to contribute to education. The AMS and MAA have supported the effort from early on, and the MAA continues to partner with AIM to host one of the "How to Run a Math Teachers' Circle" training workshops each summer. Anecdotally, more than a handful of MTC leaders have noted that their MTC involvement was a contributing factor in a positive job search experience or tenure or promotion decision. Several MTC leaders have also received partial support for their MTCs as part of the broader impacts of their NSF research grants, indicating a wider recognition that MTCs constitute a valuable contribution that mathematicians can make to society.

Final Thoughts

By their very nature, Math Teachers' Circles are a natural forum for mathematicians and mathematics departments to reach out to practicing teachers and form lasting relationships that recognize the common purpose which unites K–20 educators. Some faculty who participate in MTC meetings are inspired to seek other ways to contribute to the larger teaching community. This may include working with preservice teachers at their institution or becoming more involved with state or national educational efforts. Whether it serves as a launching point for deeper involvement with teacher education or as an end in itself, participation in an MTC can impact both teachers and students and can play an important and fulfilling role in the professional lives of many mathematicians.

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Two Essays from *Mathematicians Who Lost Their Faces*

Shoshichi Kobayashi
Translated by Hisashi Kobayashi

The following is an English translation of two articles selected from Shoshichi Kobayashi's essay book *Mathematicians Who Lost Their Faces: Essays in Idleness on Mathematics* [1] published (by Iwanami Shoten Publishers, Tokyo, Japan) in Japanese posthumously in July 2013. The complete table of contents can be found on his memorial website, along with an English translation of four additional articles.[1]

President Lincoln and Euclid[2]

The reason why Greek mathematics distinguished itself from the mathematics of the Egyptians, Babylonians, and other ancient civilizations is found in its philosophy that by starting from several principles, definitions, and axioms, it clearly stated a proposition and rigorously proved it. They allowed no compromise and proved a series of propositions by going through step by step, starting from five postulates that could not be reduced any further.

It is really strange that mathematics in which a proposition was proved by a rigorous demonstration was developed only in the Greek civilization. According to Prof. Shuntaro Ito, who studied the history of Greek science, such "demonstrative mathematics" could be formed in the city-state of ancient Greece only because it was a society where every citizen, standing on equal footing, expressed his/her opinion and, when asked for its basis, persuaded others by explaining it logically. It would have been difficult under an autocratic regime which produced a cultural climate in which even knowledge was given from its authority and was inherited as a tradition without questioning "why?" (cf. Shuntaro Ito, *Mathematics of the Greeks*, Kodan-sha Gakujutsu-bunko, 1990).

Mr. Ito's explanation has something in common with the following anecdote about Abraham Lincoln. Even primary school children know the story about Lincoln that he was born in a log cabin in the countryside of Kentucky, barely attended even a primary school, raised by parents who could not read, yet he taught himself to become a lawyer, jumped into the world of politics and became the sixteenth American president, and achieved the emancipation of slaves.

It is less known, however, that when he ran for president, he stated in his résumé that he "studied the first six volumes of Euclid's '*Elements*'" (cf. Salomon Bochner, *Role of Mathematics in the Rise of Science*, Princeton University Press, 1966; translated into Japanese by Tamotsu Murata, Misuzu Shobo Publisher, 1970). When Lincoln was asked why he studied Euclid, his answer was, "A lawyer is always asked to 'demonstrate' (i.e., to prove by reasoning or evidence). I thought therefore that in order to learn what 'demonstration' is, studying Euclid's *Elements* should be the best."

In order to win in a court case, a lawyer must convince the judge and jurors by demonstrating his claim in a systematic manner. This seems very similar to Professor Ito's theory about the mathematics of ancient Greece. (Incidentally, Q.E.D. stated at the end, when proving a proposition, is an acronym for the Latin phrase "quod erat demonstrandum," i.e., "which had to be

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[1]www.shoshichikobayashi.com/recent-publications/

[2][1], *pp. 65–67*.

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demonstrated," where "to demonstrate" here means "to prove.")

As Mr. Ito used the expression "without making any compromise or concession" in characterizing Greek mathematics, we feel about Greek mathematics something more than its emphasis on demonstration. I recall that the poet Ms. Chimako Tada (1930–2003) wrote a long time ago in a journal, probably in *Bungei-shunju,* something like "The reason why we are attracted to ancient Greece is because we are attracted to the youthfulness of its civilization. The fact that their period was ancient means that they were young as a human race. We are four thousand years older than the human race of 2000 BC." In fact, the characteristic described as "without making any compromise or concession" is an indication of youthfulness.

Just like poets find the youthfulness in Homer's poems, mathematicians feel the youthfulness of the Greek civilization in the mathematics of the Greeks.

Mathematicians and Politicians[3]

Ms. Margaret Thatcher (1925–2013), who was the prime minister of the United Kingdom, graduated from the Department of Chemistry, the University of Oxford. The current chancellor of Germany, Ms. Angela Merkel (1954–), studied physics at Leipzig University from 1973 till 1978 and obtained her Ph.D. in physics in 1990 from Berlin. She published several articles besides her doctoral thesis on quantum chemistry.

In France, there was Joseph Fourier (1768–1830), a mathematician who participated in politics. He was involved in many political movements but was primarily on the side of Napoleon, and was appointed to "Prefect" (a governor-like position) of the Isère Department (in Grenoble).

Pierre-Simon Laplace (1749–1827, celestial mechanics) was also appointed by Napoleon to be Minister of the Interior, but it did not last six months.

Émile Borel (1871–1956, measure theory, probability theory) became very active in his later years as a member of the National Assembly in 1924–1936, as the Minister of Marine in 1925 (in the cabinet of fellow mathematician Paul Painlevé), and as a member of the French Resistance during World War II.

Paul Painlevé (1863–1933, nonlinear second-order differential equations) served two terms as prime minister, both of which were short-lived (September 12–November 13, 1917, and April 17–November 22, 1925) in the unstable period of the French Third Republic (1870–1940), which included World War I (1914–1918), when the cabinets were formed and fell one after another. He also served as Minister of War and Minister of Education for many years around the period of World War I.

The former president of Peru, Alberto Fujimori (1938–) earned his master's degree in mathematics from the University of Wisconsin in Milwaukee.

Let us turn our attention to Japan. Dairoku Kikuchi (1855–1917) went to study in England at the age of eleven in 1866 under the order of the Tokugawa shogunate and received a bachelor's degree in mathematics-physics from St. John's College of the University of Cambridge at age fifteen. After returning to Japan, he later became the president of Tokyo Imperial University and then served as the Minister of Education in 1901–1903.

But among the Japanese mathematicians, one who became a full-fledged politician is a former governor of Hiroshima City, Tadatoshi Akiba (1942–). After receiving his bachelor's and master's degrees in mathematics from the University of Tokyo in 1966 and 1968, respectively, he went to the Massachusetts Institute of Technology (MIT) and received his Ph.D. under the guidance of John Milnor. His specialty is topology. After teaching at the State University of New York at Stony Brook for two years, he taught at Tufts University in Massachusetts from 1972 to 1986 and returned to Japan in 1986. After teaching at Hiroshima Shudo University from 1986 to 1987, he ran for member of the House of Representatives from the Social Democratic Party in 1990 and won the election and served as a member of the House of Representatives until 1999. From 1999 till 2011 he served as the mayor of Hiroshima, indeed for twelve years. He adhered to his position for the total abolition of nuclear weapons as a member of the Social Democratic Party and as mayor of Hiroshima. He must have seriously carried out the administration of the city, judging from the fact that he lasted as long as twelve years. [Incomplete][4]

Acknowledgments

Reference

[1] Shoshichi Kobayashi, *Mathematicians Who Lost Their Faces: Essays on Mathematics in Idleness (in Japanese)*, Iwanami Shoten Publisher, Tokyo, July 30, 2013.

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[3][1], *pp. 121–122.*

[4]*This article was not part of the initial manuscript that Shochichi sent to the editor in April 2012. The rough manuscripts of this article and another article, "Mathematical education," were found in his house at Berkeley in the spring of 2013, several months after his death.*

Why Is There Philosophy of Mathematics at All?

Reviewed by John P. Burgess

In his latest book, the noted philosopher of science Ian Hacking turns his attention to mathematics, a long-standing interest of his heretofore seldom indulged. His previous work, though it hasn't always been universally found convincing, has been unfailingly provocative. The present work fits the pattern.

Some mathematicians seeing the title of Hacking's latest book may read it as meaning something like, "Why can't we just get rid of philosophy of mathematics?" asked in a tone of voice suggesting that it would be a very good thing if we could. After all, did not Hilbert himself announce, speaking of foundational questions, that what he wanted to do with them was to get rid of them once and for all [*einfürallemal aus der Welt zu schaffen*]? But this is not what is intended. Hacking doesn't think philosophy of mathematics will ever go away for good, be got rid of once and for all, and he genuinely means to ask why this is so: What is it about mathematics that historically has kept drawing philosophers back to it time and again?

The answer suggested is that there are two factors at work. One is the experience of following a compelling proof. The seeming inevitability of the conclusion, the feeling that it is not something one is free to take or leave as one chooses, Hacking cites as an ultimate motivation behind philosophies that affirm the independent reality of a realm of mathematical facts, from Plato to Hardy [3]. The other factor is the observation that mathematical desk work again and again proves useful in dealing with the world outside the mathematician's office. How by just sitting and thinking we (or some of us) can arrive at results applicable to the world around us has puzzled thinkers from Kant to Wigner [4].

The two features are separate. That results should prove applicable to the physical universe even though they were obtained by pure desk work, without controlled experimentation on or systematic observation of the material world, can be surprising even if what the desk work produces is not compelling deductive proofs but "only" suggestive heuristic arguments. And with the two factors being separate, the material in the book is divided into two more or less separate parts, though with a lot of back and forth between them: one devoted to proof, the other to applications.

Neither the part about proof nor the part about applications is concerned *only* with their role in perennially drawing the attention of philosophers to mathematics. And, beyond the general division into these two broad topics, the book is rather loosely organized and digressive, not to say rambling, in a way that makes it quite impossible for the reviewer to summarize its contents in an even halfway adequate fashion. The analytical table of contents goes on for six pages, and there is nothing I would leave out, but this means that even to list the topics addressed would take up more space than is reasonable for a review.

One thing just leads to another: If a philosophical view is stated, some mathematical example will be wanted to illustrate it, but then at least an informal explanation of the key concepts in the example will be wanted also, and perhaps a capsule bio of the author or authors of the relevant result or results, and even perhaps in cases where they
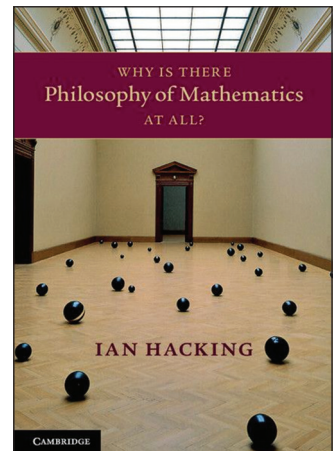
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have won prizes something by way of description of the prizes and who established or who awards them, and so on. As a result, in the index one finds Fermat and the Fields Institute, formalism and Foucault, the four-color problem, and Frege and Freud all rubbing shoulders.

Not Philosophy but *about* Philosophy

Now it is one thing to write about a field and another to work in it. Hacking asserts early and emphatically that his is a book *about* philosophy of mathematics, not a work *of* philosophy of mathematics. He is indeed quite reticent about his own philosophical views, preferring to survey those of others. And the book is wholly free of philosophical polemics: Hacking manages to find something nice to say about almost every writer he discusses or even just mentions in passing, even writers who disagree profoundly with each other, and even writers who disagree profoundly with the views with which Hacking shows himself most sympathetic. (Conflict of interest disclosure: This includes the present reviewer.)

And while Hacking has quite a bit to say about important figures in the history of philosophy and to a lesser extent of mathematics, he also avoids scholarly controversies over the interpretation of the thought of historical figures. Thus he frequently quotes one of his favorites, Ludwig Wittgenstein, about the exegesis of whose cryptic works there have notoriously been very bitter controversies, but cheerfully says that it doesn't matter to him if he has got Wittgenstein right, though he thinks he has. For what it is worth I am mostly inclined to agree, though I am struck by Hacking's omission of certain of Wittgenstein's dicta that if quoted might make the philosopher seem a less sympathetic figure to mathematicians. Try this one (directed against Hardy): "…what a mathematician is inclined to say about the objectivity and reality of mathematical facts, is not a philosophy of mathematics, but something for philosophical *treatment*…like the treatment of an illness" ([6], 254–5). Or this one (directed against Hilbert on Cantor's paradise): "Philosophical clarity will have the same effect on the growth of mathematics as sunlight has on the growth of potato shoots. (In a dark cellar they grow yards long)" ([5], 381).

More importantly, while a contrast between what Hacking calls "cartesian" and "leibnizian" proofs or conceptions of proof runs through much of his discussion, he spells the labels with a small *cee* and *el* by way of indicating that he's not especially concerned to defend any claims about the exact content of the thought of the historical Descartes and Leibniz.

One respect, apart from its livelier style, in which Hacking's book differs from conventional philosophical writing about mathematics is that an enormous amount of work goes into gathering food for thought but much less into boiling it down, chewing it over, and digesting it. For instance, the material on applications goes on at surprising length and depth about etymological issues (when did the expression "mixed mathematics" give way to "applied mathematics"?) and sociological ones (how did the organization of universities into departments in the nineteenth century differ between Britain and Germany?), but it wasn't clear to me what we are supposed to make of all this, fun as it was to read about.

The material on proof also shows a tendency to give priority to information gathering over critical analysis. This is perhaps especially so in connection with the cartesian/leibnizian distinction. It is used as a peg on which to hang the discussion of various issues and episodes and personalities, but the kind of questions that a conventional philosopher of mathematics would feel compelled to address in connection with such a distinction are just not gone into. To cite just one crucial issue: are the various rough characterizations offered of "cartesian" (or "leibnizian") proof equivalent, all pointing towards the same feature? In other words, do we have one distinction here, or are several being run together?

I suspect the latter. Hacking begins by noting that Descartes speaks (though as Hacking significantly admits, not in his *mathematical* writings) of getting an entire proof in the mind all at once. Hacking doesn't, however, mention why Descartes *needs* such a notion in his philosophical system. Descartes, towards the ultimate aim of arguing that all knowledge depends on knowledge of God, suggests that the conclusions of an atheist mathematician or any conclusion arrived at by a series of steps can be rendered doubtful by the reflection that maybe a tricky demon was just making it *seem* that one step followed another. Descartes has an argument why we can't really be deceived by such a tricky demon (the main consideration being that there is a God who would prevent it), but that argument itself consists of a series of steps and so presumably can be rendered doubtful: maybe the tricky demon's trickiest trick is to trick Descartes into believing there is no tricky demon. Only if Descartes can see the whole argument in a flash and not as a succession of steps, if he can get the entire proof into his mind all at the same time, can he be freed from the possibility of having his conclusions rendered doubtful.

But Hacking's notion of "cartesian proof" slides from this first characterization, as a proof that one can get the entirety into one's mind all at once, to a different characterization, as a proof that does not merely convince us that a result is true but explain to us why the result is true. This is a distinction about which, in the last decades, there has been a great deal of discussion by philosophers of mathematics, especially those who identify themselves

as "philosophers of mathematical practice," with rather meager and inconclusive results (a fact that should hardly surprise Hacking, familiar as he must be with how intense philosophical investigation of "scientific explanation" in theoretical physics a couple of decades back led to similarly meager and inconclusive results). And needless to say there are many quotable things mathematicians have said about such a distinction at one time or another too, not all by any means pointing in the same direction. But what does a proof's being explanatory have to do with our being able to get the entire proof into the mind all at once?

There are lots of proofs of mathematical propositions *p* that one could say explain *why p* and don't just convince *that p*. But I don't find myself able in any interesting case to get the entirety of such a proof into my mind all at once, to see the proof as a single step rather than a succession. Hacking cites Littlewood's version of the proof that there can be no decomposition of a cube into cubes all of unequal size, which appears as an epigraph to the book. I myself don't find it easy to take this in as a single step rather than a succession of several—to see in a flash why the result is true, which would presumably include seeing why the same argument doesn't work one dimension down to show that there is no decomposition of a square into squares of unequal size—especially when one fills in the reasoning needed to establish a lemma that Littlewood simply calls obvious. Well, perhaps *my* mind is just too small for this to fit in all at once. One of Hacking's more amusing, and only too true, observations about the experience of compelling proofs is that *most* people don't have it.

Glitter

If Hacking's approach does not stop to carry out the kind of critical analysis that would be needed to establish, say, that in speaking of "cartesian" and "leibnizian" proofs one is looking at a clear, univocally characterized dichotomy, my saying so is not a matter of *complaining*. It is a matter of *explaining* how what Hacking is doing in writing *about* philosophy of mathematics differs from working *in* philosophy of mathematics—how it differs and why it may be more fun. Writing *in* philosophy of mathematics generally must plod along at a slow and deliberate pace. Writing *about* philosophy of mathematics can be breezier and take us to more interesting places in less time.

If I *did* have any complaint, it would not be about the kind of book Hacking has chosen to write but about his tendency, when he wants to illustrate some phenomenon, to pass over homelier examples and go immediately for the most subtle and sophisticated—and recent. Hacking quotes Wittgenstein as warning against being taken in by "glitter": glamorous results can distract one from what is essential in philosophy of mathematics

(and not just of mathematics). Hacking himself, as he is not unaware, sometimes runs the risk of being distracted or distracting his readers in just this way.

Let me illustrate this rather abstract remark by a concrete case. In speaking of what moves some mathematicians and philosophers to speak of mathematical reality as being "out there" before we discover it, Hacking slides from talking about compelling proofs to talking about compelling results, even when the proofs are long and laborious. He mentions classification theorems, which are indeed excellent examples. There is nothing like learning that there are exactly *N* of something or other to encourage the thought that all *N* of them were "out there" before we found out about them. The five Platonic solids used to be used as an illustrative example in this way. Hacking suggests that, historically important as this example may be, it has become so familiar that we are now blasé about it and need a different example.

He then goes at once for the classification of simple groups. This provides opportunities to mention various interesting people and exotic topics, but there is no hope in a work written at a semipopular level of explaining what, say, John Conway's "monstrous moonshine" actually amounted to or even what specifically a sporadic simple group *is*. Surely there must be examples—two-manifolds, perhaps, or nonplanar graphs—less hackneyed than the Platonic solids but less ferociously technical than finite simple groups.

Another very interesting phenomenon Hacking gets into on his way to discussing the extramathematical applicability of mathematics is *intra*mathematical applicability, beginning with Descartes's application of algebra to geometry. That example by now has something in common with the Platonic solids example, namely, a degree of familiarity that makes it unexciting. Again Hacking goes off in the direction of very sophisticated material indeed—the Langlands program, no less—in search of fresher examples and gets into material so complicated that he himself is not sure whether one should speak of applying one field to another or merely of seeing analogies between fields.

Again there are near-to-hand simpler examples of the phenomenon of surprising connections between diverse mathematical specialties that could have been cited instead or as well. There is, to begin with, De Morgan's well-known old story ([1], 284–7) of an encounter with an acquaintance, apparently in the insurance business, in which they were talking of life expectancies and De Morgan cited some actuarial formula, probably related to the normal distribution, involving the symbol π for the famous constant, the ratio of circumference to diameter. The reply was, "Oh, my dear friend, that must be a delusion; what can the circle have to do with the numbers alive at the end of a given

time?" This simple example at least shows clearly the first crucial feature that needs to be mentioned in connection with surprising connections: there isn't going to be any *nonmathematical* explanation of them.

Summary

There is much more in the book. I have taken well over two thousand words without really touching on the aspects of the book touted in the publisher's blurb: discussion of the historical question where proof came from, what the distinction is between applied and pure, and the question "What is mathematics?" Any answer to this last is likely to look disappointing after Timothy Gowers's splendid editorial preface to [2], in which he quotes Russell's definition of mathematics and adds that his volume (of 1,000+ pages) is about what Russell's definition leaves out. Hacking gives the question only about thirty-five pages, but he does manage to bring in curious information you won't find in the Gowers volume.

Perhaps I should stop here. But before closing, let me mention one more respect in which Hacking's book *about* philosophy of mathematics differs from books *in* philosophy of mathematics: Since it is as far as possible from being one long, connected argument for a distinctive, unifying thesis, the reader can freely dip into it, open it almost anywhere, and start reading with pleasure and profit.

References

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[4] Eugene Wigner, The unreasonable effectiveness of mathematics in the natural sciences, *Communications in Pure and Applied Mathematics* **13** (1960), 1–14.
[5] Ludwig Wittgenstein, *Philosophical Grammar*, ed. Rush Rhees, trans. Anthony Kenney, Blackwell, 1974.
[6] _____, *Philosophical Investigations*, 3rd. ed., trans. G. E. M. Anscombe, Blackwell, 2001.

Film Review

Ramanujan and the Nature of Genius

Reviewed by Mark Saul

The Genius of Srinivasa Ramanujan
Documentary, running time 60:00
Director: Nandan Kudhyadi
Co-Producer: Vigyan Prasar and IISER Pune
Indian DVD-premiere: March, 2013
View movie trailer at: youtube.com/wash?v=uHHI OTMih7E&feature=youtu.be

We are not in control of our own minds. Our thoughts, and certainly our feelings, come to us unbidden and unbridled. Attempts to channel either meet with mixed success, and trying to assign causality to the flow of ideas quickly founders on jagged philosophical rocks. We can describe our thoughts, express our feelings, but we cannot summon them at will.

Nonetheless, thinking and feeling are the central experiences of our lives. And the experience of being a genius, while inaccessible to most of us, is the more intriguing for just that. What is genius? Is it a singular set of mental faculties that some are born with and others are not? Is it the result of upbringing? Of genetics? Of the intervention of a Higher Power? Or perhaps it is a mental illness, a syndrome that renders the sufferer capable of incredible feats of thought, from which the rest of us profit but which keeps the victim personally miserable.

The film *The Genius of Srinivasa Ramanujan* plays on this intrigue. Wisely avoiding an attempt to analyze the phenomenon that was Ramanujan's mind, it tries rather to take us through the experience of being Ramanujan or close to Ramanujan. We understand much more of Ramanujan's mathematics than we do of the mind that created

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it. And so the film poses more questions than it can answer, and leaves us wanting answers more than before.

The film is structured as a pilgrimage to places in India and England where Ramanujan's life played out. At each station of the pilgrimage, we meet mathematicians who continued Ramanujan's work, people who admired his work, or (in a few scenes) Ramanujan himself, played, often silently, by an actor. For example, we are taken to Ramanujan's birthplace in the town of Erode. Unfortunately, this home is in a dilapidated condition. But then a significant part of the filming is done in Kumbakonam where he grew up, and where he made many great discoveries. Happily the Kumbakonam home is now maintained in excellent condition, after SASTRA University's purchase[1] of it in 2003.

The film wonderfully evokes the places and times that were the backdrop of Ramanujan's work.

There is no exposition of Ramanujan's mathematics—that is for a different audience. Nor is there a scene-by-scene recounting of his life story, which can be found elsewhere. Rather, the film immerses the viewer in the India of Ramanujan's youth, the England of his all-too-brief adulthood, and the scene of his illness and death. For example, the film brings us Kumar Murty, telling us that creativity does not really stem from rationality or logic. It is, he says, more like an aesthetic experience, more a feeling than a thought. Deep mathematics (we can all relate to this) gives a feeling of intellectual pleasure. Murty's personal note is followed by a scene from Ramanujan's life: not a milestone, not a dramatic event, but Ramanujan talking with an unnamed Indian mathematician, sharing with him the joy of discovery. The mathematics is only briefly described and is not the point. Indeed, the scene begins in Tamil, not English, and so for most of us it is only the inflections of the language, the emotional experience, that is conveyed.

The film leaves unexamined some important aspects of Ramanujan's life. While the mathematical community in India was small and not well developed at the time, a number of Indian mathematicians recognized Ramanujan's gifts and supported him in several ways. And a number of British mathematicians left his letters unanswered. It was part of Hardy's genius that he considered seriously Ramanujan's letter and brought us Ramanujan's mind. But if we take as the subject of the film the experience of the genius, there is a more serious omission, and one that would be difficult to fill. That omission is the experience of struggle,

of hard work, that is central to the professional lives of most, including the geniuses among us. The triumph of understanding is often the sweeter when it is the result of hard work, deep reflection, a struggle towards the light. This is something not widely appreciated by the public. Many think of genius, or even simply intellect, as a gift that is given to some and not to others. Those to whom it is given, in this view, are blessed with facility in understanding and are merely walking along a pleasant path.

Anyone who has worked at mathematics—on almost any level—knows that this view is false. While a genius may find elementary work (which is all most people know of mathematics) easy, she or he will also find it boring until faced with a challenge. The literature on gifted education shows us that the talent of gifted students will fizzle if the students don't find mathematics intriguing. They will turn their minds to more stimulating material in other subjects if we don't offer them what they need in mathematics. A genius is both born and made.

Another important aspect of Ramanujan's life is brought out well in the film: Ramanujan's genius, in a sense, "made itself." He found only little encouragement from his environment and only a bit of mathematical guidance (famously, from Carr's *Synopsis*). Genius is as fragile as it is powerful. Ramanujan persisted, had faith in himself, knew that his results were valuable, and eventually found the right support in his own strength of character.

So is character an essential element of genius? Certainly. And this observation leads us to deeper questions. The notion that character is fate, found as early as the ancient Greek tragedies, begs an important question: What are the roots of character? How, by what forces, was Ramanujan's indomitable character formed? Family? Culture? Religion? The film does not take a position on this question except to tell us about the goddess of Namakkal, whom Ramanujan thought of as his inspiration. (This is an important element of the film, as a Western audience would probably not otherwise appreciate the religious traditions that were so vivid for Ramanujan.[2]) The film gives no answers, but does bring us to ask the questions—enough of a contribution for a 60-minute work of art.

What else contributes to the development of character, including the character of a genius? Happenstance? Well, is it happenstance that but-

[1] See src.sastra.edu/index.php?option=com_content&view=article&id=234&Itemid=345 (accessed September 2014).

[2] *Krishnaswami Alladi (University of Florida) points out a scene in the film where Ramanujan laughs, saying that he mentions the Goddess of Namakkal as an inspiration only to those who are incapable of understanding his mathematics. (The scene is in the Tamil language.) Alladi notes that this sentiment was not at all typical of Ramanujan, and contradicts other scenes in the film, where Ramanujan's veneration of the Goddess of Namakkal, and that of his family, is emphasized.*

terflies evolved to be so fragile and beautiful? That Shanghai is a great city and not a fishing village? That the dinosaurs died out? Genius, like all these phenomena, requires the right environment, the right nourishment, to flower. Were any one circumstance lacking, we might have had no Ramanujan. Indeed, a potential Ramanujan could now be working as a Nigerian cab driver or an Indonesian bank teller. All we can do is maximize the chances that he or she be found.

As educators, we can begin to think about the elements of the "right" environment for genius. Can we build institutions and structures that encourage its growth? Mathematicians and historians have long remarked on the unreasonably large number of Hungarian mathematicians. Perhaps an examination of that country's history might give us clues.[3] But probably not a template. No country can arrange to experience another country's historical development. Cultural anthropologists tell us that the phenomenon of diffusion, of one culture borrowing from another, is significantly more complicated.

These are messages for society. But viewing the film is a personal experience. What personal message does this film carry? Will the viewer get the message that he or she will be inspired by Ramanujan? Probably not. And for most of us, such a message would be fatuous. Not many can follow his example with the same results.

So what messages does the film have and for whom? Here are some suggestions. For the student (on almost any level) the film speaks to the joy of discovery, the rewards of hard work, and the experience of mathematical beauty. For the teacher (again, on almost any level) the film brings the message that students have their own thoughts and their own inspirations. There is some merit in the suggestion that a teacher would do well to assume every new student is a Ramanujan—and to be corrected almost every time. The one time in several billion that such an assumption proves correct easily makes up for the myriad times it is wrong. For the parent: A child must follow his or her own path. Ramanujan left school twice because he was so focused on mathematics. His family seems to have swallowed the disappointment. For the mathematician: Your personality and your circumstances are the genesis of your abilities, including the ability to work hard on mathematics, and therefore of your accomplishments.

For everyone: Ramanujan's goddess may not bestow her gifts on all of us. But it behooves us to listen when she speaks. We all have some gifts, in some measure, and we can learn from Ramanujan's story how passing on these gifts can be important to others and satisfying to oneself.

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[3]*See, for example,* www.franktibor.hu/img/kozl/FRANK.Social%20Construction3.doc, *accessed August 2014.*

The Improbability Principle: Why Coincidences, Miracles, and Rare Events Happen Every Day

Reviewed by Andrew I. Dale

The only law of chance is this:
extremely unlikely phenomena do not occur.

Thus writes Émile Borel in his *Les Probabilités et la Vie* [3, p. 5]. But, as we all know, such events *do* occur; we have all had the experience of bumping into an old friend, long unseen, soon after we had thought of him or of reading that the whereabouts of the body of a missing person had been correctly located by a "psychic." And even a politician can be trusted at times—though Sir Thomas Browne, writing in 1646, spoke for many when he said that statists (i.e. those skilled and expert in state affairs) and politicians "do hold, that truth is to be concealed from them; unto whom although they reveal the visible design, yet do they commonly conceal the capital intention" [5, p. 139].

In his book *Éléments de la théorie des probabilités* of 1950, translated by Freund in 1965, Borel went even further, examining those cases in which "the probability is so small that it is practically negligible"

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[p. 57], with a further subdivision into probabilities negligible from the human perspective (a value of 10^{-6}), the terrestrial perspective (10^{-15}), and the cosmic perspective (10^{-45}).

The drawing of attention to events of small probability was by no means original to Borel: Jacob Bernoulli [2], Richard Price (in his appendix to [1]), and Georges-Louis Leclerc, Comte de Buffon [6] all had something to say on the matter, and the idea of events being "morally certain," "morally impossible," or "physically certain" had been introduced.
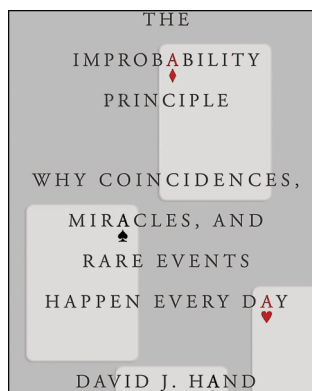
Antoine Augustin Cournot wrote, "*The physically impossible event is thus one whose mathematical probability is infinitely small*" (italics in the original) [7, p. 78]. Shafer and Vovk [11], in fact, distinguish between two forms of Cournot's Principle: the *strong*, according to which an event distinguished in advance of a single trial and of very small or zero probability will not occur on that specific trial, and the *weak*, according to which an event of very small probability will happen very rarely in repeated trials.

"Science," wrote Robert Louis Stevenson in his *Pulvis et Umbra* of 1888, "carries us into zones of speculation, where there is no habitable city for the

mind of man." It seems particularly fitting then that I. J. Good should have chosen the title *The Scientist Speculates* for an edited book. All the more fitting to our present review is the fact that Christopher Scott, in questioning the normality of anomalies in his contribution to Good's anthology, should have remarked that "if the laws of nature are constantly being broken, we should *expect* each person to find the particular anomaly he is looking for. I suggest a new law of nature: natural anomalies of all kinds occur with perceptible frequency" [9, p. 149]. In *The Improbability Principle*, and *pace* Stevenson, Hand has found a habitable city for speculation to dwell.

Hand's thesis is in a sense contrary to Borel's and even to the weak form of Cournot's: it is that not only do extremely unlikely events occur but that they keep on occurring, and are, in fact, commonplace. Much of his book is taken up with the advancement of cogent reasons for the occurrence of such rarities, and once such reasons have been advanced and accepted, the next question is how to take advantage of such occurrences.

The Improbability Principle is a thread woven of a number of strands, the main ones being the Laws of Inevitability, of Truly Large Numbers, of Selection, of the Probability Lever, and of Near Enough. But there is also discussion of lesser matters; for instance, in his second chapter, "A Capricious Universe," Hand discusses such things as superstitions, prophecies, gods and miracles, parapsychology, and Jung's synchronicity.

The reasons for superstitions are at times difficult to fathom. If we look at Sir Thomas Browne's *Pseudodoxia Epidemica* we may find his mention of the reliance of thieves on the right eye of a hedgehog, boiled in oil and preserved in a brazen vessel, to allow them to see in the dark or that the left testicle of a weasel "wrapt in the skin of a she Mule, is able to secure incontinency from conception" [1904, p. 167] to be written off as expressions of ignorance. But are such views any more ridiculous than the firm belief of some even in the twenty-first century that powdered rhinoceros horn excites a man's "amorous propensities" (to borrow a delicate phrase from Dr. Samuel Johnson)—a belief that has had dire and perhaps irreversible consequences for the rhinoceros population in Africa—or the belief that an infusion or ointment made of certain herbs or animal parts has the ability to render one impervious to bullets?

Hand mentions the predictions of Nostradamus as an example "of the ambiguity in prophecies" [p. 22]. I would suggest that one might also see therein a touch of hindsight, as followers of the apothecary/occultist might well exclaim after a certain important event has occurred, "Ah, but this was certainly foretold in Quatrain N in the Master's writings." "Coming events cast their shadows before," wrote Thomas Campbell in his poem *Lochiel's Warning*, though it is perhaps the opacity of the shadow that makes correct and precise prophecy so difficult.

Defined by Hand as "an inexplicable event (normally a welcome one) attributed to a god: a supernatural event" [p. 27], a miracle turns out to be perhaps less of a surprise than something almost to be expected. Events that seem rare, or at any rate extraordinary, are, Hand convincingly argues, seen on careful thought to be expected. (Perhaps what makes it a miracle, or at any rate worthy of my particular attention, is that it occurs to *me*. A similar view was expressed by Fisher [8, §7] on the "one chance in a million" of an occurrence.) The reader wanting to learn more about the relationship between miracles and statistics can consult Kruskal [10].

Almost everyone will be aware of experiments to investigate things like telepathy, clairvoyance, and ESP (of which J. B. S. Haldane once said, "I daresay it does happen, but it's still a damned intrusion on one's privacy" [9, p. 164]). Hand reports the result of a metastudy of 380 studies designed to see whether subjects could psychically influence the results of coin tossing. Although the result was not altogether negative, one interesting explanation proposed for this fact is that of publication bias, that is, that it is much easier to get positive results published than negative ones.

When it comes to psychic phenomena, the investigator may well approach the matter in a spirit of criticism (i.e. with a measure of initial unbelief) or with a firm belief in the existence of such things. Hand, for instance, notes that some investigators have suggested "that psychic powers are influenced by the attitudes of those carrying out the experiments, and are thus less likely to manifest themselves if observed with a critical eye" [p. 35]. However, in *New Horizons*, Vol. 1, No. 3 (January 1974) a group of psychic investigators came down strongly in favor of the importance of initial belief, concluding that "one does have to believe implicitly that the phenomena can happen, and will happen, and not be surprised when something unusual does happen" [p. 12]. Can one investigate such phenomena without initial beliefs either strongly "for" or "against"? A. K. Talbot, in his "Partly-baked Idea" in Good [9], concluded that one cannot, writing: "After many years during which I have studied and observed many strange, apparently parascientific, phenomena, I have come to the shocking conclusion that the psychical researcher, *while carrying out his investigation, cannot afford the luxury of a neutral and unbiased attitude* if he

wishes to advance beyond the vicious circle of endless repetition of half-satisfactory experiments which are the usual reward of the half-convinced experimenter" (italics in the original) [pp. 175–176].

Chapter 3 is concerned with a general discussion of chance. Here, among other things, we find a discussion of the butterfly effect: the idea here is that a (very) slight change in the initial conditions of a physical system (say) may lead to our being completely unable to say in what state the system will be after some time. For example, this year sees the centenary of the start of World War I, an explosion often seen as being set off by the assassination of Archduke Franz-Ferdinand of Austria. But what would have happened if the driver of the car in which the archduke was travelling had not taken a wrong turn after lunch on that fateful day?

The first main strand in the Improbability Principle, the Law of Inevitability, is discussed in Chapter 4. This is succinctly given by Hand as follows: "It's the simple fact that something must happen" [p. 75]. That is, if one has correctly taken account of all possible outcomes, some one of these, no matter how unlikely, must occur, a statement well illustrated with a discussion of "amazing" (repeated) wins by buyers of lottery tickets.

Another feature of lotteries is the quantity of tickets sold, and this brings Hand to a chapter on the Law of Truly Large Numbers (LTLN). Here is an example from my own experience (Hand has a similar one): I read in the paper recently of a woman (call her X) whose daughter (Y) managed to find her a secondhand copy of a book about Australia that X had been given in 1944 by her father (Z) on his return from the Second World War. Nothing surprising about that, but X lived in Australia, and the book (with Z's inscription) had been bought by Y from a bookshop, picked almost at random, in New York. The LTLN states that "with a large enough number of opportunities, any outrageous thing is likely to happen" [p. 84]. As one of his examples here, Hand considers the case of a large number of people (say 100,000) each throwing a die and supposes that one person throws a string of six 1's. This being obtained simply by chance, one should not be surprised if in a further six throws Fortunatus does *not* produce a sequence of identical numbers—an example of regression to the mean.

As another interesting example Hand discusses crashes of F-14 fighter airplanes in the mid-1990s. Using scan statistics (with a month-long window over the period from 1970 to 2006 and an appropriate Poisson distribution) he shows that "the chance of having three crashes within some month over a five-year period is well over one-half" [p. 99].

The selection of data after the event of interest has occurred (e.g. the attention that is given to a psychic, one of whose predictions has materialized, while no attention is given to the many predictions she has made which were not fulfilled) comprises the Law of Selection. The importance of taking account not only of things that occur but also of things that have not occurred has long been realized. Pierre-Simon Laplace, in writing of astrologers, diviners, and augurs in the first edition of his *Essai philosophique sur les probabilités*, drew the attention of mathematicians to this when he wrote, "Nobody reflects on the large number of non-coincidences that have made no impression, or that are unknown. However, it is only the ratio of one to the other that can give the probability of the causes that one attributes to the coincidences" [1814, p. 77] (the wording changed slightly in subsequent editions).

Another important example concerns the role of apparent selection bias in science. Hand instances research of scientists from William Withering (who examined the use of foxgloves in the treatment of dropsy and who was careful to state that he "mentioned every case in which I have prescribed the Foxglove, proper or improper, successful or otherwise") to Louis Pasteur (infectious diseases and microorganisms) and Robert Millikan (examination of the charge on the electron). (Withering had learned of the use of foxgloves in the treatment of dropsy from an old woman in Shropshire, and he identified the active ingredient as digitalis. He later felt he had been short-changed by Erasmus Darwin [Charles Darwin's grandfather], whose tract on the subject was published in the same year [1785] as Withering's.) There is also a connection here with the publication bias mentioned before.

The Law of the Probability Lever essentially says "that a slight change in circumstances can have a huge impact on probabilities" [p. 142]. This has connections with chaos theory and the butterfly effect (again). Hand finds a further manifestation in the application of the probability associated with an average person to a specific one (e.g. the chance of the average man's being struck by lightning is very much smaller than that of a lumberjack's).

The final main strand in the Improbability Principle is the Law of Near Enough, which is concerned with regarding things that are sufficiently similar as identical. Here Hand considers S. G. Soal's attempted repetition of J. B. Rhine's telepathic experiments. Soal in fact found that one of his 160 subjects (with 128,350 observations in all) gave evidence of precognition, correctly predicting cards one ahead of that currently being shown. Soal's

experiments, however, seemed to be incapable of repetition.

In Chapter 9 Hand discusses some human aspects of the Improbability Principle, including the difficulty our intuition has in assessing probabilities, the prosecutor's fallacy (difficulties with conditional probabilities and Bayes's Theorem), the base rate fallacy (a failure to take account of background probabilities), an inclination to take account of evidence that supports one's beliefs (or pet hypotheses) and forget about contrary evidence, and hindsight bias.

Chapter 10 is entitled "Life, the Universe, and Everything." Here, among other things, Hand mentions the Copernican Principle and its extension to the principle of mediocrity, which says that "earth, and by implication humanity, is not located at a special position in the universe, *and moreover that there's nothing special about the condition of humanity in other ways*" (italics in the original) [p. 210]. There is also a discussion of fundamental constants in physics (these constants, it appears, have to be either exactly what they are or very similar for the existence of stars, planets, and humanity). And, finally, there's some discussion of the anthropic principle, which, in one sense, says that "the universe in which we live is one in which we *can* live" [p. 218].

The final chapter is devoted to ways in which we can, and should, use the Improbability Principle, illustrating these ways with examples from science, medicine, business, etc. Here we also find discussions of Bayesianism and statistical vs. practical significance.

Hand reveals several flashes of wit in *The Improbability Principle*. For example, in discussing the possibility of Shakespeare's deliberate use of alliteration in his plays, Hand writes, "Could the set of similar sounds in Shakespeare's sonnets simply surface serendipitously?" [p. 226]. The reader will find many other passages displaying a quick mind.

There is, I'm afraid, a difficulty about *The Improbability Principle*, and that is that almost every section prompts one to further and wider reading. Hand's excellent discussion of the various laws (in a style that makes them readily accessible to the general reader), his wealth of illustrative examples (from coins to fighter airplanes), the occurrence of situations ranging from physics to parasensory phenomena in which seemingly inexplicable results are accounted for make this a book that should be required reading for every serious student of probability and also for everyone who from time to time entertains "a suspicion that the universe is making fun of you" [p. 92]. I recommend it wholeheartedly.

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Mathematical Reviews Celebrates 75 Years

At the January 2015 Joint Mathematics Meetings in San Antonio, Mathematical Reviews will celebrate its 75th birthday. There will be a number of celebratory activities, including cake served in the AMS booth at the Exhibits on Sunday, January 11 at 2:30. A number of past executive editors of Mathematical Reviews are expected to attend. Be sure to mark your calendar, if you plan to be in San Antonio.

Volume 1, Number 1 of the paper publication *Mathematical Reviews* was published in January of 1940. While the monthly paper publication ended its run with the December 2012 issue, Mathematical Reviews is going strong, delivering its content on a daily basis in the electronic service MathSciNet.

The mission of Mathematical Reviews (MR in the following) has remained essentially unchanged over the years: To provide a comprehensive view of the published mathematical research literature under the guidance and supervision of professional mathematicians, both internally as editors, and externally as reviewers. The dedicated reviewers remain a key component of the work of MR.

MR began its work in Providence, Rhode Island in late 1939, and the first issue of Mathematical Reviews appeared surprisingly quickly thereafter, in January of 1940. The founding editor was Otto Neugebauer, well known as an historian of mathematics, and at that time a professor at Brown University in Providence. The founding of Mathematical Reviews was a direct result of the social unrest in Germany in the 1930s associated with Nazism. Neugebauer had also founded the review journal on which Mathematical Reviews was modeled: *Zentralblatt für Mathematik*. MR has been located

in Ann Arbor, Michigan, since 1965, i.e., for fifty of its seventy-five years. The physical home for MR since 1984, the historic brick building built in 1902 had been a former brewery, back in the days when every US city had multiple breweries. Some interesting reading about the early days of Mathematical Reviews can be found at `www.ams.org/publications/mrhistoryarticles`.

At the start, MR produced a monthly publication in paper. Mathematicians of a certain age associate the orange cover ("Princeton orange") of that publication with MR. As graduate students they were likely taught early on that mathematical investigations should begin with those orange volumes. Lore has it that airport pickups of visiting mathematicians sometimes involved the local host holding an issue of *Mathematical Reviews* for identification purposes.

The key to the success of MR over the years has been the people involved in producing it, beginning with the reviewers. The reviewers for Volume 1, Number 1 of *Mathematical Reviews* are a who's who of prominent mathematicians at the time, including Lars Ahlfors, Richard Courant, Paul Erdős, Einar Hille, Alston S. Householder, D. H. Lehmer, Saunders Mac Lane, and John von Neumann, to name just a few. A complete list of the reviewers in that first issue can be found at `www.ams.org/publications/math-reviews/ReviewersVolume1.html`. From a fairly small staff and about 300 reviewers in 1940, MR has grown to a staff of over seventy-five in Ann Arbor and over 17,500 reviewers worldwide. In 2013 reviews were received from 125 countries and at the time of this writing in 2014, reviews have been received from 127 countries. Virtually all of the data and review information found in MathSciNet has been looked at by at least two sets of human eyes, and

more often by four or more. The consistency and accuracy of the data are guaranteed by the diligence of hardworking people. Although computer software helps those people perform efficiently, literally thousands of human judgments are made every day: judgments ranging from decisions about the inclusion and classification of material in the database, to the unique identification of authors in the MR Author Database, to the nuances of wording in reviews.

The year 1996 marked the launch of MathSciNet, the first web-based electronic presentation of information in the MR Database, although a number of smaller-scale electronic formats had existed before that. In a major digitization effort, the material produced prior to the mid 1980s was incorporated into MathSciNet, so that by 2000 virtually all of the content of paper *Mathematical Reviews* was available in MathSciNet. The electronic format made new content feasible: linked reference lists from original journal papers beginning in 2000; expanded coverage of applied statistics and applied computer science (Database Expansion items, as they are called) beginning in 2000; entries from pre-1940 digitization projects (DML items) beginning in 2003; citation counts beginning in 2005; and thesis data (ProQuest items) beginning in 2010.

Among scientists, mathematicians have probably been the most interested, historically, in personal connections—witness the Erdős Number and fascination with mathematical ancestry through the Mathematics Genealogy Project (MGP). These personal connections were important from the start of MR, and the work that went into the production of early author indexes made possible the creation of the MR Author Database, with unique identification of authors of mathematical works. In a real sense, the disambiguation of authors that is now a hot topic in academic publication circles has been integral to MR since 1940. This disambiguation work can be seen in the accuracy of author profiles in MathSciNet. These reliable author identifications allow not only the calculation of Erdős Numbers, but the determination of the co-author distance between any two authors in the database. They make possible the pairing of MR and MGP data, which has been an important addition to MathSciNet.

At the Joint Mathematics Meetings in Baltimore in January, 2014, the personalization of MathSciNet author profile pages was released. Authors can now log into their MathSciNet profile pages and add one or more of the following: a photo, an email address, a personal URL. A little reward (a bit of meeting "swag") awaits anyone who stops by the MR Booth in San Antonio to show off their author profile personalization.

All friends of MR are cordially invited to the annual Mathematical Reviews Reception, Monday,

January 12, 2015, from 6:00 to 7:00 pm, in Bowie B, 2nd Level, Grand Hyatt, San Antonio. There will be a number of MR staff members present, including the recently appointed Executive Editor, Edward Dunne, who is the twenty-first Executive Editor. As was already mentioned, a number of past Executive Editors are expected to attend the JMM and will be at the reception. The complete list of Executive Editors can be found at `www.ams.org/publications/math-reviews/executiveeditors`.

Anyone who visits Ann Arbor is encouraged to stop in for a visit. The MR offices are located in an historic neighborhood called the Old West Side, with many beautifully restored houses and buildings. With a day or two of advance notice, a tour can be arranged. Just send a message to `mathrev@ams.org`. Some photos and some building history can be found at `www.ams.org/publications/mrbuildingphotos`, more on the history of MR at `www.ams.org/publications/math-reviews/mrpastandpresent`, and a video about MR and its history at `www.youtube.com/watch?v=cUEOghB3MvM`.

—Norman Richert, Managing Editor
Mathematical Reviews/MathSciNet

The Kan Extension Seminar: An Experimental Online Graduate Reading Course

Emily Riehl

Daniel Kan (1927–2013) has left an indelible mark on algebraic topology and category theory, with highlights including his discovery of adjoint functors and his work developing simplicial homotopy theory. A lesser-known aspect of his lasting influence, however, is pedagogical: in the 1960s he inaugurated what is now known as the Kan seminar, which continues at MIT and has expanded elsewhere. Kan's seminar is a graduate reading course in algebraic topology designed to acquaint students rapidly with the literature. The format is as follows: over the course of a semester, each student is asked to give a few one-hour lectures summarizing classic papers in the field and to engage with the other assigned papers by writing reading responses. Each lecture is preceded by a practice talk of unbounded length conducted in private (i.e., in the absence of the lead instructor) and—importantly—before the reading responses are due. This format aims to teach students how to read papers quickly and at various levels of depth while giving them a chance to refine presentation skills. The seminar has an additional social element: Kan traditionally hosted a Halloween party where his students could mingle with members of the Boston algebraic topology community.

Regretting having never had the opportunity to participate myself, I decided to adapt Kan's model for graduate students in category theory. As is the case for many specialized subdisciplines, students interested in category theory are geographically dispersed without critical mass in any one research center. I therefore decided to move the seminar online, and the "Kan Extension Seminar" was born.[1]

In October 2013 I announced the seminar on *The n-Category Café*, a blog devoted to higher category theory and related topics of which I am a cohost. From a surplus of applications, I selected twelve students (three based in the US, eight from Western Europe, and one from Australia).[2] Together we read one paper every two weeks from January to June 2014. The papers I selected range over fifty years: I aimed to balance commonly acknowledged classics in the field with more recent papers that exposed students to a broad range of active research areas.

Each student presented one paper via a private class video chat. Over the course of the following week, that student drafted a blog post for *The n-Category Café*. The other students wrote reading responses in a shared LaTeX file and were expected to comment on the blog. At the seminar's conclusion, eight of the students convened in person to give a series of expository talks as a satellite to the 2014 International Conference in Category Theory in Cambridge, England.

A video chat is not the most obvious way to discuss mathematical ideas. Our software was simple—each participant appeared in a little box on the computer screen. More elaborate video-conference technology exists, but I did not want to assume all of my students had access to the necessary equipment. A few students prepared

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[1] *The title of one section in Saunders Mac Lane's* Categories for the Working Mathematician *asserts that "All Concepts Are Kan Extensions."*

[2] *The daylight savings time change in April significantly complicated the scheduling of class meetings.*

LATEX files that were distributed before their presentations, but most often we simply talked to one another. A side benefit of this format is that students can practice mathematical conversation without the aid of a chalkboard. Think of this as a technologically enabled complement to a skill I've romanticized after reading accounts of mathematical collaborators thinking together while taking long walks outdoors.

The Kan extension seminar functioned almost entirely online, yet despite any superficial similarities, it decidedly was not akin to a MOOC (Massive Open Online Course). Namely, part of the value of the experience was its intimacy, with each student taking a turn to present a paper and the entire class working in close collaboration. I see my students as colleagues with whom I look forward to interacting in the future.

As teaching tends to be, the experience was both more rewarding and more consuming than I had predicted. The rewards came from getting to know the students, watching them excel in their presentations, and seeing them improve in their exposition over the course of the editing process. There was also an unexpected social pleasure: I was able to meet all twelve in person over the six-month period. Our class discussions were lively and provocative. I had chosen papers that personally interested me, several of which I had never read carefully. (I had been advised that the Kan seminar was traditionally hands-off, more peer teaching than instructor driven.) Yet as students enthusiastically wrote lengthy, thoughtful reading responses, I felt impelled to give each response the consideration it deserved.

Based on an exit survey and informal conversations with class participants, the seminar was wildly successful. The reading responses spontaneously transformed into an active dialogue as students responded to one another's work. Two participants even commuted regularly to meet in person to discuss the papers.

The greater category theory community also responded positively. One colleague reported that the seminar "brought new life" to *The n-Category Café* that hosted us. A large audience, including senior colleagues, attended the satellite talks in June. Students and faculty have expressed enthusiasm for future iterations of the seminar; indeed, I've already been contacted by several prospective students.

An online seminar introduces certain issues beyond those of a typical graduate seminar. For example, I had to negotiate which aspects of the course to make public or keep private. The students' expository blog entries constitute a new resource that will benefit anyone who searches online for one of the published papers.

Nonetheless, the most problematic aspects of the course were the discussions on *The n-Category Café* (I say this not to detract at all from the content of those conversations). Most of the students were legitimately hesitant about posting comments early in their careers that will remain publicly viewable in perpetuity and leave a digital trail. Yet the larger categorical community clamored for greater access to course content: over the semester, multiple colleagues asked to observe our private discussions, as well as have video chats and the satellite conference uploaded to the Internet. I resisted these overtures in order to shelter the class from a surfeit of observers. Still, one could imagine adopting a different strategy that would benefit the wider mathematical community.

For the pilot version of the Kan Extension Seminar, I selected the best-prepared students from the applicant pool, most of whom were attached to a department active in category theory. The students' advanced backgrounds prepared them for the challenging reading assignments, and when confusion struck, many also had local experts to consult. This choice did, however, privilege those at established centers of category theory (principally abroad), leading to an unfortunate paradox: an online seminar which could reach students anywhere limited itself to participants from specific locales.

An online seminar has the potential to catalyze specialized conversations and collaboration among geographically dispersed mathematicians. A more inclusive approach than the one I took might encourage participants whose research interests diverge from the areas of expertise of their graduate departments. This would provide a welcome antidote to the social forces that accrue benefits to those on the "inside track."

A few other axes for variation: a future seminar could focus on a wider or narrower range of papers, read fewer papers (or include fewer students), or could be targeted differently to a more or less advanced level. Some students were critical of the low-tech software (dreams of peripatetic mathematical conversations aside). As tablets and digital meeting tools become more ubiquitous, it may be easier to host online "chalkboard" lectures.

Dan Kan once told me that if you shake something and it rattles, then there is something inside worthy of further contemplation—a particularly categorical viewpoint. I don't submit that the first iteration of the Kan Extension Seminar proceeded in frictionless silence. Indeed, I do think, following Kan, that that fact suggests it is worthy of further experimentation.

Mathematics People

Virag Receives Synge Award

BALINT VIRAG of the University of Toronto has been chosen the recipient of the John L. Synge Award of the Royal Society of Canada. According to the prize citation, he "is world renowned as a leader in research into probability theory. His many contributions to the subject include groundbreaking results on the subject of random walks. His remarkable concept of the 'Brownian Carousel' has solved fundamental problems in the theory of random matrices and will undoubtedly find many further applications in the years ahead. His work has been recognized internationally, including by an invitation to International Congress of Mathematicians." The Synge Award is given for outstanding research in any branch of the mathematical sciences.

—From a Royal Society announcement

Martínez Awarded Rubio de Francia Prize

ANGEL CASTRO MARTÍNEZ has been awarded the Rubio de Francia Prize of the Royal Spanish Mathematical Society (RSME) for his contributions to partial differential equations and fluid mechanics, in particular for his results in the problem of the occurrence of singularities, which in turn contribute to the understanding of the formation of turbulence in incompressible fluids.

The prize honors the memory of J. L. Rubio de Francia (1949–1988), an internationally renowned Spanish analyst. It is awarded annually to a young mathematician from Spain, or residing in Spain, and it is the highest distinction given by the RSME. The prize carries a monetary award of 3,000 euros (approximately US$3,800). The prize jury consisted of Noga Alon, Jesús Bastero Eleizalde (chair), Alvaro Pelayo, Gilles Pisier, Marta Sanz-Solé, Cédric Villani, and Claire Voisin.

Recent prize recipients, in chronological order, include A. Enciso, C. Beltran, A. Pelayo, F. Gancedo, and M. Pe Pereira.

—From a Royal Spanish Mathematical Society announcement

Prizes of the Canadian Mathematical Society

FRÉDÉRIC GOURDEAU of Université Laval has been named the recipient of the 2014 Adrien Pouliot Award in recognition of his "outstanding contributions to mathematics education in Canada." His accomplishments include launching the magazine *Accromath* in 2006 and founding and serving as president of the Association Québécoise des Jeux Mathématiques (AQJM). He gave a lecture at the 2012 International Congress in Seoul, Korea. He has served as president of the Canadian Mathematics Education Study Group and has been Canada's representative at the International Commission on Mathematical Instruction since 2011.

The Adrien Pouliot Award was inaugurated in 1995 to recognize individuals who have made significant and sustained contributions to mathematics education in Canada. The award is named for Adrien Pouliot, the second CMS president, who taught mathematics at Université Laval for fifty years and was instrumental in developing Laval's engineering and science faculty.

XIANGWEN ZHANG has been named the recipient of the 2014 Doctoral Prize for his thesis "Complex Monge-Ampére Equation and Its Applications in Complex Geometry," in which he "solves many problems related to the Monge-Ampére equations on manifolds—which have been a subject of extensive study since 1978." He was the recipient of the Alexis D. and W. Charles Pelletier Fellowship in 2012 and of the Carl Herz Prize in 2011. His work has been published in several mathematics journals.

The CMS Doctoral Prize is awarded annually to recognize a Canadian doctoral student who has demonstrated exceptional performance in the area of mathematical research.

—From CMS announcements

2014 Davidson Fellows Selected

Four high school students whose projects involved the mathematical sciences are among the twenty students

named 2014 Davidson Fellows. Ravi Jagadeesan, eighteen, of Naperville, Illinois, was awarded a top prize of a scholarship worth US$50,000 for his mathematics project "A New Galois Invariant of Dessins d'Enfants." Ritesh Ragavender, seventeen, of Kendall Park, New Jersey, was awarded a US$25,000 scholarship for his mathematics project "Odd Dunkl Operators and nilHecke Algebras." Kevin Lee, seventeen, of Irvine, California, was awarded a US$10,000 scholarship for his mathematics project "Strongly Coupled Electromechanical Modeling of the Heart in Moving Domains Using the Phase-Field Method." Sara K. Simpson, seventeen, of San Diego, California, received a top award of US$50,000 for her science project "Neuronal Nonlinear Dynamics: From an Optical Illusion to Parkinson's Disease," which involves mathematical modeling of neuron responses.

The Davidson Fellows program, a project of the Davidson Institute for Talent Development, awards scholarships to students eighteen years of age or younger who have created significant projects that have the potential to benefit society in the fields of science, technology, mathematics, literature, music, and philosophy.

—From a Davidson Fellows announcement

NDSEG Fellowships Awarded

Eleven young mathematicians have been awarded National Defense Science and Engineering Graduate (NDSEG) Fellowships by the Department of Defense (DoD) for 2014. The fellowships are sponsored by the United States Army, Navy, and Air Force. As a means of increasing the number of US citizens trained in disciplines of military importance in science and engineering, DoD awards fellowships to individuals who have demonstrated ability and special aptitude for advanced training in science and engineering.

The following are the names of the fellows in mathematics, their institutions, and the offices that awarded the fellowships: Albert Ai, University of California Berkeley, Air Force Office of Scientific Research (AFOSR); Thomas Chartrand, University of California Davis, AFOSR; Gurbir Dhillon, Stanford University, Army Research Office (ARO); Jessica Hwang, Stanford University, ARO; Eugene Kastevich, Stanford University, Office of Naval Research (ONR); Kara Karpman, Cornell University, AFOSR; Jason Kaye, New York University, AFOSR; Joseph Lee, Harvard University, AFOSR; Matthew Mizuhara, Pennsylvania State University, ARO; Kirill Serkh, Yale University, AFOSR; Lynnelle Ye, Harvard University, AFOSR.

—From an NDSEG announcement

B. H. Neumann Awards Given

The Australian Mathematics Trust has awarded two B. H. Neumann Awards for service to the mathematics profession. The honorees are Holly Gyton and Alan Parris. The awards honor Bernhard H. Neumann, who supported mathematics and mathematics teaching at all levels in Australia.

—From an Australian Mathematics Trust announcement

Klaus Peters

On July 7, 2014, mathematics lost one of its most widely known and highly respected publishers. Klaus Peters died unexpectedly at home in Sherborn, Massachusetts.

He will be long remembered for his wide influence on mathematical publishing, first with Springer and subsequently with Birkhäuser Boston, Academic Press, and

Photo by Gert-Martin Greuel, ©2007 MFO.

Klaus Peters

finally the firm A K Peters. Before he went into publishing, he earned a doctorate in complex analysis from the University of Erlangen (1962) under the supervision of Reinhold Remmert and Georg Nöbeling. After teaching at Erlangen for two years, in 1964 he was invited by Springer-Verlag to become their first in-house mathematics editor. Walter Kaufmann-Bühler was named as the second mathematics editor for Springer in Heidelberg, and together they formed a powerful editorial team. That also marked the year that Springer opened its first American office, and Klaus soon found himself dividing his time between Heidelberg and New York.

In 1972 he was named one of Springer's directors. He hired Alice Merker, who had earned degrees from Rochester and Chicago, to become a mathematics editor at Springer New York in 1972. Later that year she moved to the Heidelberg office. Kaufmann-Bühler moved to the New York office. In September 1972 Klaus and Alice were married. Seven years later they left Springer to establish the American branch of Birkhäuser, later moving to Academic Press. In 1992 Klaus and Alice formed A K Peters, Ltd., which was acquired by CRC Press/Taylor and Francis in 2010. Recently Klaus had been consulting with the American Mathematical Society on a number of different projects.

Klaus's passion for mathematics and good exposition ran deep, and in 1972 he, together with Kaufmann-Bühler and Alice Peters, introduced *The Mathematical Intelligencer* to the mathematical world. The publisher was identified as The Yellow Press. In this first issue he wrote, "I have thought for some time that we need an informal forum for debating questions of mutual interest to the mathematical community and Springer Verlag. This forum should be frank, amusing, informative, and, of course, relevant. It is not without hesitation that I offer this no. 0—the product of our spare time—for public criticism." Sections included the unusual: "Affairs and Forthcoming Weddings," "Fiction," "Exercise," "Walks in Mathematics,"

and "News from Hades." In 1976 the *Intelligencer* became a Springer publication in magazine format.

Klaus possessed a wonderful imagination that resulted in several new publishing ventures, including *The Mathematical Intelligencer*, the *Journal of Experimental Mathematics*, and some notable books, among them: *Hilbert* and *Courant*, both by Constance Reid; *The Honors Class*, by Benjamin Yandell; *The Mathematical Experience,* by Philip Davis and Reuben Hersh; *You Can Count on Monsters,* by Richard Evan Schwartz, and *A Cultural History of Physics,* by Károly Simonyi.

Klaus's love of mathematics publishing was exceeded only by his love of family. He treasured being a husband, father, and grandfather. I (D.J.A.) cannot recall a single meeting or telephone conversation in which he did not bring up the accomplishments of his three children and, as time went on, his grandchildren.

—Donald J. Albers and Gerald L. Alexanderson

Maynard Awarded 2014 SASTRA Ramanujan Prize

JAMES MAYNARD of Oxford University and the University of Montreal has been awarded the 2014 SASTRA Ramanujan Prize, awarded annually for outstanding contributions by young mathematicians to areas influenced by the work of Srinivasa Ramanujan. The age limit for the prize has been set at thirty-two because Ramanujan achieved so much in his brief life of thirty-two years. The prize will be awarded in December 2014 at the International Conference on Number Theory at SASTRA University in Kumbakonam (Ramanujan's hometown), where the prize has been given annually.

The prize citation reads as follows: "James Maynard is awarded the 2014 SASTRA Ramanujan Prize for his revolutionary contributions to prime number theory, for making the strongest advances thus far on various long-standing problems on primes, and for the ingenious techniques he has introduced, which will influence future research in the field. The prize recognizes his fundamental doctoral thesis at Oxford University and his sensational postdoctoral work at the University of Montreal. In particular, the prize is for his 2013 paper in *Acta Arithmetica*, in which he establishes the strongest known form of the Brun-Titchmarsh inequality; his 2103 paper in the *Proceedings of the Cambridge Philosophical Society*; and his 2014 paper in *Mathematika*, in which he improves all previously known results on almost prime *k*-tuples. The prize also recognizes his recent paper on small gaps between primes, to appear in the *Annals of Mathematics*, in which he establishes the sensational result that the gap between consecutive primes is no more than 600 infinitely often. The prize also makes note of his recent announcements on the solution of the large gaps problem on primes due to Erdős and his joint work with Banks and Freiberg on the limit points of the sequence of normalized prime gaps."

James Maynard was born in Chelmsford, England, in 1987 and received his PhD from Oxford University in 2013.

He was a postdoctoral fellow at the University of Montreal from 2013 to 2014.

The members of the 2014 SASTRA Ramanujan Prize Committee were: Krishnaswami Alladi (Chair; University of Florida), Roger Heath-Brown (Oxford University), Winnie Li (Pennsylvania State University), David Masser (University of Basel), Barry Mazur (Harvard University), Peter Paule (Johannes Kepler University of Linz), and Michael Rapoport (University of Bonn). Previous winners of the SASTRA Ramanujan Prize are: Manjul Bhargava and Kannan Soundararajan (2005; two full prizes), Terence Tao (2006), Ben Green (2007), Akshay Venkatesh (2008), Kathrin Bringmann (2009), Wei Zhang (2010), Roman Holowinsky (2011), Zhiwei Yun (2012), and Peter Scholze (2013).

—Krishnaswami Alladi,
University of Florida

Gurevich Receives von Kaven Award

PAVEL GUREVICH of the Freie Universität Berlin has been awarded the 2014 von Kaven Award of the Deutsche Forschungsgemeinschaft (DFG, German Science Foundation). The prize of 10,000 euros (about US$14,000) will be presented in November 2014 in Karlsruhe, on the occasion of the Gauss Lecture of the Deutsche Mathematiker-Vereinigung.

Born in Russia in 1977, Gurevich received his PhD from Lomonosov Moscow State University in 2002 and his doctor of physical-mathematical sciences degree (equivalent to a *Habilitation*) in 2009. Since 2010 he has been at the Freie Universität Berlin. In 2015 he became a Heisenberg Fellow.

Gurevich's main research interests are in partial differential equations and dynamical systems. Early on, his work centered on so-called nonlocal problems. His PhD and Habilitation theses dealt with singularities arising in solutions to nonlocal problems and with applications of these problems to multidimensional diffusion processes. Later his focus shifted to hysteresis phenomena and their connections with reaction-diffusion equations. Recently, he has been developing a new direction in the theory of hysteretic systems, namely hysteresis with diffusive thresholds.

The von Kaven Award is presented each year to an outstanding mathematician based in the European Union. The von Kaven Foundation was established in December 2004 by its benefactor, Herbert von Kaven, of Detmold, Germany, and the DFG's executive board.

—From DFG announcements

Mathematics Opportunities

AMS-AAAS Mass Media Summer Fellowships

The American Mathematical Society provides support each year for a graduate student in the mathematical sciences to participate in the American Association for the Advancement of Science (AAAS) Mass Media Science & Engineering Fellows Program. This summer fellowship program pairs graduate students with major media outlets nationwide where they will research, write, and report on science news and use their skills to bring technical subjects to the general public.

The principal goal of the program is to increase the public's understanding of science and technology by strengthening the connection between scientists and journalists to improve coverage of science-related issues in the media. Past AMS-sponsored fellows have held positions at National Public Radio, *WIRED, Scientific American*, Voice of America, *The Oregonian*, and the *Milwaukee Journal Sentinel*.

Fellows receive a weekly stipend of US$500, plus travel expenses, to work for ten weeks during the summer as reporters, researchers, and production assistants in newsrooms across the country. They observe and participate in the process by which events and ideas become news, improve their ability to communicate about complex technical subjects in a manner understandable to the public, and increase their understanding of editorial decision making and of how information is effectively disseminated. Each fellow attends an orientation and evaluation session in Washington, D.C., and begins the internship in mid-June.

Fellows submit interim and final reports to AAAS. A wrap-up session is held at the end of the summer.

Mathematical sciences faculty are urged to make their graduate students aware of this program. The deadline to apply for fellowships for the summer of 2015 is **January 15, 2015**. Further information about the fellowship program and application procedures is available online at `www.aaas.org/program/aaas-mass-media-science-engineering-fellows-program`, or 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/massmediafellow`.

—AMS Washington Office

STaR Program for Early Career Mathematics Educators

The Service, Teaching, and Research (STaR) Program is a one-year induction program for early-career mathematics educators working at institutions of higher education. The program was initiated through a grant from the National Science Foundation (NSF). It includes a five-day summer institute, academic-year networking via electronic means, and a follow-up session in conjunction with the annual meeting of the Association of Mathematics Teacher Educators (AMTE).

The Association of Mathematics Teacher Educators provides a professional home for the program. To date, 175 early-career mathematics educators working at 128 institutions of higher education (in forty-one states) have completed the program. A list of previous STaR Fellows and a summary of some current activities are available at `starfellows.com`.

The program is now accepting applications for the 2015 cohort of STaR Fellows. This cohort will meet for the summer institute in Park City, Utah, June 13–18, 2015. Eligibility is limited to new faculty with doctorates in mathematics education in their first or second years of a tenure-track appointment as mathematics educators at U.S. institutions of higher education. The faculty appointment may be in a department of mathematics or in a school, college, or department of education.

More information and application materials are available at `matheddb.missouri.edu/star/`. Completed applications are due by **December 1, 2014**. Contact Jeff Wanko at `wankojj@miamioh.edu` for more information.

—From a STaR announcement

NSF Program in Computational and Data-Enabled Science and Engineering in Mathematical and Statistical Sciences

Computational and data-enabled science and engineering in mathematical and statistical sciences (CDS&E-MSS) is emerging as a distinct intellectual and technological discipline lying at the interface of mathematics, statistics, computational science, core sciences, and engineering disciplines. CDS&E-MSS, broadly interpreted, now affects virtually every area of science and technology,

revolutionizing the way science and engineering are done. The CDS&E-MSS program in the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF), in partnership with the Office of Cyberinfrastructure, supports fundamental research at the core of this emerging discipline. It supports broadly innovative, ambitious, and transformative research that will lead to significant advancement in CDS&E-MSS. The emphasis will be on mathematical, statistical, computational, and algorithmic developments, as well as their applications in advancing modern cyberinfrastructure and scientific discovery. Multidisciplinary collaboration and the training of the next generation of data and computational scientists firmly grounded and trained in mathematics and statistics will be strongly encouraged. The research topics supported by CDS&E-MSS in mathematical and statistical sciences will be rooted in mathematics and statistics and will address computational and big data challenges and directly promote discoveries and innovations at the frontiers of science and engineering. The overall impact in the mathematical and statistical sciences of the proposed work will be a review criterion.

The window for submission of proposals is **November 25–December 9, 2014**. For more details see `www.nsf.gov/funding/pgm_summ.jsp?pims_id=504687&WT.mc_id=USNSF_25&WT.mc_ev=click`.

—From an NSF announcement

NDSEG Fellowships

As a means of increasing the number of U.S. citizens trained in disciplines of military importance in science and engineering, the Department of Defense (DoD) awards National Defense Science and Engineering Graduate (NDSEG) Fellowships each year to individuals who have demonstrated ability and special aptitude for advanced training in science and engineering. The fellowships are awarded for a period of three years for study and research leading to doctoral degrees in any of fifteen scientific disciplines.

The NDSEG Fellowship Program is open only to applicants who are citizens or nationals of the United States. NDSEG Fellowships are intended for students at or near the beginning of their graduate studies in science or engineering. Applicants must have received or be on track to receive their bachelor's degrees by fall of 2015. Fellows selected in spring 2015 must begin their fellowship tenures in fall 2015. Fellowships are tenable only at U.S. institutions of higher education offering doctoral degrees in the scientific and engineering disciplines specified. Fellows will receive full tuition and stipends for 12-month tenures: US$30,500 for the first year, US$31,000 for the second year, and US$31,500 for the third year. Applications are encouraged from women, persons with disabilities, and minorities, including members of ethnic minority groups such as African American, American Indian and Alaska Native, Asian, Native Hawaiian and other Pacific Islander, Hispanic, or Latino.

Complete applications must be submitted electronically by **December 12, 2014**. Application forms are available online at `ndseg.asee.org/apply_online`. For further information, see `ndseg.asee.org/`.

—From an NDSEG announcement

CRM Intensive Research Programs

The Centre de Recerca Matemàtica (CRM) in Barcelona, Spain, invites proposals for Intensive Research Programs in any branch of mathematics and its applications. Programs will be organized during one of the following periods: September–October 2015 and after August 2016.

CRM Intensive Research Programs consist of periods of intensive research in a given area of the mathematical sciences and their applications, bringing together researchers from different institutions to work on open problems in the chosen area and to analyze its present state and perspectives. Programs may run for periods of from one to five months.

The deadline for preliminary proposals is **December 14, 2014**. The deadine for final proposals is **January 11, 2015**. For more information see the website `www.crm.cat/en/Host/SciEvents/IRP/Pages/default.aspx`.

—From a CRM announcement

News from IPAM

The Institute for Pure and Applied Mathematics (IPAM) is a National Science Foundation (NSF) mathematics institute located at the University of California Los Angeles. IPAM offers programs that encourage collaboration across disciplines and between two areas of mathematics.

IPAM holds long programs (three months) and workshops (three to five days) throughout the academic year for junior and senior mathematicians and scientists who work in academia, the national laboratories, and industry. In the summer, IPAM offers an industrial research experience for students and a summer school for graduate students and postdocs. IPAM seeks program proposals from the math and science communities. Please send your idea for a workshop, long program, or summer school to `director@ipam.ucla.edu`.

IPAM will host the Latinas in the Mathematical Sciences Conference on April 9–11, 2015. The conference will feature talks by prominent and promising Latina/o mathematicians and statisticians. It will also include mentoring and networking activities and opportunities for students to present their research.

Applications for travel support are due **February 9, 2015**. IPAM's graduate summer school for 2015 is entitled Games and Contracts for Cyber-Physical Security and will be held at the University of California Los Angeles on July 7–23, 2015. The application deadline is **March 31, 2015**.

About the Cover

Which is the good Theta, and which is the mock?

The question posed on the cover is explained in William Duke's article on page 1314 of this issue. The film reviewed by Mark Saul in this issue also refers to mock ϑ functions quite often. The film's story brings out, once again, how extraordinary Ramanujan's insight was.

Our thanks to Cole Porter and Dick Gross for assistance.

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

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Notices
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the Question: *What Is a Mock
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Remembering Shoshichi
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Mathematicians and Teachers
page 1335

$$1 + \frac{q}{(1+q)^2}$$

$$+ \frac{q^4}{(1+q)^2(1+q^2)^2}$$

$$+ \frac{q^9}{(1+q)^2(1+q^2)^2(1+q^3)^2}$$

$$+ \frac{q^{16}}{(1+q)^2(1+q^2)^2(1+q^3)^2(1+q^4)^2}$$

$$1 + \frac{q}{(1-q)^2}$$

$$+ \frac{q^4}{(1-q)^2(1-q^2)^2}$$

$$+ \frac{q^9}{(1-q)^2(1-q^2)^2(1-q^3)^2}$$

$$+ \frac{q^{16}}{(1-q)^2(1-q^2)^2(1-q^3)^2(1-q^4)^2}$$

AMS
AMERICAN MATHEMATICAL SOCIETY

About the cover: Which is the good Theta, and which is the mock? (see page 1314)

IPAM's Research in Industrial Projects for Students (RIPS) programs will accept applications from undergraduate and graduate students through **February 12, 2015**.

IPAM's other upcoming programs follow. See the website www.ipam.ucla.edu for detailed information and application and registration forms.

January 12-February 27, 2015: Winter Workshops. You may apply for support or register for each workshop online.

January 12-16, 2015. Multiple Sequence Alignment.

January 26-30, 2015. Symmetry and Topology in Quantum Matter.

February 4-6, 2015. Computational Photography and Intelligent Cameras.

February 9-13, 2015. Zariski-Dense Subgroups.

February 23-27, 2015. Machine Learning for Many-Particle Systems.

March 9-June 12, 2015: Broad Perspectives and New Directions in Financial Mathematics. You may apply online for support to be a core participant for the entire program or to attend any of the following individual workshops.

March 10-13, 2015. Tutorials.

March 23-27, 2015. Workshop I: Systemic Risk and the Financial Networks.

April 13-17, 2015. Workshop II: The Mathematics of High Frequency Financial Markets.

May 4-8, 2015. Workshop III: Commodity Markets and Their Financialization.

May 18-22, 2015. Workshop IV: Forensic Analysis of Financial Data.

September 8-December 11, 2015. New Directions in Mathematical Approaches for Traffic Flow Management. You may apply online for support to be a core participant for the entire program or to attend any of the following individual workshops.

September 9-12, 2015. Tutorials.

September 28-October 2, 2015. Workshop I: Mathematical Foundations of Traffic.

October 12-16, 2015. Workshop II: Traffic Estimation.

October 26-30, 2015. Workshop III: Traffic Control.

November 16-20, 2015. Workshop IV: Decision Support for Traffic.

March 7-June 10, 2016: Culture Analytics. You may apply online for support to be a core participant for the entire program or to attend any of the individual workshops.

March 8-11, 2016. Tutorials.

March 21-24, 2016. Workshop I: Mathematical Analysis of Cultural Expressive Forms: Images, Videos, Music, and Cognition.

April 11-15, 2016. Workshop II: Culture Analytics and User Experience Design.

May 9-13, 2016. Workshop III: Cultural Patterns: Multiscale Data-Driven Models.

May 23-27, 2016. Workshop IV: Mathematical Analysis of Cultural Expressive Forms: Text Data.

—IPAM announcement

For Your Information

Departments Coordinate Job Offer Deadlines

For the past fifteen years, the American Mathematical Society has led the effort to gain broad endorsement for the following proposal:

> That mathematics departments and institutes agree not to require a response prior to a certain date (usually early in February of a given year) to an offer of a postdoctoral position that begins in the fall of that year.

This proposal is linked to an agreement made by the National Science Foundation (NSF) that the recipients of the NSF Mathematical Sciences Postdoctoral Fellowships would be notified of their awards, at the latest, by the end of January.

This agreement ensures that our young colleagues entering the postdoctoral job market have as much information as possible about their options before making a decision. It also allows departmental hiring committees adequate time to review application files and make informed decisions. From our perspective, this agreement has worked well and has made the process more orderly. There have been very few negative comments. Last year, one hundred sixty-eight mathematics and applied mathematics departments and four mathematics institutes endorsed the agreement.

Therefore we propose that mathematics departments again collectively enter into the same agreement for the upcoming cycle of recruiting, with the deadline set for Monday, February 2, 2015. The NSF's Division of Mathematical Sciences has already agreed that it will complete its review of applications by January 23, 2015, at the latest and that all applicants will be notified electronically at that time.

The American Mathematical Society facilitated the process by sending an email message to all doctoral-granting mathematics and applied mathematics departments and mathematics institutes. The list of departments and institutes endorsing this agreement was widely announced on the AMS website beginning November 1, 2014, and is updated weekly until mid-January.

We ask that you view this year's formal agreement at `www.ams.org/employment/postdoc-offers.html` along with **this year's list** of adhering departments.

Important: To streamline this year's process for all involved, we ask that you notify T. Christine Stevens at the AMS (`tcs@ams.org`) **if and only if**:

(1) your department is not listed and you would like to be listed as part of the agreement or

(2) your department is listed and you would like to withdraw from the agreement and be removed from the list.

Please feel free to email us with questions and concerns. Thank you for consideration of the proposal.

—Donald McClure
AMS Executive Director
—T. Christine Stevens
AMS Associate Executive Director

Inside the AMS

AMS Project NExT Fellows Chosen

Six mathematicians have been selected as AMS Project NExT fellows for the 2013–2014 academic year. Their names, affiliations, and areas of research are: TIMUR AKHUNOV, University of Rochester, existence and regularity for partial differential equations; NATHANIAL BURCH, Gonzaga University, partial differential equations and stochastic processes; JAMES COLLINS, West Texas A&M University, applied mathematics; MARTHA PRECUP, Baylor University, Lie theory, representation theory, algebraic geometry; AMANDA SCHAEFFER FRY, Metropolitan State University of Denver, representations of finite groups; MUTIARA SONDJAJA, Courant Institute of Mathematical Sciences, New York University, mathematical optimization, operations research.

Project NExT (New Experiences in Teaching) is a professional development program for new and recent PhDs in the mathematical sciences (including pure and applied mathematics, statistics, operations research, and mathematics education). It addresses all aspects of an academic career: improving the teaching and learning of mathematics, engaging in research and scholarship, and participating in professional activities. It also provides the participants with a network of peers and mentors as they assume these responsibilities. The AMS provides funding for a number of the fellowships.

—From an MAA announcement

2014 Trjitzinsky Memorial Awards Presented

The AMS has made awards to seven undergraduate students through the Waldemar J. Trjitzinsky Memorial Fund. The fund is made possible by a bequest from the estate of Waldemar J., Barbara G., and Juliette Trjitzinsky. The will of Barbara Trjitzinsky stipulates that the income from the bequest should be used to establish a fund in honor of the memory of her husband to assist needy students in mathematics.

For the 2014 awards, the AMS chose seven geographically distributed schools to receive one-time awards of US$3,000 each. The mathematics departments at those schools then chose students to receive the funds to assist them in pursuit of careers in mathematics. The schools are selected in a random drawing from the pool of AMS institutional members.

Waldemar J. Trjitzinsky was born in Russia in 1901 and received his doctorate from the University of California, Berkeley, in 1926. He taught at a number of institutions before taking a position at the University of Illinois, Urbana-Champaign, where he remained for the rest of his professional life. He showed particular concern for students of mathematics and in some cases made personal efforts to ensure that financial considerations would not hinder their studies. Trjitzinsky was the author of about sixty mathematics papers, primarily on quasi-analytic functions and partial differential equations. A member of the AMS for forty-six years, he died in 1973.

Following are the names of the selected schools for 2014, the names of the students receiving Trjitzinsky awards, and brief biographical sketches of the students.

Old Dominion University: KATHLEEN M. CHAMBERLAIN. Chamberlain is the spouse of an active-duty service member in the US military and a returning student of mathematics at Old Dominion who has maintained a 4.0 GPA at all levels of her education. She plans on using her degree to assist service members and their families in continuing their education by becoming a tutor in the Department of Defense's tutoring program. She hopes to help others see mathematics as a fascinating and invaluable tool. She previously worked with United Way Worldwide in a variety of finance-related roles, including donor-advised giving and international grant accounting.

Miami University, Oxford: DANIEL BICKLEY. Bickley is a junior computer science major with a mathematics minor. Since he started college he has wanted to learn about how the world works and found that mathematics was the language of the physical world. Since that time he has been using mathematics to guide his everyday life and decisions. He is currently working toward a career in algorithmic design but also hopes to be a college professor in order to share the reasons that applied and theoretical mathematics are vitally important to him and to the world.

Oral Roberts University: SARIAH D. REESE. Reese was born and raised in Lawton, Oklahoma, and attended Eisenhower Senior High School, maintaining a 4.0 GPA and graduating with honors. She is a sophomore at Oral Roberts. She volunteers at various functions and singing rehearsals at her church. She enjoys spending time with family and friends and strives to make them proud every day. Her career goal is to become a superintendent of a school district in order to have an impact on the lives and education of upcoming generations of students.

California State University Fullerton: HORACIO A. SANCHEZ CARDENAS. Sanchez Cardenas moved to California from Mexico when he was seventeen years old, knowing no English. He now speaks and understands the language well. He transferred from Fullerton Junior College to Cal State Fullerton this year. He works as a busboy and server at a Mexican restaurant; to concentrate on his studies he had to drop shifts at work and look to friends for assistance. He is a determined student with a passion for mathematics who aims to become a math teacher. He hopes to share the beauty he sees in mathematics with future students and to serve as a role model to

students who are overcoming obstacles to pursue their dreams, as he is doing now.

Cornell University: MATTHEW S. FARRELL. Farrell began his studies at Cornell in 2013, having transferred from the College of Idaho in his junior year. As a freshman he found that he enjoyed many subjects but came to love mathematics for the combination of power and aesthetic pleasure it afforded him. His awareness of the field underwent a dramatic change during an internship at the Lawrence Berkeley National Laboratory in the summer of 2012. The prospect of studying mathematics across a range of subject matter and of doing research brought him to Cornell intent on reaching as high a level of mathematical maturity as he could. Since arriving at Cornell he has learned mathematics at an exhilarating rate and, with his professor, made progress toward figuring out properties not yet known about sandpiles.

West Chester University of Pennsylvania: PRABHAT KUMAR. Kumar is a sophomore mathematics and physics major with a 3.825 GPA and thirty-two earned credits so far in math and physics coursework. He is a commuter student who is serious about his mathematics studies and is already interested in research.

Emporia State University: TAYLOR HUETTENMUELLER. Huettenmueller is a mathematics major and computer science minor in his junior year with a total GPA of 3.94 and a mathematics GPA of 4.0. He works on campus in the budget office to support himself through college. He is a member of numerous honor societies, including the Emporia State Honors College and Kappa Mu Epsilon. He plans to use his degree to become an actuary.

—Elaine Kehoe

From the AMS Public Awareness Office

AMS for Students. This new site offers news and information for high school and undergraduate students of mathematics, with links to explore math programs, enter competitions, find graduate programs, see where math is used, get free math help, publish and present research, see deadlines for opportunities for fellowships, meetings, and more. See `www.ams.org/students`.

National *Who Wants to Be a Mathematician*. Ten contestants from around the United States have qualified for the national game at the Joint Mathematics Meetings (JMM) in San Antonio, Texas, on January 12, 9:30–11:00 a.m., Room 103, at the Convention Center. The grand prize winner will share US$10,000 with his or her school mathematics department. JMM participants and the general public are invited to attend, to cheer on, support, and encourage the contestants, and even try to play along. "Are you smarter than a (pretty sharp) high school math student?" See `www.ams.org/wwtbam`.

AMS events at the 2015 Joint Mathematics Meetings. Visit the AMS exhibit to see books on sale; join the AMS or renew your membership; learn about AMS programs for students and mathematicians at various stages in their careers; attend the Mathematical Reviews Reception, Monday, January 12, 6:00–7:00 p.m., and meet the new executive editor, Edward Dunne; and purchase tickets with your registration for the AMS Dinner, an evening celebrating the spirit of connection and collaboration, to be held on Tuesday, January 13, at 7:30 p.m. See the entire program at `jointmathematicsmeetings.org/`.

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

Deaths of AMS Members

ALBERT BAERNSTEIN II, of St. Louis, Missouri, died on June 10, 2014. Born on April 25, 1941, he was a member of the Society for 49 years.

WILLIAM R. BALLARD, professor, University of Montana-Missoula, died on April 11, 2014. Born on February 1, 1926, he was a member of the Society for 62 years.

HOWARD E. BRANDT, of Silver Spring, Maryland, died on April 13, 2014. Born on January 2, 1939, he was a member of the Society for 22 years.

JERALD S. BRODKEY, of Cleveland, Ohio, died on May 20, 2014. Born on January 20, 1934, he was a member of the Society for 25 years.

LUTZ BUNGART of Ashland, Oregon, died on June 5, 2014. Born on January 29, 1938, he was a member of the Society for 53 years.

NIKOLAI CHERNOV, professor, University of Alabama at Birmingham, died on August 7, 2014. Born on November 10, 1956, he was a member of the Society for 20 years.

HARVEY COHN, of Laguna Woods, California, died on May 16, 2014. Born on December 27, 1923, he was a member of the Society for 72 years.

DANIEL C. COMISKEY, of Needham, Massachusetts, died on June 11, 2014. Born on May 20, 1930, he was a member of the Society for 25 years.

V. F. DEM'YANOV, professor, Saint Petersburg State University, died on April 18, 2014. Born on August 18, 1938, he was a member of the Society for 36 years.

VEIKKO O. ENNOLA, of Finland, died on January 28, 2013. Born on August 4, 1932, he was a member of the Society for 52 years.

LARS GÅRDING, professor, Lund University, died on July 7, 2014. Born on March 7, 1919, he was a member of the Society for 67 years.

FRANK D. GIANONO, of Valley Stream, New York, died on May 19, 2014. Born on October 19, 1955, he was a member of the Society for 5 years.

HAROLD W. KUHN, professor, Princeton University, died on July 2, 2014. Born on July 29, 1925, he was a member of the Society for 65 years.

KLAUS PETERS, of Sherborn, Massachusetts, died on July 7, 2014. Born on January 19, 1937, he was a member of the Society for 49 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

November 19, 2014: Applications for NRC-Ford Foundation Predoctoral Fellowships. See the website 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.

November 25–December 9, 2014: Proposals for NSF Program in Computational and Data-Enabled Science and Engineering in Mathematical and Statistical Sciences (CDS&E-MSS). See "Mathematics Opportunities" in this issue.

December 1, 2014: Applications for AMS Centennial Fellowship. See www.ams.org/ams-fellowships/ or contact the Membership and Programs Department, American Mathematical Society,

201 Charles Street, Providence, RI 02904-2294; telephone 401-455-4105; email prof-serv@ams.org.

December 1, 2014: Applications for Service, Teaching, and Research (STaR) Program. See "Mathematics Opportunities" in this issue.

December 1, 2014: Applications for Pacific Institute for the Mathematical Sciences (PIMS) postdoctoral fellowships. See www.pims.math.ca/scientific/postdoctoral or contact assistant.director@pims.math.ca.

December 1, 2014: Applications for Research Memberships and

Postdoctoral Fellowships at the Mathematical Sciences Research Institute (MSRI). See `https://www.msri.org/web/msri/scientific/memberapplication`.

December 12, 2014: Applications for National Defense Science and Engineering Graduate (NDSEG) Fellowships. See "Mathematics Opportunities" in this issue.

December 14, 2014: Preliminary proposals for Intensive Research Programs at Centre de Recerca Matematica (CRM). See "Mathematics Opportunities" in this issue.

December 15, 2014: Applications for AMS Epsilon Fund grants. See `www.ams.org/programs/edu-support/epsilon/emp-epsilon` for more information and `www.mathprograms.org` for applications.

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 "Mathematics Opportunities" in this issue.

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 `http://www.ams.org/programs/ams-fellowships/media-fellow/massmediafellow`.

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 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 12, 2015: Applications for IPAM Research in Industrial Projects for Students (RIPS) programs. See "Mathematics Opportunities" in this issue.

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

March 31, 2015: Applications for IPAM graduate summer school on Games and Contracts for Cyber-Physical Security. See "Mathematics Opportunities" in this issue.

April 15, 2015: Applications for fall 2015 semester of Math in Moscow. See `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 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.

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.

NSF Mathematics Education Staff

The Directorate for Education and Human Resources (EHR) of the National Science Foundation (NSF) sponsors a range of programs that support educational projects in mathematics, science, and engineering. Listed below is contact information for those EHR program officers whose fields are in the mathematical sciences or mathematics education. These individuals can provide information about the programs they oversee, as well as information about other EHR programs of interest to mathematicians. The postal address is: Directorate for Education and Human Resources, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230. The EHR webpage is `www.nsf.gov/dir/index.jsp?org=EHR`.

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IMU Executive Committee

The Executive Committee of the International Mathematical Union (IMU) conducts the business of the Union. Following are the members of the Executive Committee for the term 2015–2018.

Shigefumi Mori, President
Helge Holden, Secretary
Alicia Dickenstein, Vice President
Vaughan Jones, Vice President
Benedict H. Gross, Member-at-Large
Hyungju Park, Member-at-Large
Christiane Rousseau, Member-at-Large
Vasudevan Srinivas, Member-at-Large
John Francis Toland, Member-at-Large
Wendelin Werner, Member-at-Large
Ingrid Daubechies, Ex-officio Member (Past President)

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.

Good Math: A Geek's Guide to the Beauty of Numbers, Logic, and Computation, by Mark C. Chu-Carroll. Pragmatic Bookshelf, July 2013. ISBN-13: 978-19377-853-38.

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 in this issue.)

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 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.

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.*

Naming Infinity: A True Story of Religious Mysticism and Mathematical Creativity, by Loren Graham and Jean-Michel Kantor. Belknap Press of Harvard University Press, March 2009. ISBN-13: 978-06740-329-34. (Reviewed January 2014.)

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.

The Outer Limits of Reason: What Science, Mathematics, and Logic Cannot Tell Us, by Noson S. Yanofsky. MIT Press, August 2013. ISBN-13: 978-02620-193-54.

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.

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.)

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.

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 Calculu*s, 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 `http://www.ams.org/cgi-bin/mathcal-submit.pl`. The most comprehensive and up-to-date Mathematics Calendar information is available on the AMS website at `http://www.ams.org/mathcal/`.

December 2014

1–5 AIM Workshop: Beyond Kadison-Singer - paving and consequences, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2014, p. 664)

1–5 38th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing (ACCMCC), Victoria University of Wellington, Wellington, New Zealand. (Mar. 2014, p. 317)

1–5 Automorphic forms, Shimura varieties, Galois representations and L-functions, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul 2014, p. 664)

1–5 BioInfoSummer 2014: Summer Symposium in Bioinformatics, Monash University (Caulfield), Melbourne, Australia. (Oct. 2014, p. 1105)

1–5 International Conference on Applied Mathematics — in honour of Professor Roderick S. C. Wong's 70th Birthday, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Hong Kong. (May 2014, p. 556)

1–12 4th African Mathematical School: Mathematical Tools for Financial and Actuarial Sciences, University of Douala, Douala, Cameroon. (Nov. 2014, p. 1274)

1–12 Winter School on Operator Spaces, Non-commutative Probability and Quantum Groups, Métabief, France. (Feb. 2014, p. 214)

* **4–5 Workshop on Integrable Systems**, School of Mathematics and Statistics, University of Sydney, NSW, Australia.
Organizers: Nalini Joshi, Sarah Lobb, Christopher Lustri, Milena Radnovic
Description: `http://wp.maths.usyd.edu.au/igs/workshops/december2014/`.

6–31 The Info-Metrics Annual Prize in Memory of Halbert L. White Jr., Washington, DC. (Feb. 2014, p. 214)

8–10 IMA Conference on Game Theory and its Applications, St. Anne's College, Oxford, United Kingdom. (Jun/Jul 2014, p. 665)

8–12 AIM Workshop: Transversality in contact homology, American Institute of Mathematics, Palo Alto, California. (May 2014, p. 556)

8–12 The 5th International Conference on Scientific Computing and Partial Differential Equations, Hong Kong Baptist University, Hong Kong, China. (Oct. 2014, p. 1106)

8–12 8th Australia – New Zealand Mathematics Convention, University of Melbourne, Melbourne, Australia. (Apr. 2014, p. 433)

8–12 (NEW DATE) International Conference on Pure and Applied Mathematics, Goroka 2014: ICPAM-GOROKA (2014), University of Goroka, Goroka, Eastern Highlands Province, Papua, New Guinea. (Sept. 2014, p. 978)

9–10 First call for the training programme "Collaborative Mathematical Research", Centre de Recerca Matematica, Bellaterra, Barcelona, Spain. (Mar. 2014, p. 317)

9–19 Recent Advances in Operator Theory and Operator Algebras-2014, Bangalore, India. (Dec. 2013, p. 1497)

9–20 Vertex algebras, W-algebras, and applications, Centro di Ricerca Matematica Ennio De Giorigi, Pisa, Italy. (Jun/Jul 2014, p. 665)

10–12 I Brazilian Congress of Young Researchers in Pure and Applied Mathematics, Mathematics and Statistics Institute, University of São Paulo, São Paulo, Brazil. (Aug. 2014, p. 795)

* **10–15 Hamiltonian Dynamics, Nonautonomous Systems, and Patterns in PDE's**, Lobachevsky State University of Nizhny Novgorod, Nizhny Novgorod, Russia.

This section contains announcements of meetings and conferences of interest to some segment of the mathematical public, including ad hoc, local, or regional meetings, and meetings and symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. A complete list of meetings of the Society can be found on the last page of each issue.

An announcement will be published in the *Notices* if it contains a call for papers and specifies the place, date, subject (when applicable), and the speakers; a second announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in every third issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared. Asterisks (*) mark those announcements containing new or revised information.

In general, announcements of meetings and conferences carry only the date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. If there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the *Notices* in care of the American Mathematical Society in Providence or electronically to `notices@ams.org` or `mathcal@ams.org`.

In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence **eight months** prior to the scheduled date of the meeting.

The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June/July, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.

The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through the AMS website on the World Wide Web. To access the AMS website, use the URL: `http://www.ams.org/`.

Description: Lobachevsky State University of Nizhny Novgorod and Nizhny Novgorod Mathematical Society organize the conference-school "Hamiltonian Dynamics, Nonautonomous Systems, and Patterns in PDE's", dedicated to the 70th birthday of Professors Lev Lerman and Albert Morozov.

Topics: Hamiltonian Dynamics (chaos, integrable and near-integrable systems, reversible systems); Nonautonomous Systems (periodic, quasiperiodic, random, general); Patterns in PDEs (emergence, bifurcations, spatio-temporal behavior); Applications of dynamical systems. The conference will also feature a number of mini-courses for students and postdoctoral researchers. A limited financial support for young participants will be available. Nizhny Novgorod has an airport with connecting flights from Moscow, Saint Petersburg, Frankfurt, and other places. It can be conveniently reached from Moscow by railway with several daytime and overnight intercity trains.
Information: `http://www.hamidyn.unn.ru/en`.

11–20 **Foundations of Computational Mathematics Conference**, Universidad de la República, Montevideo, Uruguay. (Feb. 2014, p. 214)

15–16 **4th International Conference on Internet and Cloud Computing Technology (ICI2CT 2014)**, Hotel Changi Village, Singapore. (Nov. 2014, p. 1274)

15–17 **10th IMA International Conference on Mathematics in Signal Processing**, Austin Court, Birmingham, United Kingdom. (Jun/Jul 2014, p. 665)

* 15–17 **International Conference on Algebra and Its Applications**, Department of Mathematics, Aligarh Muslim University, Uttar Pradesh, India.
Description: The purpose of the conference is to contribute to the development of algebra and to bring together the algebraists from all over the world working in related areas to present their researches, to exchange new ideas, to discuss challenging issues, to foster future collaborations and to expose young researchers.
Information: `http://www.amu.ac.in/newevent/event/9769.pdf`.

16–17 **IMA Conference on the Mathematical Challenges of Big Data**, Woburn House, London, United Kingdom. (Nov. 2014, p. 1274)

16–17 **1st International Conference on Security Standardisation Research**, Royal Holloway, University of London (RHUL), Egham Hill, Egham, United Kingdom. (Jun/Jul 2014, p. 665)

* 17–19 **Shilnikov Workshop-2014**, Lobachevsky State University of Nizhny Novgorod, Nizhny Novgorod, Russia.
Description: International Conference "Shilnikov Workshop-2014" dedicated to the 80th birthday of Leonid Shilnikov (1934–2011). The Shilnikov Workshop has been held at the University annually since 2012, its date is close to birthday of Leonid Shilnikov, December 17. The conference will cover various topics of the theory of dynamical systems: bifurcations, strange attractors, dynamics of Hamiltonian and reversible systems, as well as applications of the theory to mathematical models from sciences and engineering. This year the conference became international thanks to a support of the Russian Science Foundation (grant 14-41-00044). We expect that many young researches, Ph.D. students, and graduate students will participate; mini-courses on bifurcation theory and theory of strange attractors are planned for them. We invite you to take part at the conference and are looking forward for the further fruitful collaboration towards the advance of the theory of dynamical systems.
Information: `http://www.shilnikov2014.unn.ru/en`.

18–21 **International Conference on Geometric Function Theory and its Applications (ICGFTA-2014)**, Department of Mathematics, Indian Institute of Technology, Kharagpur, Kharagpur-721302, West Bengal, India. (Oct. 2014, p. 1106)

19–21 **International Conference on Current Developments in Mathematics and Mathematical Sciences (ICCDMMS-2014)**, Calcutta Mathematical Society, AE-374, Sector-1, Salt Lake City, Kolkata-700064 West Bengal, India. (Apr. 2014, p. 433)

19–21 **2014 Fourth International Conference on Emerging Applications of Information Technology (EAIT 2014)**, Indian Statistical Institute, Kolkata, India. (May 2014, p. 556)

19–21 **Workshop on Mathematical Biology and Nonlinear Analysis**, The University of Miami, Coral Gables, Florida. (Sept. 2014, p. 980)

21–23 **8th International Conference of IMBIC on "Mathematical Sciences for Advancement of Science and Technology (MSAST 2014)"**, IMBIC, Salt Lake City, Kolkata, India. (Jun/Jul 2014, p. 665)

21–23 **International Conference on Recent Trends in Mathematical Analysis and Its Applications**, Indian Institute of Technology Roorkee, Roorkee-247667 Uttarakhand, India. (Sept. 2014, p. 980)

January 2015

1–March 31 **High Performance and Parallel Computing for Materials Defects and Multiphase Flows**, Institute for Mathematical Sciences, National University of, Singapore, Singapore. (Jun/Jul 2014, p. 666)

4–6 **ACM-SIAM Symposium on Discrete Algorithms (SODA15), being held with Analytic Algorithmics and Combinatorics (ANALCO15) and Algorithm Engineering and Experiments (ALENEX15)**, The Westin Gaslamp Quarter, San Diego, California. (Feb. 2014, p. 214)

* 4–10 **Hyperbolic Geometry and Minimal Surfaces**, IMPA, Rio de Janeiro, Brazil.
Description: The study of hyperbolic manifolds has advanced considerably. Many problems and conjectures in the subject have recently been resolved. Incompressible surfaces in hyperbolic manifolds have played an important role in this research. Minimal surfaces have been used as well: Embedded incompressible surfaces are isotopic to least area minimal surfaces. The conference will focus on various problems in the intersection of hyperbolic geometry and the minimal surface theory. We believe that a joint meeting of specialists in minimal surface theory and hyperbolic geometry will encourage collaboration to study the global geometry of minimal surfaces in hyperbolic manifolds.
Topics: The topics of the conference will include minimal surfaces in hyperbolic manifolds, min-max techniques in hyperbolic geometry, systoles in expanding families of hyperbolic manifolds.
Information: `http://www.impa.br/opencms/en/eventos/store/evento_1501`.

5–9 **AIM Workshop: Tumor-immune dynamics**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2014, p. 665)

5–10 **ICMC 2015: The Second International Conference on Mathematics and Computing**, Haldia Institute of Technology Haldia, West Bengal, India. (Oct. 2014, p. 1106)

5–June 26 **Periodic and Ergodic Spectral Problems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2013, p. 365)

6–9 **Winter Meeting on Bruhat-Tits Buildings**, Imperial College London, London, United Kingdom. (Oct. 2014, p. 1106)

12–16 **Multiple Sequence Alignment**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 795)

12–May 22 **Dynamics on Moduli Spaces of Geometric Structures Program**, Mathematical Sciences Research Institute, Berkeley, California. (Jan. 2014, p. 117)

12–July 3 **Random Geometry**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2013, p. 365)

15–16 **Connections for Women: Dynamics on Moduli Spaces of Geometric Structures**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul 2014, p. 665)

19–February 6 **Lie Theory and Representation Theory**, Centro di Ricerca Matematica Ennio De Giorigi, Pisa, Italy. (Jun/Jul 2014, p. 665)

20–23 **AIM Workshop: Inference in high-dimensional regression**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 795)

20–23 **Introductory Workshop: Dynamics on Moduli Spaces of Geometric**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul 2014, p. 665)

21–25 **The Ninth International Conference on Nonlinear Analysis and Convex Analysis (NACA2015)**, Rimkok Resort Hotel, Chiang Rai, Thailand. (Oct. 2014, p. 1106)

26–30 **AIM Workshop: Graph Ramsey Theory**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2014, p. 665)

26–30 **Symmetry and Topology in Quantum Matter**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 795)

* 26–30 **Symmetry and Topology in Quantum Matter**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, CA.
Description: Topological phases of matter are remarkable both for their richness of physical phenomena, and for their mathematical description by topological quantum field theories (TQFTs). Recently, the prediction and experimental discovery of topological insulators has spurred physicists to explore the role of symmetry in topological phases, leading to the identification of new classes of phases of matter, and new insights into their classification, properties, and potential physical realizations. This is an area with a history of strong connections between physics and mathematics, and the time is ripe for the emerging understanding of symmetric topological phases to benefit from new mathematical ideas in TQFTs, and vice versa.
Information: `http://www.ipam.ucla.edu/programs/work-shops/symmetry-and-topology-in-quantum-matter/`.

29–30 **Connections for Women: Geometric and Arithmetic Aspects of Homogeneous Dynamics**, Mathematical Sciences Research Institute, Berkeley, California. (Aug. 2014, p. 796)

February 2015

2–6 **Introductory Workshop: Geometric and Arithmetic Aspects of Homogeneous Dynamics**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2014, p. 1275)

2–6 **MBI Workshop on Tumor Heterogeneity and the Microenvironment**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul 2014, p. 665)

2–March 8 **ICERM Semester Program: Phase Transitions and Emergent Properties**, Brown University, Providence, Rhode Island. (Mar. 2014, p. 317)

4–6 **Computational Photography and Intelligent Cameras**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Sept. 2014, p. 982)

5–7 **4rd International Conference on Mathematics & Information Science**, Zewail City, Cairo, Egypt. (Oct. 2014, p. 1106)

7–8 **Southern California Geometric Analysis Seminar**, UCSD, La Jolla, California. (Nov. 2014, p. 1275)

8–28 **Algebraic topology, geometric and combinatorial group theory**, Centro di Ricerca Matematica Ennio De Giorigi, Pisa, Italy. (Jun/Jul 2014, p. 665)

9–13 **Crystals, Quasicrystals and Random Networks**, Brown University, Providence, Rhode Island. (Mar. 2014, p. 317)

9–13 **Zariski-dense Subgroups**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 796)

13–15 **Mathemusical Conversations: Mathematics and Computation in Music Performance and Composition**, Yong Siew Toh Conservatory of Music and Institute for Mathematical Sciences, National University of Singapore, Singapore. (Oct. 2014, p. 1106)

16–20 **MBI Workshop on Treatment, Clinical Trials and Resistance of Cancer**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul 2014, p. 667)

* 23–26 **Workshop in Memory of Sergio Console**, University of Torino, Torino, Italy.
Invited Speakers: J. Lauret (Cordoba, AR); L. Nicolodi (Parma, IT); C. Olmos (Cordoba, AR); G. Ovando (Rosario, AR); F. Ricci (SNS Pisa, IT); M. Rigoli (Milano, IT); J. P. Rossetti (Cordoba, AR); E. Samiou (Nicosia, CY); S. Salamon (KCL, UK); G. Thorbergsson (Köln, DE).
Information: `http://www.personalweb.unito.it/annamaria.fino/WorkshopSergioConsole.html`.

23–27 **Machine Learning for Many-Particle Systems**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 796)

25–March 1 **Introductory Workshop**, Uppsala University, Uppsala, Sweden. (Jun/Jul 2014, p. 667)

28–March 1 **Ohio River Analysis Meeting 5**, University of Cincinnati, Cincinnati, Ohio. (Nov. 2014, p. 1275)

March 2015

2–5 **Flow(ers) & Friends in Frankfurt (a workshop on Geometric Analysis)**, Goethe Universitaet Frankfurt, Frankfurt am Main, Germany. (Oct. 2014, p. 1106)

9–June 12 (NEW DATE) **Broad Perspectives and New Directions in Financial Mathematics**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2014, p. 796)

* 10–13 **Financial Mathematics Tutorials**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: The long program opens with four days of tutorials that will provide an introduction to major themes of the entire program and the four workshops, aimed at providing a foundation for the participants of this program who have diverse scientific backgrounds. The tutorials will include courses on: The mathematics of systemic risk (4 hours); energy and commodity markets (4 hours); high frequency markets (4 hours); portfolio theory (4 hours).
Registration: Registration for tutorials is free, to encourage broad participation. Applications for financial support are due Tuesday, January 13, 2015. Consult the webpage for more information.
Information: `http://www.ipam.ucla.edu/fmtut`.

14–18 (UPDATED) **SIAM Conference on Computational Science and Engineering (CSE15)**, The Calvin L. Rampton Salt Palace Convention Center, Salt Lake City, Utah. (Jun/Jul 2014, p. 667)

* 15–20 **ALCOMA 15 - Algebraic Combinatorics and Applications**, Kloster Banz, Germany.
Description: The intention of ALCOMA 15 is to bring together researchers that work in particular in the field of constructive theory of combinatorial designs and error-correcting codes or on closely related topics. A special focus of the conference is on q-analogues of designs and their recent application in random network coding. ALCOMA15 is dedicated to the memory of Axel Kohnert Topics * Design theory * Coding theory * q-analogues * Finite geometry * Finite group actions.
Location: `http://alcoma15.uni-bayreuth.de/`.

16–20 **6th International Conference on High Performance Scientific Computing**, Hanoi, Vietnam. (Sept. 2014, p. 983)

16–20 **Small Clusters, Polymer Vesicles and Unusual Minima**, Brown University, Providence, Rhode Island. (Mar. 2014, p. 317)

18–20 **Critical Issues in Mathematics Education 2015: Developmental Mathematics: For whom? Toward what ends?**, Mathematical Sciences Research Institute, Berkeley, California. (Oct. 2014, p. 1107)

18–20 **IAENG International Conference on Scientific Computing 2015**, Royal Garden Hotel, Hong Kong. (Aug. 2014, p. 796)

23–27 **AIM Workshop: Dynamical algebraic combinatorics**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 796)

23–27 **MBI Workshop on Targeting Cancer Cell Proliferation and Metabolism Networks**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul 2014, p. 667)

* 23–27 **Systemic Risk and Financial Networks**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: The recent financial crisis has highlighted the importance of the stability of the financial system as a whole and the FMWS1 Poster interconnectedness of its components, prompting new research efforts directed at understanding the key determinants of the structure and stability of the network(s) underlying the financial system and the mechanism which govern the onset of systemic risk and the propagation of distress propagation across financial markets and institutions. This interdisciplinary workshop will bring together mathematical scientists, economists and regulators who have made key contributions to the recent research efforts for explaining, monitoring or regulating systemic risk. Capital requirements, central clearing, default contagion through insolvency and illiquidity, and nonlinear feedback effects are some of the proposed key elements of recent models and will be discussed in the workshop.
Deadline: January 26, 2015.
Information: `http://www.ipam.ucla.edu/programs/workshops/workshop-i-systemic-risk-and-financial-networks/`.

27 **Philosophy of Information and Information Processing**, Pembroke College, Oxford, United Kingdom. (Jun/Jul 2014, p. 667)

30–31 **3rd IMA International Conference on Flood Risk**, Swansea University, Wales, United Kingdom. (Jun/Jul 2014, p. 667)

30–April 30 **Sets and Computations**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Oct. 2014, p. 1107)

April 2015

* 9–11 **Latina/os in the Mathematical Sciences Conference**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: IPAM will host a three day conference showcasing the achievements of Latina/os in the mathematical sciences. The conference will feature talks by junior and senior researchers, as well as events for undergraduates, graduate students, and postdoctoral fellows. There will be plenary lectures, community lectures, panel discussions, and activities to facilitate networking. The goal of the conference is to encourage Latina/os to pursue careers in the mathematical sciences, to promote the advancement of Latina/os currently in the discipline, to showcase research being conducted by Latina/os at the forefront of their fields, and, finally, to build a community around shared academic interests. Applications for travel support are due February 9, 2015. Please consult the webpage for more information.
Information: `http://www.ipam.ucla.edu/lat2015`.

13–17 **Dynamics on Moduli Spaces**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul 2014, p. 667)

13–17 **Limit Shapes**, Brown University, Providence, Rhode Island. (Mar. 2014, p. 317)

13–17 **MBI Workshop on Stem Cells, Development, and Cancer**, Mathematical Biosciences Institute, The Ohio State University, Jennings Hall 3rd Floor, 1735 Neil Ave., Columbus, Ohio. (Jun/Jul 2014, p. 667)

* 19–22 **15th International Conference on Numerical Combustion**, Palais des Papes, Avignon, France.
Description: Continuous advances in computational algorithms, hardware and software, as well as progress in chemistry description and turbulent combustion modeling, have a revolutionary impact on combustion sciences. The forthcoming Fifteenth International Conference on Numerical Combustion will focus on the integration of theory, modeling and numerical implementation to perform high-fidelity simulations of basic combustion physics and technological applications. Contributed presentations (15 min talk followed by 5 min discussion) as well as mini-symposia (two-hour sessions devoted to well-focused subjects and consisting in four 25-mn presentations) are encouraged in all areas of numerical combustion. This conference follows a series of conferences, the more recent held in St. Petersburg Beach (1991), Garmisch-Patenkirchen (1993), New Orleans (1996), York (1998), Amelia Island (2000), Sorrento (2002), Sedona (2004), Granada (2006), Monterey (2008), Corfu (2011) and San Antonio (2013).
Information: `http://www.nc15.ecp.fr`.

19–25 **Spring School on Variational Analysis, Paseky**, Paseky nad Jizerou, Czech Republic. (Nov. 2014, p. 1275)

* 24–25 **Finger Lakes Seminar**, University of Rochester, Rochester, New York.
Description: This is an annual conference for probabilists in or near upstate New York. Others are also very welcome.
Talks: There will be 4 talks, on the pattern of the Midwest Probability Colloquium.
Speakers: Yuri Bakhtin (main speaker, Courant), Sevak Mkrtchyan (Rochester), and Pierre Patie (Cornell).
Information: `http://www.math.rochester.edu/people/faculty/cmlr/Finger-Lakes-Seminar/`.

May 2015

3–7 **Mal'tsev Meeting**, Sobolev Institute of Mathematics (SB RAS), Novosibirsk, Russia. (Nov. 2014, p. 1275)

* 4–8 **Commodity Markets and their Financialization**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, CA.
Description: The proliferation of commodity indexes and the dramatic increase of investors gaining commodity exposure through ETFs tracking indexes have changed the landscape of the commodity markets and increased the correlations between commodities and equity, and among commodities included in the same indexes. On the other hand, because of the crucial role played by commodities in modern economies, the growing concern about environmental issues inherent to the production of energy, and the combination of both physical and financial trades, the commodity markets require a treatment independent of the traditional equity, fixed income, foreign exchange and credit markets. A growing number of economists, econometricians and mathematicians are studying the financialization of the commodity markets, which has been taking place over the last 10 years and which cannot be explained by relying on the fundamentals of the physical markets
Information: `http://www.ipam.ucla.edu/programs/workshops/workshop-iii-commodity-markets-and-their-financialization/`.

4–15 **Workshop on Stochastic Processes in Random Media**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Oct. 2014, p. 1107)

* 6–10 **Arithmetic and Algebraic Differentiation: Witt Vectors, Number Theory and Differential Algebra**, University of California, Berkeley, California.
Description: Number theory, algebraic topology and applied model theory have traditionally been quite separate fields, and it has not been easy for experts on Witt vectors and arithmetic differentiation in one of these fields to keep on top of developments in the others, even though they are working with largely the same mathematical objects. The purpose of the conference, then, is to remedy this. We will bring together researchers in these fields who study Witt vectors and arithmetic differentiation from their own points of view and for their own purposes. This will allow them to learn about the latest developments in other fields. Further, we hope that bringing together researchers from very different traditions with very different ways of thinking about the same mathematical objects will lead to jolts forward in all of these fields.
Location: http://www.math.berkeley.edu/~scanlon/ardi15.html.

6–10 **Representation Theory Workshop**, Uppsala University, Uppsala, Sweden. (Jun/Jul 2014, p. 668)

11–15 **Advances in Homogeneous Dynamics**, Mathematical Sciences Research Institute, Berkeley, California. (Jun/Jul 2014, p. 668)

13–16 **13th Viennese Workshop on Optimal Control and Dynamic Games**, Vienna University of Technology, Vienna, Austria. (Nov. 2014, p. 1275)

17–21 **SIAM Conference on Applications of Dynamical Systems (DS15)**, Snowbird Ski and Summer Resort, Snowbird, Utah. (May 2014, p. 556)

18–22 **AIM Workshop: Carleson theorems and multilinear operators**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 796)

* 18–22 **Forensic Analysis of Financial Data**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: This workshop will bring together researchers in machine learning from computer science, statistics, and electrical engineering; financial engineers and economists; applied mathematicians; legal scholars; econometricians; practitioners; and regulators to address the challenging questions raised by the post-mortem analysis of financial crisis data. In light of recent theoretical, empirical, and technological progress (e.g., big data analytics, better understanding of fire sales and liquidity shocks, and secure multi-party computation), the participants will revisit recent market anomalies to find, in hindsight, what could have been done to predict, prepare for, and/or prevent them given the current technology. This workshop will feature the 2014 Green Family Lectures by Andrew Lo. This series consists of a public lecture (Monday, 5/18), a research lecture (Tuesday, 5/19), and a technical lecture (Monday, 5/18). Applications for travel support are due Monday, March 23, 2015.
Information: http://www.ipam.ucla.edu/fmws4.

18–22 **International Conference on Differential & Difference Equations and Applications 2015**, Military Academy, Amadora, Portugal. (Sept. 2014, p. 985)

18–29 **Workshop on New Directions in Stein's Method**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Oct. 2014, p. 1107)

* 26–29 **8th Chaotic Modeling and Simulation International Conference**, Henri Poincaré Institute (IHP), Paris, France.
Description: IHP is the ideal place for the conference as Henri Poincaré is considered as the father of chaotic modeling with his Poincaré recurrence theorem and Poincaré map.

You are kindly invited to participate and to address a talk or to organize an invited session. (The abstract or paper submissions page for all types of submissions (invited or contributed) is open at http://www.cmsim.org/abstractpaper.html.
Topics: The general topics and the special sessions proposed for the conference include but are not limited to: Chaos and nonlinear dynamics, stochastic chaos, chemical chaos, data analysis and chaos, hydrodynamics, turbulence and plasmas, optics and chaos, chaotic oscillations and circuits, chaos in climate dynamics, geophysical flows, biology and chaos, neurophysiology and chaos, Hamiltonian systems, chaos in astronomy and astrophysics, chaos and solitons, micro- and nano- electro-mechanical systems, neural networks and chaos, ecology and economy. The publications of the conference include: 1. The Book of Abstracts in electronic and in paper form 2. Electronic Proceedings in the web in a permanent website 3. Publication in the Journal of "Chaotic Modeling and Simulation" (CMSIM) 4. Book Publications devoted to CHAOS2015 International Conference
Information: For more information and abstract/paper submission and special session proposals please visit the conference website at: http://www.cmsim.org or send email to the conference secretariat at: Conf@cmsim.eu.

27–30 **Seventh International Conference on Dynamic Systems and Applications & Fifth International Conference on Neural, Parallel, and Scientific Computations**, Department of Mathematics, Morehouse College, Atlanta, Georgia. (Aug. 2014, p. 797)

* 28–30 **Geometry, Arithmetic and Physics: Around Motives**, University of Strasbourg, Strasbourg, France.
Description: The conference is part of the series "Encounter between Mathematicians and Theoretical Physicists".
Invited speakers: Norbert A. Campo (Basel), Joseph Ayoub (Zürich), Pierre Cartier (IHES), Hélène Esnault (Berlin), Annette Huber (Freiburg), Bruno Kahn (Paris), Dirk Kreimer (Berlin), Pierre Lochak (Paris), Olav Arnfinn Laudal (Oslo), Hiroaki Nakamura (Osaka), Leila Schneps (Paris), Christophe Soulé (IHES), Walter van Suijlekom (Nijmegen), Pierre Vanhove (IHES), Jörg Wildeshaus (Paris).
Language: English.
Talks: Some of the talks will be survey talks indended for a general audience. Graduate students and young mathematicians are welcome. Registration is required (and free of charge) at this link. Hotel booking can be asked for through the registration link. For practical matters and other questions please contact the organizers: Florence Lecomte: lecomte@math.unistra.fr; Athanase Papadopoulos: athanase.papadopoulos@math.unistra.fr.
Information: http://www-irma.u-strasbg.fr/article1450.html.

28–31 **3rd International Conference on "Applied Mathematics & Approximation Theory-AMAT 2015"**, Ankara, Turkey. (May 2014, p. 557)

31–June 6 **Spring School on Analysis 2015: Function Spaces and Lineability IX**, Paseky nad Jizerou, Krkonose Mountains, Czech Republic. (Nov. 2014, p. 1275)

June 2015

1–5 **AIM Workshop: Stochastic methods for non-equilibrium dynamical systems**, American Institute of Mathematics, Palo Alto, California. (Sept. 2014, p. 985)

1–5 **Integrability in Mechanics and Geometry: Theory and Computations**, Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, Rhode Island. (Nov. 2014, p. 1275)

1–July 31 **Networks in Biological Sciences**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Oct. 2014, p. 1107)

* 5–10 **XVII-th International Conference on Geometry, Integrability and Quantization**, Sts. Constantine and Elena resort, Varna, Bulgaria.
Description: This conference is next in a row of previous meetings on Geometry and Mathematical Physics which took place in Bulgaria - Zlatograd (1995) and annual conferences under the same title in Varna (1998–2014). The overall aim is to bring together experts in classical and modern differential geometry, complex analysis, mathematical physics and related fields, to assess recent developments in these areas and to stimulate new investigations and the international collaboration.
Principal speakers: Metin Gurses, Integrable Curves and Surfaces; Jedrzej Sniatycki, Geometric Quantization; Jose Vargas, The Kaehler Calculus.
Information: `http://www.bio21.bas.bg/conference`.

8–12 **AIM Workshop: Mathematical aspects of physics with non-self-adjoint operators**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 797)

* 14–19 **BIOMATH 2015: International Conference on Mathematical Methods and Models in Biosciences**, University Centre Bachinovo, South-West University, Blagoevgrad, Bulgaria.
Description: The conference is devoted to recent research in life sciences based on applications of mathematics as well as mathematics applied to or motivated by biological studies. It is a multidisciplinary meeting forum for researchers who develop and apply mathematical and computational tools to the study of phenomena in the broad fields of biology, ecology, medicine, biotechnology, bioengineering, environmental science, etc. Contributed talks in any of these fields are invited. Proceedings in volume 4 (2015) of the journal *Biomath*. Selected papers will be published in special issues of other science journals.
International Steering Committee: R. Anguelov (Univ. of Pretoria), Y. Dumont (CIRAD, France), J. Farkas (Univ. of Stirling), P. Hingley (European Patent Office), P. Hinow (Univ. of Wisconsin-Milwaukee), H. Kojouharov (Univ. of Texas at Arlington), J. Lubuma (Univ. of Pretoria), S. Markov (IMI-BAS), N. Pesheva (IMech-BAS), M. R. Roussel (Univ. of Lethbridge), S. Schnell (Univ. of Michigan).
Deadline: Abstracts: March 30, 2015.
Information: `http://www.biomath.bg/2015`.

* 14–21 **Fifty-third International Symposium on Functional Equations (53rd ISFE)**, Hotel Pegaz, Krynica-Zdrój, Poland.
Description: The symposium is devoted to functional equations and inequalities, mean values, equations on algebraic structures, Hyers-Ulam stability, regularity properties of solutions, conditional equations, iteration theory, and their applications to the natural, social and behavioral sciences. Participation is by invitation only. Those wishing to attend the 53rd ISFE should send information on their scientific interests and, preferably, publications, together with their postal and email addresses to Roman Ger, Institute of Mathematics, University of Silesia, Bankowa 14, 40-007 Katowice, Poland; `romanger@us.edu.pl` by January 15, 2015.
Organizing Committee: Consists of M. C. Zdun (chairman), A. Bahyrycz, K. Ciepliński, Z. Leśniak, J. Olko, M. Piszczek, and P. Solarz.
Scientific Committee: R. Ger (chairman), Zs. Páles, J. Rätz, J. Schwaiger, A. Sklar, J. Aczél (honorary chairman), W. Benz, Z. Daróczy, and L. Reich (honorary members).
Information: `http://53isfe.up.krakow.pl/`.

15–19 **Connections in Discrete Mathematics**, Simon Fraser University, Vancouver, Canada. (Jun/Jul 2014, p. 668)

15–19 **MEGA 2015: Effective Methods in Algebraic Geometry**, University of Trento, Povo (Trento), Italy. (Oct. 2014, p. 1107)

15–26 **Summer Graduate School — Geometric Group Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2014, p. 1275)

22–24 **3rd International Conference on "Graph Modelling in Engineering"**, University of Bielsko-Biala, Bielsko-Biala, Poland. (Jun/Jul 2014, p. 668)

22–26 **International conference "Dynamical Systems and Their Applications"**, Institute of Mathematics of National Academy of Sciences of Ukraine, Kiyv, Ukraine. (Sept. 2014, p. 985)

* 26–July 1 **The Eighth Congress of Romanian Mathematicians**, University A.I. Cuza, Iasi, Romania.
Description: The meeting continues an old tradition of holding congresses of Romanian mathematicians; it is largely open to international participation.
Organizer: The Section of Mathematical Sciences of the Romanian Academy, the Romanian Mathematical Society, the Simion Stoilow Institute of Mathematics of the Romanian Academy, the Faculty of Mathematics of "Alexandru Ioan Cuza" University of Iasi, the Faculty of Mathematics and Computer Science of the University of Bucharest, and the "Octav Mayer" Institute of Mathematics of the Romanian Academy, Iasi. Talks will be given in nine main sections. Proposals for special sections are also welcome.
Deadline: December 1, 2014. Preliminary registration by email should be sent to `congmatro@imar.ro`, containing name, affiliation, section of congres, and intention to give a talk.
Information: `http://www.imar.ro/congmatro8/conf.php`.

29–July 10 **Summer Graduate School — Mathematical Topics in Systems Biology**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2014, p. 1276)

July 2015

* 5–12 **24th International Conference on Nearrings, Nearfields and Related Topics**, Manipal Institute of Technology, Manipal University Manipal - 576 104, Karnataka, India.
Description: Algebra is often described as the language of mathematics. Historically, the terms algebra and algorithm originate from the same source. The theory of nearrings is now a sophisticated theory in algebra. The connections between nearrings (especially nearfields) and geometry are well-known. There will be plenary talks, invited talks, and short communication sessions. In addition there will be few special sessions on algebra. Nearring conferences are held approximately every two years to discuss new ideas, share results and identify new trends. The conferences were held previously in countries namely Germany, Italy, USA, UK, Canada, South Africa, Austria etc, starting from the year 1968. In Asia the conference took place earlier in India (in the year 1985) and in Taiwan (in the year 2005).
Information: `http://conference.manipal.edu/nearrings2015`.

6–10 **Classical and quantum hyperbolic geometry and topology/ Topologie et géométrie hyperbolique classique et quantique**, Université Paris-Sud, Orsay, France. (Jun/Jul 2014, p. 668)

6–10 **Equadiff 2015**, Université Claude Bernard Lyon 1, Lyon, France. (Oct. 2014, p. 1107)

6–10 **10th IMACS Seminar on Monte Carlo Methods**, Johannes Kepler University Linz and Radon Institute for Computational and Applied Mathematics, Linz, Austria. (Oct. 2013, p. 1205)

8–10 **SIAM Conference on Control and Its Applications (CT15)**, Maison de la Mutualit, Paris, France. (Jun/Jul 2014, p. 668)

12–24 **Summer Graduate School — Gaps between Primes and Analytic Number Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2014, p. 1276)

13–17 **Computational and Analytical Aspects of Image Reconstruction**, Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, Rhode Island. (Nov. 2014, p. 1276)

13–17 **12th International Conference on Finite Fields and Their Applications (Fq12)**, Skidmore College, Saratoga Springs, New York. (Feb. 2014, p. 214)

13–December 18 **Coupling Geometric PDEs with Physics for Cell Morphology, Motility and Pattern Formation**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2014, p. 318)

14–17 **International Conference on Nonlinear Operators, Differential Equations and Applications, ICNODEA-2015**, Babes-Bolyai University, Cluj-Napoca, Romania. (Aug. 2014, p. 797)

20–24 **The 11th International Conference on Fixed Point Theory and Its Applications**, Galatasaray University, Istanbul, Turkey. (Dec. 2013, p. 1497)

20–August 14 **Metric and Analytic Aspects of Moduli Spaces**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2014, p. 318)

* 27–August 1 **XVIII International Congress on Mathematical Physics, ICMP 2015**, Pontificia Universidad Catolica de Chile, Santiago de Chile, RM, Chile.
Description: The International Congress of Mathematical Physics (ICMP), on its three-year cycle, is the most important conference of the International Association of Mathematical Physics (IAMP). The ICMP 2015 will be a major event, where new results and future challenges will be discussed, illustrating the richness and vitality of Mathematical Physics. Following a tradition started in London in 2000, the ICMP 2015 will be preceded by the Young Researchers Symposium (July 24 and 25, 2015). Several satellite meetings are being organized in Valparaiso and Santiago (Chile) and in Sao Paulo (Brazil) either before or after ICMP2015.
Information: `http://www.icmp2015.cl`.

27–August 7 **Summer Graduate School — Incompressible Fluid Flows at High Reynolds Number**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2014, p. 1276)

August 2015

3–7 **AIM Workshop: First passage percolation and related models**, American Institute of Mathematics, Palo Alto, California. (Aug. 2014, p. 797)

3–7 **Differential and combinatorial aspects of singularities**, TU Kaiserslautern, Germany. (Aug. 2014, p. 797)

3–7 **The 3rd Strathmore International Mathematics Conference Theme: Exploring Mathematics and Its Applications**, Strathmore University, Nairobi, Kenya. (Oct. 2014, p. 1107)

* 17–21 **20th International Summer School on Global Analysis and Applications "General Relativity: 100 Years after Hilbert"**, Stara Lesna, High Tatras, Slovakia.
Description: International Summer Schools on Global Analysis and its Applications belong to traditional scientific mathematical meetings, organized annually since 1996 by professor Demeter Krupka and his collaborators. The 2015 Summer School entitled "General Relativity: 100 Years after Hilbert", celebrates the anniversary of the Hilbert variational principle and is devoted to the foundations of general relativity.
Information: `http://www.lepageri.eu/summer-school`.

19–December 18 **Mathematical, Foundational and Computational Aspects of the Higher Infinite**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Sept. 2014, p. 987)

September 2015

1–August 31 **Call for Research Programmes 2015–2016**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Sept. 2014, p. 987)

1–4 **IMA Conference on Numerical Methods for Simulation**, Mathematical Institute, University of Oxford, UK. (Aug. 2014, p. 797)

* 8–December 11 **New Directions in Mathematical Approaches for Traffic Flow Management**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: The recent emergence of new technologies such as sensor networks, smartphones, and new paradigms such as crowdsourcing social networks has induced profound transformations in the way traffic management will be done in the future. Sensor networks have enabled robust and resilient monitoring of the backbone of the transportation network. Smartphones have provided ubiquitous coverage of the transportation network, but provide unpredictable, sometimes unreliable data, which requires a significant amount of filtering. Finally, the emergence of social networks has enabled direct access to people's mobility patterns and the ability to interact with them, thus presenting an opportunity to incentivize behavior change (either through a social group or the social network). Applications for travel support are due Monday, June 8, 2015. Please consult the webpage for more information.
Information: `http://www.ipam.ucla.edu/tra2015`.

9–11 **IMA Conference on Mathematics of Robotics**, St. Anne's College, Oxford, United Kingdom. (Sept. 2014, p. 987)

9–December 4 **ICERM Semester Program: Computational Aspects of the Langlands Program**, Brown University, Providence, Rhode Island. (Jun/Jul 2014, p. 669)

14–18 **The European Numerical Mathematics and Advanced Applications (ENUMATH) Conference**, Institute of Applied Mathematics, Middle East Technical University, Ankara, Turkey. (Dec. 2013, p. 1497)

* 17–19 **The 96th Encounter between Mathematicians and Theoretical Physicists: Geometry and Biophysics**, University of Strasbourg, Strasbourg, France.
Description: The conference is part of the series "Encounters between Mathematicians and Theoretical Physicists".
Invited speakers: Ebbe Sloth Andersen (Aarhus), Joergen Andersen (Aarhus), Hiroyuki Fuji (Tsinghua U.), Misha Gromov (IHES), Sigeo Ihara (Tokyo), Herv Isambert (Paris), Masahide Manabe (Warsaw), Nadya Morozova (IHES), Jose Onuchic (Rice U.), Renzo Ricca (Milan), Piotr Sulkowski (Warsaw and Caltech), Michael Waterman (USC).
Talks: The talks will be in English. Some of the talks will be survey talks intended for a general audience. Graduate students and young mathematicians are welcome.
Registration: Is required (and free of charge) at this link. Hotel booking can be asked for through the registration link. For practical matters and other questions please contact the organizers: Athanase Papadopoulos: `athanase.papadopoulos@math.unistra.fr`; Bob Penner: `rpenner@caltech.edu` and Joanna Sulkowska: `jsulkowska@chem.uw.edu.pl`.
Information: `http://www-irma.u-strasbg.fr/article1453.html`.

21–26 **International Conference in Mathematics Education**, Catania, Sicily, Italy. (Aug. 2014, p. 797)

October 2015

* 12–16 **Workshop II: Traffic Estimation**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: The last decade has seen a sharp increase in the amount of data available for traffic estimation, and furthermore the types of data available has also drastically diversified itself. This evolution has been particularly quick in the last few years, with the explosion of cellular devices, leading to novel sources of traffic data. The workshop will investigate techniques which are commonly used for traffic estimation for partial differential equations, ranging from straight extensions of Kalman filtering to statistical methods such as particle filters (subtopic 1). It will also focus on methods which are statistically based, in particular for the arterial networks for which there is not necessarily sufficient amounts of data (subtopic

2). Subtopic 3 will cover optimization methods applied to networks of PDEs, with specific emphasis on traffic models.

Deadline: Applications received by Monday, August 17, 2015 will receive fullest consideration.

Information: `http://www.ipam.ucla.edu/traws2.`

* 26–30 **Traffic Control**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, CA.

Description: In the past decades, traffic control has mainly included approaches based on ramp metering, i.e., actuation on the freeway via lights preventing a too high flow from entering the freeway during congestion times. In the last years, with the advent of distributed computing, wireless communication and ubiquitous sensing, metering can be achieved at large scale (not only locally), and can be allied with numerous other approaches such as variable speed limits, special use lanes, etc. The mathematical formulation of the underlying problems is quite challenging (for example variable speed limits changes the underlying flow model used in the problem set up). The formulation of the corresponding control problems is also quite difficult, as many times it results in nonlinear nonconvex optimization problems. Numerous approaches have been investigated to solve these problems, which include Lyapunov techniques, adjoint based optimization, and convex relaxation.

Information: `http://www.ipam.ucla.edu/programs/ workshops/workshop-iii-traffic-control/.`

November 2015

* 16–20 **Decision Support for Traffic**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

Description: The next decade will see numerous decision support tools emerge for traffic management. This is mainly due to the fact that all pieces necessary for the development of these tools are now at our disposal, and have emerged in the recent years. This includes sensing, communication, high performance, and modeling capabilities. All over the world, several Departments of Transportation have started to investigate the steps required to build tools capable of advising humans in charge of optimization of mobility at the scale of a city. Specific breakthroughs are already visible in Australia, France, and in the Netherlands. Such tools require significant amount of modeling (the interplay of various control schemes on a distributed parameter system, which can be modeled as a partial differential equation), which will be presented in the first subtopic of the workshop.

Deadline: September 21, 2015.

Information: `http://www.ipam.ucla.edu/programs/ workshops/workshop-iv-decision-support-for- traffic/.`

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

December 2015

* 31–January 4 **String Mathematics 2015**, Sanya, Hainan, China.

Description: String theory plays a central role in theoretical physics as a candidate for the quantum theory unifying gravity with other interactions. It has profound connections with broad branches of modern mathematics ever since the birth. In the last decades, the prosperous interaction, built upon the joint efforts from both mathematicians and physicists, has given rise to marvelous deep results in supersymmetric gauge theory, topological string, M-theory, and duality on the physics side as well as in algebraic geometry, differential geometry, algebraic topology, representation theory, and number theory on the mathematics side. The interplay is two-fold. The mathematics has provided powerful tools to fulfill the physical interconnection of ideas and clarify physical structures to understand the nature of string theory. On the other hand, ideas from string theory and quantum field theory have been a source of significant inspirations to reveal surprising mathematical structures and create new spectrums of mathematics. The aim of the String-Math annual conference is to bring together researchers working at the rapidly developing interface of these two academic fields to exchange current significant ideas and explore future directions.

Information: `http://msc.tsinghua.edu.cn/ sanya/StringMath2015/home.aspx.`

January 2016

* 5–9 **Conference on General Relativity**, Sanya, Hainan, China.

Description: Einstein's general relativistic field equations govern the universe, in particular phenomena in cosmology, astrophysics, and notably gravitational waves. The study of these equations has led to thriving new mathematical research in the areas of geometric analysis, nonlinear partial differential equations (PDE) of hyperbolic and elliptic character, differential geometry as well as in scattering theory and the analysis of asymptotic behavior of solutions. Purely analytic and numerical methods complement each other on this road. Modern mathematical breakthroughs allow to attack and solve physical problems that have been a challenge for the last century. Among these are the study and detection of gravitational waves. These are produced in mergers of black holes or neutron stars or in core-collapse supernovae. Our era faces the verge of detection of these waves, which we can think of as fluctuations in the curvature of the spacetime. Mathematically gravitational waves are investigated by means of geometric analysis as well as numerics. Through geometric analysis Christodoulou's findings of a nonlinear memory effect of gravitational waves, displacing test masses permanently has sparked new research leading to insights into this very effect for other fields coupled to Einstein equations. Moreover, Christodoulou's results on black hole formation have likewise launched abundant activities in hyperbolic PDE. Further the stability of Minkowski spacetime, the stability of black hole spacetimes, the study of the constraint equations, the evolution equations or the Penrose inequality have pushed further mathematical and physical research, thereby having created more challenging questions for the future. This conference discusses recent developments in these areas.

Information: `http://msc.tsinghua.edu.cn/sanya/ 2016/CGR2016/synopsis and organizers.aspx.`

March 2016

* 7–June 10 **Culture Analytics**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

Description: The explosion in the widespread use of the Internet and social media and the ubiquity of low-cost computing have increased the possibilities for understanding cultural behaviors and expressions, while at the same time have facilitated opportunities for making cultural artifacts both accessible and comprehensible. The rapidly proliferating digital footprints that people leave as they crisscross cyberspace offer a treasure trove of cultural information, where culture is considered to be expressive of the norms, beliefs, and values of a group. This program encourages the exploration of the unsolved mathematical opportunities that are emerging in this cultural information space. The application deadline is Monday, December 7, 2015.

Information: `http://www.ipam.ucla.edu/ programs/long-programs/culture-analytics/.`

New Publications Offered by the AMS

Algebra and Algebraic Geometry
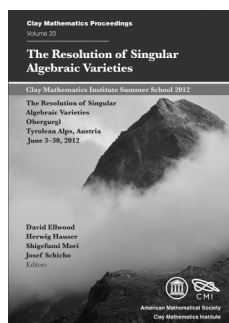
The Resolution of Singular Algebraic Varieties

David Ellwood, *Harvard University, Cambridge, MA*, **Herwig Hauser**, *Universtitat Wien, Vienna, Austria*, **Shigefumi Mori**, *RIMS, Kyoto University, Japan*, and **Josef Schicho**, *Austrian Academy of Sciences, Linz, Austria*, Editors

Resolution of Singularities has long been considered as being a difficult to access area of mathematics. The more systematic and simpler proofs that have appeared in the last few years in zero characteristic now give us a much better understanding of singularities. They reveal the aesthetics of both the logical structure of the proof and the various methods used in it. The present volume is intended for readers who are not yet experts but always wondered about the intricacies of resolution. As such, it provides a gentle and quite comprehensive introduction to this amazing field. The book may tempt the reader to enter more deeply into a topic where many mysteries—especially the positive characteristic case—await to be disclosed.

Titles in this series are co-published with the Clay Mathematics Institute (Cambridge, MA).

Contents: H. Hauser, Blowups and resolution; **A. Bravo** and **O. E. Villamayor U.**, On the behavior of the multiplicity on schemes: Stratification and blow ups; **J. Schicho**, A simplified game for resolution of singularities; **S. D. Cutkosky**, Resolution of singularities in char *p* and monomialization; **S. Encinas**, Resolution of toric varieties; **A. Frühbis-Krüger**, Desingularization in computational applications and experiments; **H. Kawanoue**, Introduction to the idealistic filtration program with emphasis on the radical saturation; **J. Schicho** and **J. Top**, Algebraic approaches to FlipIt; **T. Yasuda**, Higher Semple-Nash blowups and F-blowups.

Clay Mathematics Proceedings, Volume 20

January 2015, approximately 347 pages, Softcover, ISBN: 978-0-8218-8982-4, LC 2014031965, 2010 *Mathematics Subject Classification:* 14-01, 14-06, 14Bxx, 14Exx, 13-01, 13-06, 13Hxx, 32Bxx, 32Sxx, 58Kxx, **AMS members US$80.80**, List US$101, Order code CMIP/20
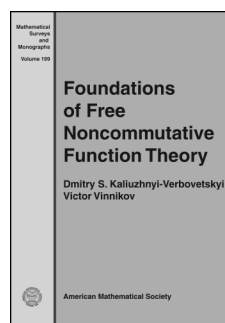
Foundations of Free Noncommutative Function Theory

Dmitry S. Kaliuzhnyi-Verbovetskyi, *Drexel University, Philadelphia, PA*, and **Victor Vinnikov**, *Ben Gurion University of the Negev, Beer Sheva, Israel*

In this book the authors develop a theory of free noncommutative functions, in both algebraic and analytic settings. Such functions are defined as mappings from square matrices of all sizes over a module (in particular, a vector space) to square matrices over another module, which respect the size, direct sums, and similarities of matrices. Examples include, but are not limited to, noncommutative polynomials, power series, and rational expressions.

Motivation and inspiration for using the theory of free noncommutative functions often comes from free probability. An important application area is "dimensionless" matrix inequalities; these arise, e.g., in various optimization problems of system engineering. Among other related areas are those of polynomial identities in rings, formal languages and finite automata, quasideterminants, noncommutative symmetric functions, operator spaces and operator algebras, and quantum control.

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

Contents: Introduction; NC functions and their difference-differential calculus; Higher order nc functions and their difference-differential calculus; The Taylor-Taylor formula; NC functions on nilpotent matrices; NC polynomials vs. polynomials in matrix entries; NC analyticity and convergence of TT series; Convergence of nc power series; Direct summands extensions of nc sets and nc functions; (Some) earlier work on nc functions; Appendix A. Similarity invariant envelopes and extension of nc functions; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 199

December 2014, 183 pages, Hardcover, ISBN: 978-1-4704-1697-3, LC 2014025799, 2010 *Mathematics Subject Classification:* 17A50, 40A05, 46-02, 46L52, 46L54, 47A60, 47L25, **AMS members US$61.60**, List US$77, Order code SURV/199

Analysis
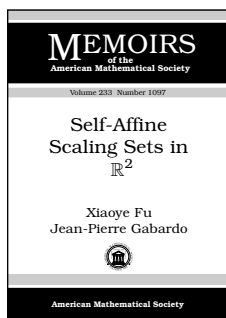
Self-Affine Scaling Sets in $\mathbb{R}^2$

Xiaoye Fu, *The Chinese University of Hong Kong, Shatin, Hong Kong*, and **Jean-Pierre Gabardo**, *McMaster University, Hamilton, ON, Canada*

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

Contents: Introduction; Preliminary results; A sufficient condition for a self-affine tile to be an MRA scaling set; Characterization of the inclusion $K \subset BK$; Self-affine scaling sets in $\mathbb{R}^2$: the case $0 \in \mathcal{D}$; Self-affine scaling sets in $\mathbb{R}^2$: the case $\mathcal{D} = \{d_1, d_2\} \subset \mathbb{R}^2$; Conclusion; Bibliography.
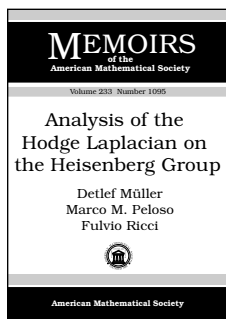
Analysis of the Hodge Laplacian on the Heisenberg Group

Detlef Müller, *Universität Kiel, Germany*, **Marco M. Peloso**, *Universita Degli Studi Di Mila, Milano, Italy*, and **Fulvio Ricci**, *Scuola Normale Superiore, Pisa, Italy*

Contents: Introduction; Differential forms and the Hodge Laplacian on H_n; Bargmann representations and sections of homogeneous bundles; Cores, domains and self-adjoint extensions; First properties of Δ_k; exact and closed forms; A decomposition of $L^2\Lambda_H^k$ related to the ∂ and $\bar{\partial}$ complexes; Intertwining operators and different scalar forms for Δ_k; Unitary intertwining operators and projections; Decomposition of $L^2\Lambda^k$; L^p-multipliers; Decomposition of $L^p\Lambda^k$ and boundedness of the Riesz transforms; Applications; Appendix; Bibliography.

Applications
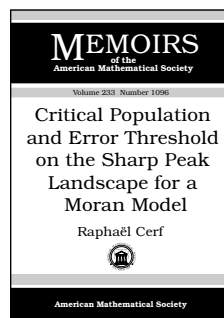
Critical Population and Error Threshold on the Sharp Peak Landscape for a Moran Model

Raphaël Cerf, *Université Paris Sud, Orsay, France*

Contents: Introduction; The model; Main results; Coupling; Normalized model; Lumping; Monotonicity; Stochastic bounds; Birth and death processes; The neutral phase; Synthesis; Appendix on Markov chain; Bibliography; Index.

Discrete Mathematics and Combinatorics
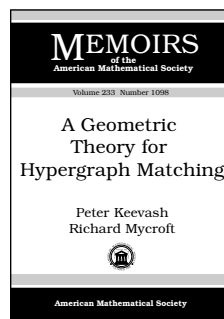
A Geometric Theory for Hypergraph Matching

Peter Keevash, *Queen Mary University of London, United Kingdom*, and **Richard Mycroft**, *University of Birmingham, United Kingdom*

Contents: Introduction; Results and examples; Geometric motifs; Transferrals; Transferrals via the minimum degree sequence; Hypergraph regularity theory; Matchings in k-systems; Packing tetrahedra; The general theory; Bibliography.
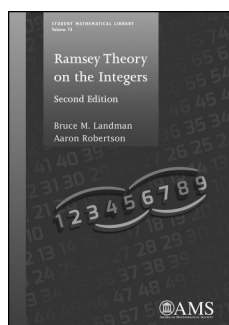
Ramsey Theory on the Integers

Second Edition

Bruce M. Landman, *State University of West Georgia, Carrollton, GA*, and **Aaron Robertson**, *Colgate University, Hamilton, NY*

Ramsey theory is the study of the structure of mathematical objects that is preserved under partitions. In its full generality, Ramsey theory is quite powerful, but can quickly become complicated. By limiting the focus of this book to Ramsey theory applied to the set of integers, the authors have produced a gentle, but meaningful, introduction to an important and enticing branch of modern mathematics. *Ramsey Theory on the Integers* offers students a glimpse into the world of mathematical research and the opportunity for them to begin pondering unsolved problems.

For this new edition, several sections have been added and others have been significantly updated. Among the newly introduced topics are: rainbow Ramsey theory, an "inequality" version of Schur's theorem, monochromatic solutions of recurrence relations, Ramsey results involving both sums and products, monochromatic sets avoiding certain differences, Ramsey properties for polynomial progressions, generalizations of the Erdős-Ginzberg-Ziv theorem, and the number of arithmetic progressions under arbitrary colorings. Many new results and proofs have been added, most of which were not known when the first edition was published. Furthermore, the book's tables, exercises, lists of open research problems, and bibliography have all been significantly updated.

This innovative book also provides the first cohesive study of Ramsey theory on the integers. It contains perhaps the most substantial account of solved and unsolved problems in this blossoming subject. This breakthrough book will engage students, teachers, and researchers alike.

Reviews of the Previous Edition:

Students will enjoy it due to the highly accessible exposition of the material provided by the authors.

—*MAA Horizons*

What a wonderful book! … contains a very "student friendly" approach to one of the richest areas of mathematical research … a very good way of introducing the students to mathematical research … an extensive bibliography … no other book on the subject … which is structured as a textbook for undergraduates … The book can be used in a variety of ways, either as a textbook for a course, or as a source of research problems … strongly recommend this book for all researchers in Ramsey theory … very good book: interesting, accessible and beautifully written. The authors really did a great job!

—*MAA Online*

Contents: Preliminaries; Van der Waerden's theorem; Supersets of AP; Subsets of AP; Other generalizations of $w(k;r)$; Arithmetic progressions (mod m); Other variations on van der Waerden's theorem; Schur's theorem; Rado's theorem; Other topics; Notation; Bibliography; Index.

Student Mathematical Library, Volume 73

December 2014, approximately 396 pages, Softcover, ISBN: 978-0-8218-9867-3, LC 2014025399, 2010 *Mathematics Subject Classification:* 05D10, **All Individuals US$48.80**, List US$61, Institutional member US$48.80, Order code STML/73

Geometry and Topology
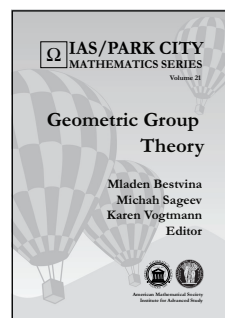
Geometric Group Theory

Mladen Bestvina, *University of Utah, Salt Lake City, UT*, **Michah Sageev**, *Technion-Israel Institute of Technology, Haifa, Israel*, and **Karen Vogtmann**, *University of Warwick, Coventry, United Kingdom*

Geometric group theory refers to the study of discrete groups using tools from topology, geometry, dynamics and analysis. The field is evolving very rapidly and the present volume provides an introduction to and overview of various topics which have played critical roles in this evolution.

The book contains lecture notes from courses given at the Park City Math Institute on Geometric Group Theory. The institute consists of a set of intensive short courses offered by leaders in the field, designed to introduce students to exciting, current research in mathematics. These lectures do not duplicate standard courses available elsewhere. The courses begin at an introductory level suitable for graduate students and lead up to currently active topics of research. The articles in this volume include introductions to CAT(0) cube complexes and groups, to modern small cancellation theory, to isometry groups of general CAT(0) spaces, and a discussion of nilpotent genus in the context of mapping class groups and CAT(0) groups. One course surveys quasi-isometric rigidity, others contain an exploration of the geometry of Outer space, of actions of arithmetic groups, lectures on lattices and locally symmetric spaces, on marked length spectra and on expander graphs, Property tau and approximate groups.

This book is a valuable resource for graduate students and researchers interested in geometric group theory.

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

Titles in this series are co-published with the Institute for Advanced Study/Park City Mathematics Institute. Members of the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM) receive a 20% discount from list price.

Contents: **M. Sageev**, CAT(0) cube complexes and groups; **V. Guirardel**, Geometric small cancellation; **P.-E. Caprace**, Lectures on proper CAT(0) spaces and their isometry groups; **M. Kapovich**, Lectures on quasi-isometric rigidity; **M. Bestvina**, Geometry of outer space; **D. W. Morris**, Some arithmetic groups that do not act on the circle; **T. Gelander**, Lectures on lattices and locally symmetric spaces; **A. Wilkinson**, Lectures on marked length spectrum rigidity; **E. Breuillard**, Expander graphs, property (τ) and approximate groups; **M. R. Bridson**, Cube complexes, subgroups of mapping class groups, and nilpotent genus.

IAS/Park City Mathematics Series, Volume 21

January 2015, 405 pages, Hardcover, ISBN: 978-1-4704-1227-2, LC 2014029886, 2010 *Mathematics Subject Classification:* 20F65, **AMS members US$72**, List US$90, Order code PCMS/21
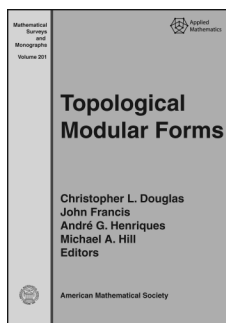
Topological Modular Forms

Christopher L. Douglas, *Oxford University, United Kingdom*, **John Francis**, *Northwestern University, Evanston, IL*, **André G. Henriques**, *Utrecht University, Netherlands*, and **Michael A. Hill**, *University of Virginia, Charlottesville, VA*, Editors

The theory of topological modular forms is an intricate blend of classical algebraic modular forms and stable homotopy groups of spheres. The construction of this theory combines an algebro-geometric perspective on elliptic curves over finite fields with techniques from algebraic topology, particularly stable homotopy theory. It has applications to and connections with manifold topology, number theory, and string theory.

This book provides a careful, accessible introduction to topological modular forms. After a brief history and an extended overview of the subject, the book proper commences with an exposition of classical aspects of elliptic cohomology, including background material on elliptic curves and modular forms, a description of the moduli stack of elliptic curves, an explanation of the exact functor theorem for constructing cohomology theories, and an exploration of sheaves in stable homotopy theory. There follows a treatment of more specialized topics, including localization of spectra, the deformation theory of formal groups, and Goerss–Hopkins obstruction theory for multiplicative structures on spectra. The book then proceeds to more advanced material, including discussions of the string orientation, the sheaf of spectra on the moduli stack of elliptic curves, the homotopy of topological modular forms, and an extensive account of the construction of the spectrum of topological modular forms. The book concludes with the three original, pioneering and enormously influential manuscripts on the subject, by Hopkins, Miller, and Mahowald.

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

Contents: C. Redden, Elliptic genera and elliptic cohomology; C. Mautner, Ellliptic curves and modular forms; A. Henriques, The moduli stack of elliptic curves; H. Hohnhold, The Landweber exact functor theorem; C. L. Douglas, Sheaves in homotopy theory; T. Bauer, Bousfield localization and the Hasse square; J. Lurie, The local structure of the moduli stack of formal groups; V. Angeltveit, Goerss-Hopkins obstruction theory; M. Hopkins, From spectra to stacks; M. Hopkins, The string orientation; M. Hopkins, The sheaf of E_∞ ring spectra; M. Behrens, The construction of tmf; A. Henriques, The homotopy groups of tmf and of its localizations; M. J. Hopkins and H. R. Miller, Ellitpic curves and stable homotopy I; M. Hopkins and M. Mahowald, From elliptic curves to homotopy theory; M. J. Hopkins, $K(1)$-local E_∞ ring spectra; C. L. Douglas, J. Francis, A. G. Henriques, and M. A. Hill, Glossary.

Mathematical Surveys and Monographs, Volume 201

December 2014, 315 pages, Hardcover, ISBN: 978-1-4704-1884-7, LC 2014029076, 2010 *Mathematics Subject Classification:* 55N34, 55N35, 55N22, 57R77, 55T05, 55T15, 18G40, 14H52, 14D23, 13D03, **AMS members US$80**, List US$100, Order code SURV/201
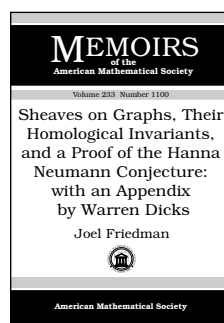
Sheaves on Graphs, Their Homological Invariants, and a Proof of the Hanna Neumann Conjecture

Joel Friedman, *University of British Columbia, Vancouver, Canada* with an Appendix by Warren Dicks

This item will also be of interest to those working in discrete mathematics and combinatorics.

Contents: Foundations of sheaves on graphs and their homological invariants; The Hanna Neumann conjecture; Appendix A. A direct view of ρ-kernels; Appendix B. Joel Friedman's proof of the strengthened Hanna Neumann conjecture *by Warren Dicks*; Bibliography.

Memoirs of the American Mathematical Society, Volume 233, Number 1100

January 2015, 106 pages, Softcover, ISBN: 978-1-4704-0988-3, 2010 *Mathematics Subject Classification:* 20E05, 05C10, 55N30, 18F20; 20E08, 05C05, 05C50, 18F10, 18F20, 14F20, **Individual member US$45**, List US$75, Institutional member US$60, Order code MEMO/233/1100

Math Education
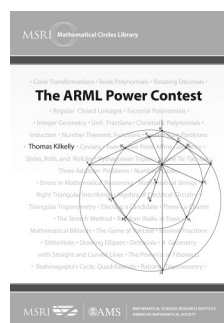
The ARML Power Contest

Thomas Kilkelly, *Wayzata High School (retired), Plymouth, MN*

The ARML (American Regions Math League) Power Contest is truly a unique competition in which a team of students is judged on its ability to discover a pattern, express the pattern in precise mathematical language, and provide a logical proof of its conjectures. Just as a team of students can be self-directed to solve each problem set, a teacher, math team coach, or math circle leader could take these ideas and questions and lead students into problem solving and mathematical discovery.

This book contains thirty-seven interesting and engaging problem sets presented at ARML Power Contests from 1994 to 2013. They are generally extensions of the high school mathematics classroom and often connect two remote areas of mathematics. Additionally, they provide meaningful problem situations for both the novice and the veteran mathlete.

Thomas Kilkelly has been a mathematics teacher for forty-three years. During that time he has been awarded several teaching honors and has coached many math teams to state and national championships. He has always been an advocate for more discovery, integration, and problem solving in the mathematics classroom.

In the interest of fostering a greater awareness and appreciation of mathematics and its connections to other disciplines and everyday life, MSRI and the AMS are publishing books in the Mathematical

Circles Library series as a service to young people, their parents and teachers, and the mathematics profession.

Titles in this series are co-published with the Mathematical Sciences Research Institute (MSRI).

Contents: Color transformations; Induction; Rook polynomials; Rotating decimals; Regular closed linkages; Factorial polynomials; Integer geometry; Unit fractions; Chromatic polynomials; Twenty-five point affine geometry; Square-sum partitions; Slides, rolls, and rolides; Pythagorean triples; Cevians; Insane tic-tac-toe; Three addition problems; Number theoretic functions; Errors in mathematical reasoning; Number theoretic functions; Right triangular inscribings; Algebra of electrical circuitry; Triangular trigonometry; Electing a candidate; Three's a charm!; The stretch method; Random walks in trees; Mathematical billiards; The game of Yahtzee; Basimal fractions; Slitherlinks; Drawing ellipses; Deltorials; A geometry with straight and curved lines; Number puzzles; The power(s) of Fibonacci; Brahmagupta's cyclic quadrilaterals; Rational trigonometry.

MSRI Mathematical Circles Library, Volume 15

December 2014, 376 pages, Softcover, ISBN: 978-1-4704-1880-9, LC 2014027946, 2010 *Mathematics Subject Classification:* 00-XX, 97-XX, 51-XX, 05-XX, 12-XX, **AMS members US$36**, List US$45, Order code MCL/15

Mathematical Physics
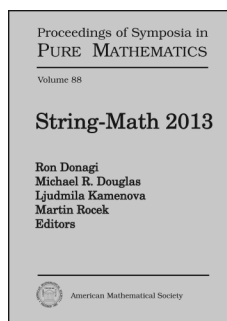
String-Math 2013

Ron Donagi, *University of Pennsylvania, Philadelphia, PA*, and **Michael R. Douglas, Ljudmila Kamenova**, and **Martin Rocek**, *Stony Brook University, NY*, Editors

This volume contains the proceedings of the conference 'String-Math 2013' which was held June 17–21, 2013 at the Simons Center for Geometry and Physics at Stony Brook University. This was the third in a series of annual meetings devoted to the interface of mathematics and string theory.

Topics include the latest developments in supersymmetric and topological field theory, localization techniques, the mathematics of quantum field theory, superstring compactification and duality, scattering amplitudes and their relation to Hodge theory, mirror symmetry and two-dimensional conformal field theory, and many more.

This book will be important reading for researchers and students in the area and for all mathematicians and string theorists who want to update themselves on developments in the math-string interface.

Contents: *Plenary talks:* **K. Costello**, Integrable lattice models from four-dimensional field theories; **D. S. Freed**, Anomalies and invertible field theories; **L. Katzarkov** and **Y. Liu**, Categorical base loci and spectral gaps, via Okounkov bodies and Nevanlinna theory; **B. Pioline**, Rankin-Selberg methods for closed string amplitudes; **S. Schäfer-Nameki**, Singular fibers and Coulomb phases; **P. Vanhove**, The physics and the mixed Hodge structure of Feynman integrals; *Contributed talks:* **M. Alim**, Polynomial rings and topological strings; **L. B. Anderson**, Exploring novel geometry in heterotic/F-theory dual pairs; **M. Bertolini, I. V. Melnikov**, and

M. R. Plesser, Massless spectrum for hybrid CFTs; **I. Brunner, N. Carqueville**, and **D. Plencner**, A quick guide to defect orbifolds; **C. Daenzer**, Geometric t-dualization; **A. Dey**, Mirror symmetry in flavored affine D-type quivers; **T. Dimofte**, Duality domain walls in class $S[A_1]$; **J. Gray, A. Haupt**, and **A. Lukas**, Calabi-Yau fourfolds in products of projective space; **T. Johnson-Freyd**, Poisson AKSZ theories and their quantizations; **C. A. Keller**, Modularity, Calabi-Yau geometry and 2d CFTs; **P. Koroteev**, Three dimensional mirror symmetry and integrability; **A. Lai**, Strict deformation quantisation of the G-connections via Lie groupoid; **T. Okazaki** and **S. Yamaguchi**, Supersymmetric boundary conditions in 3d $\mathcal{N} = 2$ theories; **C. Papageorgakis** and **A. B. Royston**, Instanton-soliton loops in 5D super-Yang-Mills; **C. Y. Park**, 2d SCFT from M-branes and its spectral network.

Proceedings of Symposia in Pure Mathematics, Volume 88

January 2015, approximately 374 pages, Hardcover, ISBN: 978-1-4704-1051-3, LC 2014030695, 2010 *Mathematics Subject Classification:* 14-XX, 18-XX, 19-XX, 22-XX, 53-XX, 58-XX, 81-XX, 81Txx, 83Exx, 83E30, **AMS members US$80.80**, List US$101, Order code PSPUM/88
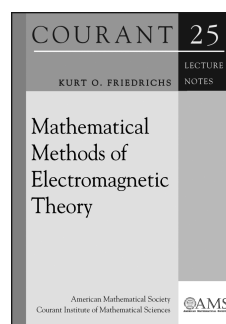
Mathematical Methods of Electromagnetic Theory

Kurt O. Friedrichs

This text provides a mathematically precise but intuitive introduction to classical electromagnetic theory and wave propagation, with a brief introduction to special relativity. While written in a distinctive, modern style, Friedrichs manages to convey the physical intuition and 19th century basis of the equations, with an emphasis on conservation laws. Particularly striking features of the book include: (a) a mathematically rigorous derivation of the interaction of electromagnetic waves with matter, (b) a straightforward explanation of how to use variational principles to solve problems in electro- and magnetostatics, and (c) a thorough discussion of the central importance of the conservation of charge. It is suitable for advanced undergraduate students in mathematics and physics with a background in advanced calculus and linear algebra, as well as mechanics and electromagnetics at an undergraduate level.

Apart from minor corrections to the text, the notation was updated in this edition to follow the conventions of modern vector calculus.

This item will also be of interest to those working in differential equations.

Titles in this series are co-published with the Courant Institute of Mathematical Sciences at New York University.

Contents: Preliminaries; Electrostatics; Currents and Ohm's law; Magnetostatics; Electromagnetic fields changing in time; Transmission lines. Method of the Laplace transformation; Electromagnetodynamics of moving bodies and the principle of relativity; Electromagnetic wave propagation; The scattering problem; References.

Courant Lecture Notes, Volume 25

December 2014, 145 pages, Softcover, ISBN: 978-1-4704-1711-6, LC 2014027921, 2010 *Mathematics Subject Classification:* 78-01, 78-03, 78A30, 78A40, 35-01, **AMS members US$27.20**, List US$34, Order code CLN/25

Probability and Statistics
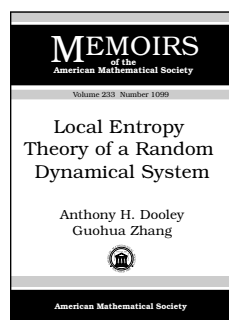
Local Entropy Theory of a Random Dynamical System

Anthony H. Dooley, *University of Bath, United Kingdom*, and **Guohua Zhang**, *Fudan University, Shanghai, People's Republic of China*

Contents: Introduction; *Preliminaries:* Infinite countable discrete amenable groups; Measurable dynamical systems; Continuous bundle random dynamical systems; *A Local Variational Principle for Fiber Topological Pressure:* Local fiber topological pressure; Factor excellent and good covers; A variational principle for local fiber topological pressure; Proof of main result Theorem 7.1; Assumption (♠) on the family **D**; The local variational principle for amenable groups admitting a tiling Følner sequence; Another version of the local variational principle; *Applications of the Local Variational Principle:* Entropy tuples for a continuous bundle random dynamical system; Bibliography.

Memoirs of the American Mathematical Society, Volume 233, Number 1099

January 2015, 106 pages, Softcover, ISBN: 978-1-4704-1055-1, 2010 *Mathematics Subject Classification:* 37A05, 37H99; 37A15, 37A35, **Individual member US$45**, List US$75, Institutional member US$60, Order code MEMO/233/1099

New AMS-Distributed Publications

Logic and Foundations
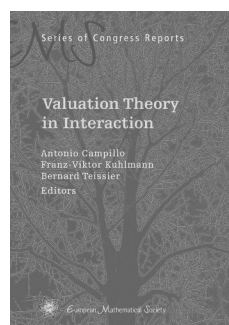
Valuation Theory in Interaction

Antonio Campillo Lopez, *Universidad de Valladolid, Spain*, **Franz-Viktor Kuhlmann**, *University of Saskatchewan, Saskatoon, Canada*, and **Bernard Teissier**, *Institut de Mathematiques de Jussieu, Paris, France*, Editors

For more than a century, valuation theory has had its classical roots in algebraic number theory, algebraic geometry and the theory of ordered fields and groups. In recent decades it has seen an amazing expansion into many other areas. Moreover, having been dormant for a while in algebraic geometry, it has now been reintroduced as a tool to attack the open problem of resolution of singularities in

positive characteristic and to analyze the structure of singularities. Driven by this topic, and by its many new applications in other areas, the research in valuation theory itself has also been intensified, with a particular emphasis on the deep open problems in positive characteristic.

The multifaceted development of valuation theory has been monitored by two International Conferences and Workshops: the first in 1999 in Saskatoon, Canada, and the second in 2011 in Segovia and El Escorial in Spain. This book grew out of the second conference and presents high quality papers on recent research together with survey papers that illustrate the state of the art in several areas and applications of valuation theory.

This book is addressed to researchers and graduate students who work in valuation theory or the areas where it is applied, as well as a general mathematical audience interested in the expansion and usefulness of the valuation theoretical approach, which has been called the "most analytic" form of algebraic reasoning. For young mathematicians who want to enter these areas of research, it provides a valuable source of up-to-date information.

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

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: K. Aghigh, **A. Bishnoi**, **S. Kumar**, and **S. K. Khanduja**, A study of irreducible polynomials over Henselian valued fields via distinguished pairs; **L. Bary-Soroker** and **A. Fehm**, On fields of totally $\mathfrak{s}$-adic numbers—With an appendix by Florian Pop; **A. Blaszczok**, Infinite towers of Artin-Schreier defect extensions of rational function fields; **S. Boucksom**, **C. Favre**, and **M. Jonsson**, A refinement of Izumi's Theorem; **P. Cassou-Noguès** and **A. Libgober**, Multivariable Hodge theoretical invariants of germs of plane curves. II; **V. Cossart**, **M. Matusinski**, and **G. Moreno-Socías**, Existence des diviseurs dicritiques, d'après S. S. Abhyankar; **V. Cossart**, **O. Piltant**, and **A. J. Reguera**, Invariants of the graded algebras associated to divisorial valuations dominating a rational surface singularity; **P. C. Kovacsics**, An introduction to *C*-minimal structures and their cell decomposition theorem; **S. D. Cutkosky**, Valuation semigroups of Noetherian local domains; **S. Durhan**, Additive polynomials over perfect fields; **D. Gondard-Cozette**, On $\mathbb{R}$-places and related topics; **F. J. Herrera Govantes**, **M. A. Olalla Acosta**, **M. Spivakovsky**, and **B. Teissier**, Extending valuations to formal completions; **A. Granja**, **M. C. Martínez**, and **C. Rodríguez**, Extending real valuations to skew polynomial rings; **I. Halupczok**, Stratifications in valued fields; **E. Hrushovski**, Imaginaries and definable types in algebraically closed valued fields; **F.-V. Kuhlmann** and **A. Naseem**, Defects of algebraic function fields, completion defects and defect quotients; **M. Matusinski**, On generalized series fields and exponential-logarithmic series fields with derivations; **H. Mourtada**, Jet schemes of rational double point singularities; **J. Novacoski**, Valuations centered at a two-dimensional regular local domain: infima and topologies; **J. Novacoski** and **M. Spivakovsky**, Reduction of local uniformization to the rank one case; **F. Pop**, Little survey on large fields—old and new; **S. Sarussi**, Quasi-valuations—topology and the weak approximation theorem; **B. Teissier**, Overweight deformations of affine toric varieties and local uniformization; **A. Topaz**, Detecting valuations using small Galois groups; **L. van den Dries**, Truncation in Hahn fields; **E. Yurova**, The ergodicity of 1-Lipschitz transformations on 2-adic spheres; **L. Xiao** and **I. Zhukov**, Ramification of higher local fields, approaches and questions.

EMS Series of Congress Reports, Volume 10

August 2014, 670 pages, Hardcover, ISBN: 978-3-03719-149-1, **AMS members US$94.40**, List US$118, Order code EMSSCR/10

Classified Advertisements

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

CALIFORNIA

CALIFORNIA INSTITUTE OF TECHNOLOGY
Harry Bateman Research Instructorships in Mathematics

Description: Appointments are for two years with one-year terminal extension expected. The academic year runs from approximately October 1 to June 1. Instructors typically are expected to teach one course per quarter for the full academic year and to devote the rest of their time to research. During the summer months there are no duties except research.

Eligibility: Open to persons who have recently received their doctorates in mathematics.

Deadline: January 1, 2015.

Application information: Please apply online at `http://mathjobs.org`. You can also find information about this position at `http://www.math.caltech.edu/positions.html`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000067

CALIFORNIA INSTITUTE OF TECHNOLOGY
Scott Russell Johnson Senior Postdoctoral Scholar in Mathematics

Description: There are three terms in the Caltech academic year. The fellow is typically expected to teach one course in two terms each year, and is expected to be in residence even during terms when not teaching. The initial appointment is for three years with an additional three-year terminal extension expected.

Eligibility: Offered to a candidate within six years of having received the PhD who shows strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Deadline: January 1, 2015.

Application information: Please apply online at `http://mathjobs.org`. You can also find information about this position at `http://www.math.caltech.edu/positions.html`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000068

CALIFORNIA INSTITUTE OF TECHNOLOGY
Olga Taussky and John Todd Instructorships in Mathematics

Description: Appointments are for three years. There are three terms in the Caltech academic year, and instructors typically are expected to teach one course in all but two terms of the total appointment. These two terms will be devoted to research. During the summer months there are no duties except research.

Eligibility: Offered to persons within three years of having received the PhD who show strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Deadline: January 1, 2015.

Application information: Please apply online at `http://mathjobs.org`. You can also find information about this position at `http://www.math.caltech.edu/positions.html`. To avoid duplication of paperwork, your application may also be considered for a Harry Bateman Research Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000069

CALIFORNIA STATE UNIVERSITY, FULLERTON
Mathematics Department

The Department of Mathematics invites applications for two tenure-track positions in Mathematics Education. Candidates for these positions should be mathematics educators or mathematicians with a strong interest and experience in Mathematics Education. A complete description of the position is available at `math.fullerton.edu`. Applicants must submit their materials through `www.mathjobs.org`. Review of applications will begin on

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October 6, 2014, and continue until the position is closed.

California State University Fullerton celebrates all forms of diversity and is deeply committed to fostering an inclusive environment within which students, staff, administrators, and faculty thrive. Individuals interested in advancing the university's strategic diversity goals are strongly encouraged to apply. EEO Employer. Reasonable accommodations will be provided for qualified applicants with disabilities who self-disclose.

000102

UNIVERSITY OF CALIFORNIA SAN DIEGO
Stefan E. Warschawski Visiting Assistant Professorship - 7/1/2015

The Department of Mathematics within the Division of Physical Sciences at the University of California, San Diego (`http://www.math.ucsd.edu`), is committed to an excellent and diverse faculty, staff, and student body. We are seeking an outstanding candidate for a special three-year visiting assistant professorship, the S. E. Warschawski Visiting Assistant Professorship, pending funding approval. We encourage applications in any area of pure mathematics, applied mathematics, or statistics. The nine-month salary is $61,100. This is a three-year nonrenewable appointment.

Applicants should possess a recent PhD degree (received no earlier than 2010) in mathematics. Candidates should have excellent teaching skills and excellent research potential. Candidates with teaching and research interests compatible with current faculty are sought. The successful candidate will have potential for leadership in areas contributing to diversity, equity, and inclusion.

For full consideration, applications should be submitted by December 1, 2014, to `http://apptrkr.com/524242` AA/EOE.

000095

UNIVERSITY OF CALIFORNIA SANTA BARBARA
Career Lecturer Position in the Department of Mathematics

The Department of Mathematics at the University of California, Santa Barbara, seeks applications for a full-time career Lecturer with Potential Security of Employment (similar to tenure-track), beginning July 1, 2015.

Qualifications: Candidates must possess a PhD in mathematics or a closely related field. The successful applicant will be a broadly trained mathematician who is dedicated to undergraduate teaching and pedagogy, and who is interested in belonging to a stimulating research department.

Duties and Responsibilities: In addition to making significant contributions to lower-division teaching, the Lecturer PSOE will assist with curriculum development, advise undergraduate students, and participate in service activities. Specific duties include the development and implementation of new courses and curricula at the undergraduate level and leadership roles in undergraduate activities and advising, in community outreach activities and in improving instructional resources. It is expected that the Lecturer PSOE will be involved in the submission of grants, attend relevant professional meetings, review programs, and mentor visiting and junior faculty. The Lecturer PSOE will interact directly with senior faculty, virtually all of whom teach in the lower division on a regular basis.

Further information about mathematics at UCSB can be found at `http://www.math.ucsb.edu`.

To apply for this position, applicants should submit a letter of interest outlining experiences and qualifications including teaching philosophy and mathematical interests and accomplishments together with a curriculum vita, and arrange for at least three letters of recommendation to be sent. Materials should be submitted electronically via `http://www.mathjobs.org`. Applications received on or before January 1, 2015, will be given full consideration. For questions or additional information, please email: `recruitment@math.ucsb.edu`.

The department is especially interested in candidates who can contribute to the diversity & excellence of the academic community through teaching and service. The University of California, Santa Barbara, is an Equal Opportunity/Affirmative Action Employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, or any other characteristic protected by law including protected veterans, and individuals with disabilities.

000094

UNIVERSITY OF SOUTHERN CALIFORNIA
Department of Mathematics

The Department of Mathematics in the Dana and David Dornsife College of Letters, Arts, and Sciences of the University of Southern California in Los Angeles, California, seeks to fill two tenure-track Assistant Professor positions with an anticipated start date of August 2015.

Candidates with research interests either in analysis or in statistics-related areas will be considered. Candidates should have demonstrated excellence in research and a strong commitment to graduate and undergraduate education. A doctoral degree is required at the time of appointment.

To apply, please submit the following materials: letter of application and curriculum vitae, including your email address, telephone numbers, preferably with the standardized AMS Cover Sheet.

Candidates should also arrange for at least three letters of recommendation that address research, at least one of which also addresses teaching skills. Please submit applications electronically through MathJobs at `http://www.mathjobs.org`. In order to be considered for this position, applicants are also required to submit an electronic USC application; follow this job link or paste in a browser: `http://jobs.usc.edu/postings/29916`.

Review of applications will begin October 15, 2014. Additional information about the USC Dornsife's Department of Mathematics can be found at our website `dornsife.usc.edu/mathematics/`.

USC is an Equal Opportunity Educator and Employer, proudly pluralistic and firmly committed to providing equal opportunity for outstanding persons of every race, gender, creed, and background. The university particularly encourages women, members of underrepresented groups, veterans and individuals with disabilities to apply. USC will make reasonable accommodations for qualified individuals with known disabilities unless doing so would result in an undue hardship. Further information is available by contacting `uschr@usc.edu`.

000075

INDIANA

DEPAUW UNIVERSITY
Mathematics Department - Statistics

Description: Tenure-track position beginning August 2015. PhD preferred, ABD considered. Rank/salary commensurate with experience. Demonstrated effectiveness in teaching undergraduate mathematics, statistics, and actuarial science courses and interest in undergraduate research preferred. Teaching: service courses in calculus, discrete mathematics, statistics, actuarial science, and First-Year Seminar program. Exceptional faculty development programs including pre-tenure leave and internal grants. For application instructions see `http://apply.interfolio.com/26530`. Applications received by December 31, 2014, will receive full consideration. EEOE. Women and members of underrepresented groups encouraged to apply.

000097

KANSAS

UNIVERSITY OF KANSAS
Bischoff-Stouffer Distinguished Professor

The Department of Mathematics at the University of Kansas invites applications for the Bischoff-Stouffer Distinguished Professor of Mathematics. The position is open to all fields of mathematics.

Candidates must demonstrate an outstanding record of research and be acknowledged leaders in their field. Candidates must also be strongly committed to excellence in teaching. We anticipate the appointment to be made at the level of full professor with tenure, though outstanding candidates at the associate professor level are also encouraged to apply. Position is expected to begin August 18, 2015. For a complete announcement and to apply online, go to `https://employment.ku.edu/academic/1840BR` or `https://employment.ku.edu` and click "Search Faculty Jobs"; search by key word [BISCHOFF-STOUFFER]. Initial review of applications begins November 15, 2014, and continues as needed to ensure a large, high quality, and diverse applicant pool. KU is an EO/AAE. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex (including pregnancy), age, national origin, disability, genetic information, or protected veteran status.

000092

UNIVERSITY OF KANSAS
Department of Mathematics

Applications are invited for a Visiting Assistant Professor position in algebra. Position expected to begin August 18, 2015. This appointment is a non-tenure-track, limited term appointment for three academic years (272 days). Preference will be given to candidates whose research meshes well with current faculty interests in the designated area. PhD or ABD in math or a related field is expected by the start date of the appointment; commitment to excellence in teaching mathematics and commitment to excellence in research are expected. For a complete announcement and to apply online, go to `https://employment.ku.edu/academic/1843BR` and click "Search Faculty Jobs" or search by "VAP MATH." A complete online application includes: C.V., cover letter, research and teaching statements, and the names and contact information for four references. In addition, at least four recommendation letters (teaching ability must be addressed in at least one letter) should be submitted electronically to `https://www.mathjobs.org/jobs/jobs/`, position #6341. Initial review of applications will begin December 1, 2014, and continue as long as needed to identify a qualified pool. KU is an EO/AAE. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex (including pregnancy), age, national origin, disability, genetic information, or protected veteran status.

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MARYLAND

JOHNS HOPKINS UNIVERSITY
Tenure-track Position
in Financial Mathematics

The Department of Applied Mathematics and Statistics at Johns Hopkins University invites applications to fill a tenure-track position in financial mathematics. Exceptionally qualified candidates at all ranks will be considered. A successful candidate must have a doctorate in mathematics, applied mathematics, or a closely related field and will be expected to develop a successful research program in financial mathematics. The Department of Applied Mathematics and Statistics currently has ten tenure-track or tenured faculty members in the fields of probability, statistics, discrete mathematics, optimization, and partial differential equations. Electronic submission of applications to `https://www.mathjobs.org/jobs/jobs/6230` is strongly preferred. If necessary, paper applications may be sent to:

Faculty Search Committee: Financial Mathematics
Department of Applied Mathematics and Statistics
Johns Hopkins University
100 Whitehead Hall
3400 N. Charles Street
Baltimore, MD 21218-2682

Applications should include a cover letter describing the principal expertise of the applicant, a statement of teaching philosophy, a statement of research interests and experiences, and a curriculum vitae. Junior applicants should arrange to have 3-5 letters of recommendation sent. Applicants awarded a PhD in June 2013 or later should provide photocopies of graduate transcripts. The department will start reviewing applications by December 31, 2014. Applications received after this date may still be considered, provided that the position remains available. The department is committed to building a diverse educational environment; women and minorities are strongly encouraged to apply. The Johns Hopkins University is an EEO/AA Employer.

000084

MASSACHUSETTS

BOSTON COLLEGE
Full-Time, Non-Tenure-Track Position

The Department of Mathematics at Boston College invites applications for the position of Assistant Professor of the Practice of Mathematics, a full-time, non-tenure-track position beginning in Fall 2015. The initial appointment will be for 3 years, with the possibility of ongoing renewals. Our priority is to hire an outstanding teacher, qualified to teach courses at both the lower-division and upper-division levels. Preference will be given to candidates who are qualified to teach courses in statistics, who are able to expand the repertoire of upper-division electives offered by our department (e.g., new courses related to statistical theory and practice), or who are able to expand the research opportunities available to our undergraduate majors (e.g., through an REU program). Requirements include a PhD or equivalent in mathematics or statistics, and demonstrated excellence in teaching mathematics or statistics. Candidates with expertise in statistics should demonstrate success in working on a data-intensive project and in teaching both mathematics and statistics courses. A completed application should contain a cover letter, a curriculum vitae, a teaching statement that includes a description of specific ways in which the candidate could enhance our undergraduate program, and at least four letters of recommendation. Three or more of the letters of recommendation should primarily deal with the candidate's teaching. Applications completed no later than December 31, 2014, will be assured our fullest consideration. Please submit all application materials through `http://MathJobs.org`. Applicants may learn more about the department, its faculty and its programs, and about Boston College at `http://www.bc.edu/math`. Electronic inquiries concerning this position may be directed to `math-search@bc.edu`. Boston College is an Affirmative Action/Equal Opportunity Employer. Applications from women, minorities, and individuals with disabilities are encouraged.

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BOSTON COLLEGE
Postdoctoral Position

The Department of Mathematics at Boston College invites applications for a postdoctoral position beginning Fall 2015. This position is intended for a new or recent Ph.D. with outstanding potential in research and excellent teaching. This is a 3-year Visiting Assistant Professor position, and carries a 2-1 annual teaching load. Research interests should lie within Number Theory, Representation Theory, or related areas. Candidates should expect to receive their PhD prior to the start of the position and have received the PhD no earlier than Spring 2014. Applications must include a cover letter, description of research plans, teaching statement, curriculum vitae, and four or more letters of recommendation, with at least one addressing the candidate's teaching qualifications. Applications received no later than January 1, 2015, will be assured our fullest consideration. Please submit all application materials through `MathJobs.org`. Applicants may learn more about the department, its Faculty and its programs and about Boston College at `http://www.bc.edu/math`. Email inquiries concerning this position may be directed to `postdoc-search@bc.edu`. Boston College is an

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TUFTS UNIVERSITY
Department of Mathematics
Tenure-Track Position
Number Theory

Applications are invited for a tenure-track Assistant Professor position in number theory, including arithmetic geometry, to begin September 1, 2015. Applicants must hold a doctorate by the beginning of the appointment, must have an active research program, must show promise of outstanding research, and must exhibit a strong commitment to excellence in teaching. Preference may be given to candidates who show potential for interaction with mathematical researchers in the department. The position has a teaching load of two courses per semester. Applications should include a cover letter, curriculum vitae, a research statement, and a teaching statement. These documents should be submitted electronically through `https://www.mathjobs.org/jobs/jobs/6270`. In addition, applicants should arrange for three letters of recommendation to be submitted electronically on their behalf through `http://www.mathjobs.org`. If a recommender cannot submit online, we will also accept signed PDF attachments sent to `george.mcninch@tufts.edu` or paper letters mailed to NT Search Committee Chair, Department of Mathematics, Bromfield-Pearson Hall, Tufts University, Medford, MA 02155. Review of applications will begin on December 1, 2014, and will continue until the position is filled. Tufts University is an Affirmative Action/Equal Opportunity Employer and is committed to increasing the diversity of its faculty. Members of underrepresented groups are strongly encouraged to apply.

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WILLIAMS COLLEGE
Department of Mathematics and Statistics

The Williams College Department of Mathematics and Statistics invites applications for one tenure-track position in mathematics, beginning fall 2015, at the rank of assistant professor (in an exceptional case, a more advanced appointment may be considered). We are seeking highly qualified candidates who have demonstrated excellence in teaching, who will establish an active and successful research program, and who will have a PhD by the time of appointment. Williams College is a private, coeducational, residential, highly selective liberal arts college with an undergraduate enrollment of approximately 2,000 students. The teaching load is two courses per 12-week semester and a winter term course every other January. Applicants are encouraged to apply electronically at `http://mathjobs.org` or send a vita and have three letters of recommendation on teaching and research sent to Mihai Stoiciu, Chair of the Hiring Committee, Department of Mathematics and Statistics, Williams College, 18 Hoxsey Street, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluation of applications will begin on November 17 and will continue until the position is filled. All offers of employment are contingent upon completion of a background check. Further information is available here: `faculty.williams.edu/prospective-faculty/background-check-policy/`. For more information on the Department of Mathematics and Statistics, visit `http://math.williams.edu/`. Williams College is a coeducational liberal arts institution located in the Berkshire Hills of western Massachusetts with easy access to the culturally rich cities of Albany, Boston, and New York City. The college is committed to building and supporting a diverse population of students, and to fostering an inclusive faculty, staff, and curriculum. Williams has built its reputation on outstanding teaching and scholarship and on the academic excellence of its students. Please visit the Williams College website `http://www.williams.edu/`. Beyond meeting fully its legal obligations for non-discrimination, Williams College is committed to building a diverse and inclusive community where members from all backgrounds can live, learn, and thrive.

000055

MICHIGAN

MICHIGAN STATE UNIVERSITY
Computational Mathematics, Science and Engineering

The Department of Computational Mathematics, Science and Engineering (CMSE), a new department being created at Michigan State University, invites applications from outstanding candidates for two tenure system open-rank faculty positions in the broad area of mathematical foundations of data science. While all areas of data science will be considered, a special consideration will be given to candidates with a background in applied harmonic analysis, topology of big data and optimization. These two positions are part of a committed multi-year effort to build the Department of Computational Mathematics, Science and Engineering. The positions will be joint appointments with the Department of Mathematics with tenure home in CMSE. The anticipated start date is August 16, 2015.

A significant area of research focus within CMSE will be on the synergy between forward modeling and data science in physical and biological sciences. The majority of positions within the CMSE will be jointly held with other departments on campus, with tenure home in CMSE. Furthermore, the new department will have a mandate to develop an innovative curriculum at the graduate and undergraduate levels that expands upon the role of algorithm development, heterogeneous computing, and the use of computational tools in problem solving. Faculty in the new unit will normally have a 1-1 teaching load.

Preference will be given to candidates with at least two years postdoc experience beyond the PhD. Online application is required. To complete the online application, please go to `https://www.mathjobs.org/jobs/jobs/6393`. The application dossier should include a cover letter, a CV, statements on research and teaching, and at least four letters of recommendation; one of the recommendation letters must specifically address the applicant's ability to teach. Applications received by Dec. 1, 2014, will receive full consideration, but the search will continue until the positions are filled. Questions regarding the position may be directed to Prof. Jianliang Qian, Chair of the Search Committee (`qian@msu.edu`).

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MICHIGAN STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics at Michigan State University will have two tenure-track positions to begin Fall 2015. It is expected that successful applicants will be appointed at the rank of Assistant Professor, but truly outstanding candidates for appointment at higher ranks will be considered. Candidates will be evaluated on their merits in both research and teaching, and excellence is essential in both. Preference will be given to candidates with at least 2 years of experience beyond the Ph.D. Outstanding applicants from all mathematical research areas will be considered. Applicants should send a vita, statement on research and teaching, and should arrange for at least 4 letters of recommendation to be sent, one of which must specifically address the applicant's ability to teach, and apply online at this link: `https://www.mathjobs.org/jobs/jobs/6299`. Review of applications began 10/27/2014 and will continue until the position is filled.

000093

MISSISSIPPI

UNIVERSITY OF MISSISSIPPI
Department of Mathematics

The Department of Mathematics at the University of Mississippi invites applications to fill one tenure-track position at the rank of assistant professor beginning

in January or August 2015. A successful applicant will be expected to teach six hours per week and is expected to conduct a vigorous research program as well as mentoring at the graduate and undergraduate levels.

A PhD in mathematics or a related field, and a specialization in algebra or number theory, or a closely related field, is required. A degree should be earned no later than December 15, 2014, for a January start date, and no later than August 15, 2015, for an August start date.

Applications must be made at `https://jobs.olemiss.edu`, where a CV and statements of both research and teaching are to be uploaded. This same documentation plus a minimum of three letters of recommendation, with at least one concerning teaching, must be uploaded at `mathjobs.org` or mailed directly to Dr. Micah Milinovich, The University of Mississippi, Department of Mathematics, P.O. Box 1848, University, MS 38677-1848, USA. Inquiries concerning the position may be sent to `mdepart@olemiss.edu`. Review of applications will begin immediately and will continue until the position is filled.

The University of Mississippi is located in Oxford, about one hour south of Memphis, TN. *USA Today* named Oxford the "Thriving New South Arts Mecca" and "one of the top six college towns in the nation." The Mathematics Department consists of seventeen tenure/tenure-track professors, one instructional and three visiting professors, nine instructors, and 28 graduate students. It received the AMS Diversity award "Department that Makes a Difference" in 2009. For more information see `http://www.olemiss.edu`.

The University of Mississippi is an EOE/AA/Minorities/Females/Vet/Disability/Title VI/Title IX /504/ADA/ADEA Employer.

000100

UNIVERSITY OF MISSISSIPPI
Department of Mathematics

The Department of Mathematics at the University of Mississippi invites applications to fill one tenure-track position at the rank of assistant professor beginning in August 2015. The successful candidate will teach six (6) hours per week and is expected to conduct a vigorous research program as well as mentoring at the graduate and undergraduate levels.

A PhD in mathematics or a related field, earned no later than August 15, 2015, is required. We encourage applications from outstanding candidates in all areas of analysis, particularly those with research expertise in probability, dynamical systems, ergodic theory, mathematical physics, or a related field.

Applications must be made at `https://jobs.olemiss.edu`, where a CV and statements of research and teaching are to be uploaded. This same documentation plus

a minimum of three (3) letters of recommendation, with at least one addressing teaching, has to be either uploaded at `http://www.mathjobs.org/jobs` or mailed directly to Dr. Erwin Mina-Diaz, The University of Mississippi, P.O. Box 1848, Department of Mathematics, University, MS 38677-1848, USA.

Inquiries about the position may be sent to `mdepart@olemiss.edu`. Review of applications will begin immediately and continue until the position is filled. The University of Mississippi is located in Oxford, about one hour south of Memphis, TN. *USA Today* named Oxford the "Thriving New South Arts Mecca" and "one of the top six college towns in the nation." The department currently consists of 17 tenure/tenure-track professors, one instructional and three visiting professors, 9 instructors, and 28 graduate students. It received the AMS diversity award "Department that Makes a Difference" in 2009. For more information see `www.olemiss.edu`.

The University of Mississippi is an EOE/AA/Minorities/Females/Vet/Disability/Title VI/Title IX /504/ADA/ADEA Employer.

000101

NEW HAMPSHIRE

DARTMOUTH COLLEGE
Department of Mathematics

Instructorships in Applied and Computational Mathematics, 2-3 years, new or recent PhD graduates with research interest in applied and computational mathematics. Teach 3 ten-week courses spread over 3 terms. Appointment for 26 months, with possible 12-month renewal; monthly salary of $5,202 including two-month research stipend for Instructors in residence during 2 of 3 summer months; if not in residence, salary adjusted accordingly. To initiate an application go to `http://www.mathjobs.org`. Position ID: IACM #6022. You can also access the application through a link at `http://www.math.dartmouth.edu/activities/recruiting/`. General inquiries can be directed to Tracy Moloney, Administrator, Department of Mathematics: email: `tfmoloney@math.dartmouth.edu`. Applications completed by January 5, 2015, considered first. Dartmouth College is committed to diversity and strongly encourages applications from women and minorities.

000060

DARTMOUTH COLLEGE
Department of Mathematics

The Department of Mathematics anticipates a senior opening with initial appointment in the 2015-2016 academic year. The successful applicant will have a research profile with a concentration in

computational or applied mathematics, will be appointed at the level of Full Professor and is expected to have an overall record of achievement and leadership consonant with such an appointment. Applicants should apply online at `http://www.mathjobs.org`. Position ID: PACM #6023. Applications received by December 15, 2014, will receive first consideration. For more information about this position, please visit our website: `http://www.math.dartmouth.edu/activities/recruiting/`. Dartmouth is committed to diversity and encourages applications from women and minorities.

000061

DARTMOUTH COLLEGE
Department of Mathematics

John Wesley Young Research Instructorships, 2-3 years, new or recent PhD graduates whose research overlaps a department member's. Teach 3 ten-week courses spread over 3 terms. Appointment for 26 months, with possible 12-month renewal; monthly salary of $5,202, including two-month research stipend for Instructors in residence during 2 of 3 summer months; if not in residence, salary adjusted accordingly. To initiate an application go to `http://www.mathjobs.org`. Position ID: JWY #6021. You can also access the application through a link at `http://www.math.dartmouth.edu/activities/recruiting/`. General inquiries can be directed to Tracy Moloney, Administrator, Department of Mathematics, `tfmoloney@math.dartmouth.edu`. Applications completed by January 5, 2015, considered first. Dartmouth College is committed to diversity and strongly encourages applications from women and minorities.

000062

DARTMOUTH COLLEGE
Department of Mathematics

The Dartmouth College Department of Mathematics is pleased to announce a tenure-track opening for the academic year 2015-2016. There is a preference for a junior appointment, but appointment at higher rank, with tenure, is possible. The successful applicant will have a research profile with a concentration in applied or computational mathematics. Applicants should apply online at `http://www.mathjobs.org`. Position ID: APACM #6024. Applications received by December 15, 2014, will receive first consideration. For more information about this position, please visit our website: `http://www.math.dartmouth.edu/activities/recruiting/`. Dartmouth is committed to diversity and encourages applications from women and minorities.

000063

NEW YORK

BROOKLYN COLLEGE
Assistant, Associate, or Full Professor–Dynamic Systems (Mathematics)
CUNY Job ID 11216

The Department of Mathematics at Brooklyn College of the City University of New York invites applications for a tenure-track position **Assistant, Associate, or Full Professor–Dynamic Systems (CUNY Job ID 11216)** to begin Fall 2015.

The department seeks a candidate whose research expertise will contribute to the applied mathematics track of the department's Bachelor's Program in Science and whose committee experience will contribute to the department's leadership. PhD in mathematics.

Review of applications will begin on November 15, 2014, and will continue until the position is filled.

For more information and to apply, please visit `http://www.brooklyn.cuny.edu/facultyjobs` and scroll down to Job ID 11216.

AA/EO Employer.

000082

OHIO

THE OHIO STATE UNIVERSITY
Columbus, Ohio
Visiting Assistant Professor
Department of Mathematics

Description: The Department of Mathematics in the College of Arts and Sciences at The Ohio State University anticipates having a tenure-track assistant professor position available in analysis, effective autumn semester 2015. Preference will be given to candidates in harmonic analysis. Further information about the department can be found at `http://www.math.ohio-state.edu`.

Applications will be considered on a continuing basis, but the annual review process begins November 14, 2014.

Requirements: Candidates are expected to have a PhD in mathematics (or related area) and to present evidence of excellence in teaching and research.

Application Instructions: Applications should be submitted online at `http://www.mathjobs.org`. If you cannot apply online, please contact `facultysearch@math.ohio-state.edu` or write to: Hiring Committee, Department of Mathematics, The Ohio State University, 231 W. 18th Avenue, Columbus, Ohio 43210.

Application Deadline: For full consideration, applications must be received online no later than 1/31/2015.

The Ohio State University is an Equal Opportunity Employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation or identity, national origin, disability status, or protected veteran status.

000087

OKLAHOMA

THE UNIVERSITY OF TULSA
Department of Mathematics
Tenure-Track Assistant Professor

The University of Tulsa invites applications for a tenure-track position at the rank of Assistant Professor, beginning fall 2015. Requirements include a PhD in mathematics, a commitment to teaching excellence at undergraduate and graduate levels, and clear indication of potential for productive research in applied mathematics. The successful candidate will be expected to mentor doctoral students.

Current faculty research areas include applied analysis, numerical methods, mathematical physics, mathematical biology, and statistics. Opportunities exist for interdisciplinary research in fields such as computer science, engineering, bioinformatics, neuro-informatics, and physics. More details can be found at `http://www.utulsa.edu/math`.

The University of Tulsa is a privately endowed university ranked in the top 100 Best National Universities by *U.S. News and World Report*.

Review of applications will begin immediately and will continue until the position is filled. Applicants should submit a CV, three letters of reference, and a statement addressing teaching and research through `http://www.mathjobs.org/`. The University of Tulsa is an Equal Opportunity Employer F/M/Disabled/Veteran.

000091

RHODE ISLAND

BROWN UNIVERSITY
ICERM

The Institute for Computational and Experimental Research in Mathematics (ICERM) at Brown University invites applications for its postdoctoral fellowship positions:

ICERM's two Postdoctoral Institute Fellowships are 9-month salaried positions (with possibility of summer support), both commencing in September 2015. One will participate in the fall 2015 "Computational Aspects of the Langlands Program" semester program and remain as a researcher-in-residence during the spring 2016 semester. The other will begin as a researcher-in-residence during the fall 2015 semester and will participate in the spring 2016 "Dimension and Dynamics" semester program.

ICERM's eight Postdoctoral Fellowships are semester-long positions that come with stipends. Four begin in September 2015 during the "Computational Aspects of the Langlands Program" semester program. The other four start in February 2016 during the "Dimension and Dynamics" semester program.

Fall 2015 program: `http://icerm.brown.edu/sp-f15/`. Spring 2016 program: `http://icerm.brown.edu/programs/sp-s16/`.

All Postdoctoral Fellows are matched with faculty advisors.

Eligibility: Applicants must have completed their PhD within three years of the start of the appointment. Applicants must submit an AMS Standard Cover Sheet, curriculum vitae (including publication list), cover letter, research statement, and three letters of recommendation via `Mathjobs.org` (`http://www.mathjobs.org/jobs/ICERM`). Applications will be accepted until all positions are filled.

000088

SOUTH CAROLINA

SMARTSTATE CHAIR IN DATA ANALYSIS, SIMULATION, IMAGING, AND VISUALIZATION
Department of Mathematics
University of South Carolina, Columbia, SC

The University of South Carolina invites inquiries, nominations, and applications for a SmartState Chair in Data Analysis, Simulation, Imaging, and Visualization (DASIV) in conjunction with the Williams-Hedberg-Hedberg Endowed Chair of Mathematics. The Center is co-sponsored with $2 million from the South Carolina Centers of Economic Excellence (CoEE) program (`http://smartstatesc.org/`) for a total endowment of $4 million. The position requires a PhD in mathematics or a related area and an outstanding record of research and teaching. For a complete description of qualifications, go to: `http://www.math.sc.edu/DASIV-Chair`. Applications should be submitted electronically to Professor Pencho Petrushev (`coee@math.sc.edu`). Applicants are encouraged to submit a letter describing their interests and credentials, curriculum vitae, a list of publications, a statement of research interests and accomplishments, and three letters of reference. Applications will be evaluated as they are received by the Search Committee. The University of South Carolina is an Affirmative Action/Equal Opportunity Employer. Minorities and women are especially encouraged to apply. The University of South Carolina does not discriminate in educational or employment opportunities or decisions for qualified persons on the basis of race, color, religion, sex, national origin, age, disability, sexual orientation, or veteran status.

000089

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

UTAH

UNIVERSITY OF UTAH
Department of Mathematics
Hiring Ad 2014-2015

The Department of Mathematics at the University of Utah invites applications for the following faculty positions:

· Several full-time tenure-track or tenured appointments at the level of Assistant, Associate, or Full Professor in all areas of mathematics and statistics.

· Three-year Wylie, Burgess and Tucker Assistant Professor Lecturer positions.

· Three-year RTG postdoctoral fellows in Algebraic Geometry and Topology.

· Three-year RTG postdoctoral fellows in Mathematical Biology.

Applications for all positions must be completed through the website http://www.mathjobs.org/jobs/Utah, and will be accepted until the position(s) have been filled. All applications will be reviewed when they are complete.

The University of Utah is an Affirmative Action/Equal Opportunity Employer and is committed to diversity in its workforce. In compliance with applicable federal and state laws, University of Utah policy of equal employment opportunity prohibits discrimination on the basis of race or ethnicity, religion, color, national origin, sex, age, sexual orientation, gender identity/expression, veteran's status, status as a qualified person with a disability, or genetic information. Individuals from historically underrepresented groups, such as minorities, women, qualified persons with disabilities, and protected veterans are strongly encouraged to apply. Veterans' preference is extended to qualified applicants, upon request and consistent with university policy and state law. Reasonable accommodations in the application process will be provided to qualified individuals with disabilities. To request an accommodation or for further information about university AA/EO policies, please contact the Office of Equal Opportunity and Affirmative Action, 201 S. Presidents Cr., Rm 135, (801) 581-8365 (V/TDD), email: oeo@umail.utah.edu. For more information see http://www.math.utah.edu/positions or email hiring@math.utah.edu.

000076

VIRGINIA

UNIVERSITY OF VIRGINIA
Department of Mathematics
Open Rank in Mathematics

The Department of Mathematics at the University of Virginia, Charlottesville, VA, invites applications for one tenure-track and one tenure-track or tenured open rank full-time positions, to begin in the fall semester of 2015. Applicants must present evidence of outstanding accomplishments and promise in both research and teaching. We seek candidates dedicated to our mission and passionate about teaching in a world-class institution. In addition to developing external funding to support research endeavors, candidates will be expected to teach at the graduate and undergraduate levels and provide service to the university, department and professional organizations. The appointment start date will be August 25, 2015. Applicants must be on track to receive a PhD in the relevant field by May 2015 and must hold a PhD at the time of appointment. Priority will be given to applicants whose research program is in PDEs or combinatorics, but all candidates whose research interests complement the strengths of the department's current faculty will be considered. In targeted areas, evidence of computational research is a plus.

To apply, candidates must submit a Candidate Profile through Jobs@UVa (https://jobs.virginia.edu), search on posting number 0614817 and electronically attach the following: a cover letter of interest describing research agenda and teaching experience, a curriculum vitae, and contact information for four references.

Review of applications will begin November 1, 2014; however, the positions will remain open until filled.

In addition, please submit the following required documents electronically through www.MathJobs.org: A cover letter, an AMS Standard Cover Sheet, a curriculum vitae, a publication list, a description of research, and a statement about teaching interests and experience. The applicant must also have at least four letters of recommendation submitted, of which one must support the applicant's effectiveness as a teacher.

Questions regarding the application process in JOBS@UVa should be directed to: Zvezdana Kish, zk4g@virginia.edu (434)924-9437.

For additional information about the position contact: math-employment@Virginia.EDU.

The university will perform background checks on all new faculty hires prior to making a final offer of employment.

The University of Virginia is an Equal Opportunity and Affirmative Action Employer. Women, minorities, veterans, and persons with disabilities are encouraged to apply.

000103

BRAZIL

FAPESP POSTDOCTORAL RESEARCH FELLOWSHIP
Instituto de Ciências Matemáticas e de Computação,
Universidade de São Paulo at São Carlos, S.P., Brazil

Applications welcome for a postdoctoral position in singularity theory. The position is supported by the FAPESP grant 2014/00304-2. The candidates will be selected based on the following documents: curriculum vitae, short research project, letter indicating the motivation for the position and short description of their expertise. The deadline for proposals is 15, January 2015. Applications should be send to Professor Maria Aparecida Soares Ruas (maasruas@icmc.usp.br).

000083

SINGAPORE

NATIONAL UNIVERSITY OF SINGAPORE (NUS)
Department of Mathematics

The Department of Mathematics at the National University of Singapore (NUS) invites applications for tenured, tenure-track and visiting positions at all levels, beginning in August 2015.

NUS is a research intensive university that provides quality undergraduate and graduate education. The Department of Mathematics has about 65 faculty members and teaching staff whose expertise cover major areas of contemporary mathematical research.

We seek promising scholars and established mathematicians with outstanding track records in any field of pure and applied mathematics. The department, housed in a newly renovated building equipped with state-of-the-art facilities, offers internationally competitive salary with start-up research grants, as well as an environment conducive to active research, with ample opportunities for career development. The teaching load for junior faculty is kept especially light.

The department is particularly interested in, but not restricted to, considering applicants specializing in any of the following areas:
· Partial Differential Equations and Applied Analysis
· Computational Science, Imaging and Data Science
· Operations Research and Financial Mathematics
· Probability
· Combinatorics

Application materials (as PDF files) should be sent to the Search Committee via email search@math.nus.edu.sg.

Please include the following supporting documentation in the application:
1. NUS Personal Data Consent for Job Applicants
http://www.nus.edu.sg/careers/potentialhires/applicationprocess/
NUS-Personal-Data-Consent-for-Job-Applicants.pdf;
2. an American Mathematical Society Standard Cover Sheet;
3. a detailed CV including publications list;
4. a statement (max. of 3 pages) of research accomplishments and plan;
5. a statement (max. of 2 pages) of teaching philosophy and methodology. Please attach evaluation on teaching from faculty members or students of your current institution, where applicable;
6. at least three letters of recommendation including one which indicates the candidate's effectiveness and commitment in teaching.

Please ask your referees to send their letters directly to search@math.nus.edu.sg.

Enquiries may also be sent to this email address. Review process will begin on 15 October, and will continue until positions are filled.

For further information about the department, please visit http://www.math.nus.edu.sg.

000066

PUBLICATIONS FOR SALE

FUNDAMENTALS OF STATISTICS AND PROBABILITY THEORY

A Tutorial Approach has significantly raised the ability of students to learn. Details: http://www.StatsTutorial-Text.com.

000049

Meetings & Conferences of the AMS

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

Washington, District of Columbia

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.

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, *Title to be announced.*

Alexander Furman, University of Illinois at Chicago, *Title to be announced.*

Vera Mikyoung Hur, University of Illinois at Urbana-Champaign, *Title to be announced.*

Mihnea Popa, Northwestern 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 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** 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 Mathematical Modeling of the Financial Markets (Code: SS 32A), **Albert Cohen**, Michigan State University, and **Nick Costanzino**, University of Toronto.

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.

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.

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, *Title to be announced.*

M. Gregory Forest, University of North Carolina at Chapel Hill, *Title to be announced.*

Dan Margalit, Georgia Institute of Technology, *Title to be announced.*

Paul Pollack, University of Georgia, *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.

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**, The 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.

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 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.

Arithmetic Geometry (Code: SS 18A), **Katherine E. Stange**, University of Colorado, Boulder, and **Bianca Viray**, University of Washington.

Cloaking and Metamaterials (Code: SS 9A), **Jichun Li**, University of Nevada, Las Vegas, and **Fernando Guevera Vasquez**, University of Utah.

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 (AMS-AAAS).

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 (AMS-AAAS).

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 PDEs and Variational Methods (Code: SS 5A), **David Costa**, **Zhonghai Ding**, and **Hossein Tehrani**, University of Nevada, Las Vegas.

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.

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.

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 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 www.ams.org/cgi-bin/abstracts/abstract.pl.

Computational Analysis (Code: SS 1A), **George Anastassiou**, 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 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 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.

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 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:

Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 99 in the January 2014 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.)

December 8–12, 2014: ICPAM-Goroka 2014: International Conference on Pure and Applied Mathematics, University of Goroka, Papua, New Guinea.

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.

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2015 Joint Mathematics Meetings Advance Registration/Housing Form

JMM JOINT MATHEMATICS MEETINGS
SAN ANTONIO · JAN 10-13, 2015
AMERICAN MATHEMATICAL SOCIETY
MATHEMATICAL ASSOCIATION OF AMERICA
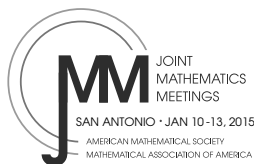
Name _____
(please write name as you would like it to appear on your badge)

Mailing Address _____

_____

Telephone _____ Fax: _____

In case of emergency (for you) at the meeting, call: Day # _____ Evening #: _____

Email Address _____ Additional email address for receipt _____

Acknowledgment of this registration and any hotel reservations will be sent to the email address(es) given here. **Check this box to receive a copy in U.S. Mail:** ☐

Affiliation for badge _____ Nonmathematician guest badge name: _____
(company/university) (Note fee of US$15)

☐ **I DO NOT want my program and badge to be mailed to me on 12/12/14. (Materials will be mailed to the address listed above unless you check this box.)**

Registration Fees

Membership please ✓ all that apply. First row is eligible to register as a JMM member.
☐ AMS ☐ MAA ☐ ASL ☐ CMS ☐ SIAM
☐ AWM ☐ NAM ☐ YMN ☐ AMATYC

Joint Meetings	by Dec 23	at mtg	Subtotal
☐ Member AMS, MAA, ASL, CMS, SIAM	US$ 252	US$ 331	
☐ Nonmember	US$ 400	US$ 510	
☐ Graduate Student (Mem. of AMS or MAA)	US$ 56	US$ 66	
☐ Graduate Student (Nonmember)	US$ 90	US$ 100	
☐ Undergraduate Student	US$ 56	US$ 66	
☐ High School Student	US$ 5	US$ 11	
☐ Unemployed	US$ 56	US$ 66	
☐ Temporarily Employed	US$ 205	US$ 235	
☐ Developing Countries Special Rate	US$ 56	US$ 66	
☐ Emeritus Member of AMS or MAA	US$ 56	US$ 66	
☐ High School Teacher	US$ 56	US$ 66	
☐ Librarian	US$ 56	US$ 66	
☐ Press	US$ 0	US$ 0	
☐ Exhibitor (Commercial)	US$ 0	US$ 0	
☐ Artist Exhibitor (work in JMM Art Exhibit)	US$ 0	US$ 0	
☐ Nonmathematician Guest of registered mathematician	US$ 16	US$ 16	

$_____

AMS Short Course: *Finite Frame Theory: A Complete Introduction to Overcompleteness (1/8–1/9)*

☐ Member of AMS	US$ 108	US$ 142	
☐ Nonmember	US$ 160	US$ 190	
☐ Student, Unemployed, Emeritus	US$ 56	US$ 77	

$_____

MAA Minicourses (see listing in text)
I would like to attend: ☐ One Minicourse ☐ Two Minicourses
Please enroll me in MAA Minicourse(s) #_____ and #_____
Price: US$ 85 for each minicourse.
(For more than 2 minicourses, call or email the MMSB.) $_____

Graduate School Fair
☐ Graduate Program Table   US$ 75   US$ 75
   (includes table, posterboard & electricity) $_____

Receptions & Banquets
☐ Graduate Student/First Time Attendee Reception? (1/10) (no charge)
☐ NAM Banquet (1/12) US$63 #____Chicken #____Vegan
                              #____Kosher
(Additional fees may apply for Kosher meals.)

☐ AMS Dinner (1/13) Regular Price   #____US$ 67
                         Student Price)   #____US$ 25
                                                        $_____

Total for Registrations and Events $_____

Registration for the Joint Meetings is not required for the short course but it is required for the minicourses and the Employment Center. To register for the Employment Center, go to www.ams.org/profession/employment-services/employment-center.

Payment

Registration & Event Total (total from column on left) $ _____

Hotel Deposit (only if paying by check) $ _____

Total Amount To Be Paid $ _____

Method of Payment
☐ **Check**. Make checks payable to the AMS. Checks drawn on foreign banks must be in equivalent foreign currency at current exchange rates. For all check payments, please keep a copy of this form for your records.

☐ **Credit Card**. All major credit cards accepted. For your security, we do not accept credit card numbers by postal mail, email or fax. If the MMSB receives your registration form by fax or postal mail, it will contact you at the phone number provided on this form. For questions, contact the MMSB at mmsb@ams.org.

Signature:_____

☐ **Purchase Order** #_____ (please enclose copy)

Other Information

Mathematical Reviews field of interest # _____
☐ I am a mathematics department chair.
☐ For planning purposes for the MAA Two-year College Reception, please check if you are a faculty member at a two-year college.
☐ Please do not include my name and postal address on any promotional mailing lists. (The JMM does not share email addresses.)
☐ Please do not include my name on any list of JMM participants other than the scientific program if I am, in fact, making a presentation that is part of the meeting.
☐ Please ✓ this box if you have a disability requiring special services.

Deadlines

Eligible for the complimentary room drawing:	**Nov. 3, 2014**
Receiving badges/programs in the mail:	**Nov. 18, 2014**
Housing reservations, changes/cancellations through the JMM website:	**Dec. 17, 2014**
Advance registration for the Joint Meetings, short course, minicourses, and tickets:	**Dec. 23, 2014**
50% refund on banquets, cancel by	**Jan. 5, 2015***
50% refund on advance registration, minicourses, and short course, cancel by	**Jan. 6, 2015***

*no refunds issued after this date

Mailing Address/Contact:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887 Fax: 401-455-4004; **Email:** mmsb@ams.org
Telephone: 401-455-4144 or 1-800-321-4267 x4144 or x4137

2015 Joint Mathematics Meetings Hotel Reservations – San Antonio, TX

(Please see the hotel page in the announcement or on the web for detailed information on each hotel.) To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc. in the column on the left and by circling the requested bed configuration. If your requested hotel and room type is no longer available, you will be assigned a room at the next available comparable rate. Please call the MMSB for details on suite configurations, sizes, availability, etc. All reservations, including suite reservations, must be made through the MMSB to receive the JMM rates. Reservations made directly with the hotels before **December 19, 2014** may be changed to a higher rate. All rates are subject to a 16.75% sales/occupancy tax. **Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.**
☐ **Deposit enclosed (see front of form)**
☐ **Hold with my credit card. For your security, we do not accept credit card numbers by postal mail, email or fax.** If the MMSB receives your registration form by postal mail or fax, we will contact you at the phone number provided on the reverse of this form.

Date and Time of Arrival _____ Date and Time of Departure _____ Number of adult guests in room _____

Name of Other Adult Room Occupant _____ Arrival Date _____ Departure Date _____

Name of Other Adult Room Occupant _____ Arrival Date _____ Departure Date _____

Housing Requests: (example: rollaway cot, crib, nonsmoking room, low floor) _____

☐ I have disabilities as defined by the ADA that require a sleeping room that is accessible to the physically challenged. My needs are: _____

☐ I am a member of a hotel frequent-travel club and would like to receive appropriate credit. The hotel chain and card number are: _____

☐ I am not reserving a room. I am sharing with _____, who is making the reservation.

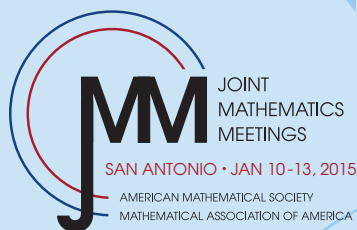| Order of choice	Hotel	Single (1 adult) Rate	Double Rate (2 adults - 1 bed)	Double Rate (2 adults - 2 beds)	Triple (3 adults) Rate	Quad (4 adults) Rate	Rollaway Cot Fee (add to special requests)
	Grand Hyatt San Antonio (hqtrs)	US$ 189	US$ 209	US$ 209	US$ 229	US$ 249	No charge, king rooms only
	Student Rate	US$ 159	US$ 159	US$ 159	US$ 179	US$ 199	No charge, king rooms only
	San Antonio Marriott Rivercenter	US$ 185	US$ 185	US$ 185	US$ 205	US$ 225	US$ 15 one-time fee, king rooms only
	Student Rate	US$ 175	US$ 175	US$ 175	US$ 195	US$ 215	US$ 15 one-time fee, king rooms only
	San Antonio Marriott Riverwalk	US$ 185	US$ 185	US$ 185	US$ 205	US$ 225	US$ 15 one-time fee, king rooms only
	Student Rate	US$ 175	US$ 175	US$ 175	US$ 195	US$ 215	US$ 15 one-time fee, king rooms only
	Hilton Palacio del Rio	US$ 179	US$ 179	US$ 179	US$ 199	US$ 219	air mattresses at US$ 25 one-time fee instead of rollaways, king rooms only
	Student Rate	US$ 159	US$ 159	US$ 159	US$ 179	US$ 199	air mattresses at US$ 25 one-time fee instead of rollaways, king rooms only
	Hyatt Regency San Antonio	US$ 159	US$ 159	US$ 159	US$ 184	US$ 209	US$ 25 per day, king rooms only
	Student Rate	US$ 135	US$ 135	US$ 135	US$ 155	US$ 175	US$ 25 per day, king rooms only
	Hotel Contessa	US$ 140	US$ 140	US$ 140	US$ 190	US$ 215	no rollaways, all rooms have sleeper sofas
	Student Rate	US$ 130	US$ 130	US$ 130	US$ 155	US$ 180	no rollaways, all rooms have sleeper sofas
	LaQuinta Inn & Suites	US$ 135	US$ 135	US$ 135	US$ 135	US$ 135	no rollaways on property
	Student Rate	US$ 125	US$ 125	US$ 125	US$ 125	US$ 125	no rollaways on property
	The Westin Riverwalk San Antonio	US$ 135	US$ 135	US$ 135	US$ 175	US$ 195	No charge, king rooms only
	The Crockett	US$ 130	US$ 130	US$ 130	US$ 140	US$ 150	US$ 25 per day, king rooms only
	Student Rate	US$ 120	US$ 120	US$ 120	US$ 130	US$ 140	US$ 25 per day, king rooms only
	Springhill Suites by Marriott	US$ 94	US$ 94	US$ 94	US$ 94	US$ 94	no rollaways on property; all suites include a sofa-sleeper
	Student Rate	US$ 84	US$ 84	US$ 84	US$ 84	US$ 84	no rollaways on property; all suites include a sofa-sleeper
	Fairfield Inn & Suites by Marriott	US$ 94	US$ 94	US$ 94	US$ 94	US$ 94	no rollaways on property
	Student Rate	US$ 84	US$ 84	US$ 84	US$ 84	US$ 84	no rollaways on property
	Red Roof Plus San Antonio Downtown	US$ 83	US$ 83	US$ 83	US$ 88	US$ 93	no rollaways on property
	Student Rate	US$ 73	US$ 73	US$ 73	US$ 78	US$ 83	no rollaways on property

People interested in suites should contact the MMSB directly by email at mmsb@ams.org or by calling 800-321-4267, ext. 4137 or 4144 (401-455-4137 or 401-455-4144).

Who Wants to Be a Mathematician

$X^2 + X + 1 = 0$

High School Students Compete for $10,000

Photo by Sandy Huffaker.

Photo by Sandy Huffaker.

Photo by Sandy Huffaker.

JMM JOINT MATHEMATICS MEETINGS

SAN ANTONIO · JAN 10-13, 2015

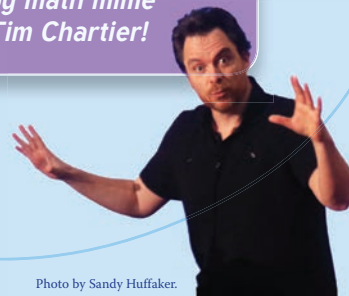AMERICAN MATHEMATICAL SOCIETY
MATHEMATICAL ASSOCIATION OF AMERICA

2015 National Contest
**Monday, January 12
9:30–11:00 a.m.
Henry B. Gonzalez
Convention Center,
Room 103**

Special appearance by math mime Tim Chartier!

Photo by Sandy Huffaker.

Sponsored by:

Special thanks to our technology sponsor, Maplesoft.

www.ams.org/wwtbam