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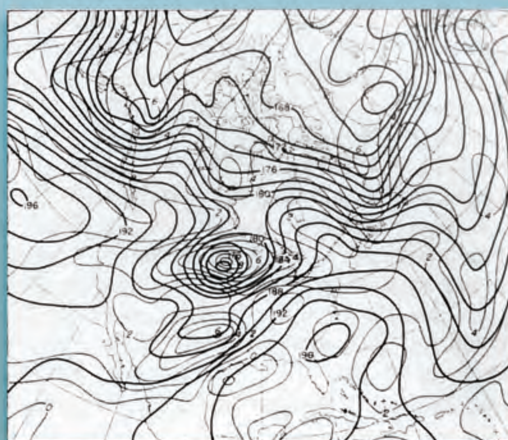

125th Anniversary
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About the cover: 63 years since ENIAC broke the ice *(see page 1113)*

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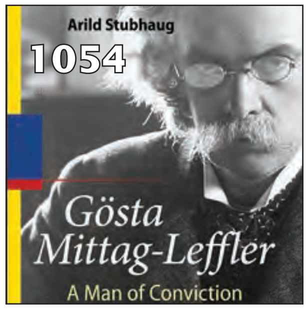
Communications

Commentary



The September issue features an article about the important Arf-Kervaire invariant from algebraic topology. We also have a report about a digital math library in Czechoslovakia that may prove to be a model for other libraries. Another article considers a "fingerprinting" technology for mathematics papers. Finally, there is a discussion of the calculus concept inventory.

—Steven G. Krantz, Editor

Features

Notices

of the American Mathematical Society

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From the AMS Secretary

American Mathematical Society

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Letters to the Editor

More on Galois

Davide Bondoni ("Galois's first memoir", *Notices*, May 2013) suggests today's Galois theory is collective work, not purely Galois's creation. He suggests that we would best go indirectly at the "master's work".

Bondoni's article may rightly react to the recent C. Curtis review (*Notices*, December 2012) of P. Neumann's book *The Mathematical Writings of Evariste Galois*. Curtis restated the myth of Galois's death consequent on a duel. Mathematicians have long accepted that was over a "tart" the night after he "created his theory of groups." Bondoni refers only to Galois's Theory erupting overnight.

I address Galois's supposed lack of clarity.

1. His work wasn't just about groups (as we might guess from Curtis's review), or even groups delineating fields.
2. Where Galois aimed remains still unreached.

L. T. Rigatelli, *Evariste Galois: 1811–1832*, Italian-to-English translation by John Denton, *Vita Math.* **11** (Birkhäuser, Basel, 1996) remains strangely unacknowledged. Several use her cover picture of Galois while repeating myths she debunks. Rigatelli documents that the girl in question was hardly a tart. Also, Galois was more likely a suicide than a duel victim.

Galois used Abel's introduction of modular curves we now call $X_0(p)$. Thereby, Abel explained the smooth variation of his famous elliptic curve function theorem. Galois's unsolvability theorem showed these equations—excluding finitely many—were unsolvable in j invariant radicals.

Galois deftly connected finite groups (even profinite by introducing the groups $\mathrm{SL}_2(p^k)$) and systems of analytic spaces—before he was twenty-one and without the best education to boot.

Spaces, especially profinite systems, have components, cusps, differentials. These force you beyond profinite thinking. (Contrary to what Curtis once insisted in my UCI office.) Riemann, a certified genius, only partially fulfilled over thirty years later what Galois ended in 1832.

Even from Riemann—despite Gauss' early help—much remains unfinished. I still hear complaints about Riemann's clarity. For my meaning on finite groups among profinite situations, and Riemann's relevance, see M. Fried, "Alternating groups and moduli space lifting invariants", arXiv #0611591v4, *Israel J. Math.* **179** (2010), 57–125, (DOI 10.1007/s11856-010-0073-2), and my website's attached html file on modular towers and modular representations.

We gain much by looking back at the optimism of Galois, Abel, and others, to pursue results before they had a clue as to the outcome. Yes, newcomers would need help from those who have continued such topics.

A variant on Rigatelli is in my *Bulletin London Math. Soc.* **34** (2002), 109–112, review of Matzat and Malle's *Inverse Galois Theory*: `http://www.math.uci.edu/~mfried/booklist-vol/Matzat-MalleInvGal.pdf`.

—Mike Fried, Emeritus
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(Received May 6, 2013)

Reply to Mike Fried

Let me ponder two questions present in Mike Fried's letter.

1. As a matter of fact, all mathematicians do understand mathematical objects by relying on their own personal experience. We must thank people like Klein for a structural reading of the concept of *group*. While for Galois the concept of *group* was only instrumental in proving the nonresolution of a fifth degree equation by radicals, other mathematicians regarded the concept of *group* from a metamathematical perspective, i.e., as a concept of a theory useful for studying structured sets. Yet in 1874 the German mathematician Ernst Schröder in a short pamphlet [Sch74] accomplished an analysis of such mathematical structures, attaining the definitions of *loops*, *semi-groups*, and (*commutative*) *groups*, starting from his personal structural philosophy of mathematics.[1] According to such a point of view, an object in itself does not exist; it exists only in a given context. Mathematics is not neutral, but it is only context-dependent, as the various interpretations of Galois's work testify.

[1] *I had occasion to write on this topic extensively (see* [Bon11], [Bon12] *and my introductory essay* Algebra, what else? *in* [Sch12, pp. ix–xli]).

2. About Galois's death, I argue that it was a suicide in disguise caused by Galois's inability to integrate himself into a social group (be it academic, political, or other). Galois's suicide, *masked* as a duel, was the only way he could affirm control of his life. Apparent homicides were explained as suicides recently by Goeschel [Goe09] and by Emil Durkheim in his 1897 masterwork [Dur13].

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—Davide Bondoni
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(Received June 28, 2013)

Mathematics and Historical Chronology

The *Notices* published in August 2013 two letters related to my invited article "Mathematical methods in the study of historical chronology", [*Notices,* April 2013], which was duly reviewed by seven anonymous referees. This piece is based on my book *The Lost Millennium—History's Timetables Under Siege*, an objective account of the debate between historians and revisionists of the established chronology, the latter group known to include many cranks, such as Immanuel Velikovsky. Among other issues, I analyze there the controversial work of Anatoli Fomenko and his collaborators, which I divide into three categories: good (follows established mathematical results and has not been refuted, so far), mediocre or weak (unconventional or questionable applications of otherwise sound mathematics), and blunders (conclusions drawn using false premises or reasoning). In my *Notices* article I focus on some mathematical methods used in chronology that have already helped historians with dating events or may do so in the future. But in the eyes of the letter writers, Fomenko steals the show.

Claude LeBrun openly trashes Fomenko's work without providing any evidence against my article, which he nevertheless dislikes, mostly for not having any mathematical content. Well, had he read what I wrote, he might have learned that one of the issues I deal with is the motion of the moon, so it embodies results in celestial mechanics (mainly differential equations) obtained by Newton, Lagrange, Laplace, Poisson, Jacobi, Poincaré, Hill, and others. My article also refers to other branches of mathematics.

The letter by Alex Emerenko and Victor Grinberg attempts, at least, to argue against the publication of my article. But the way they do it reminds me of a joke about a man who was trying to find his keys around a lamppost, though aware that he had lost them in the dark, a block away. Instead of discussing the issues I present, they take my statements out of context, apply them to all of Fomenko's work, then quote some of Fomenko's blunders, and finally let the reader decide whether my article is worth its salt. Arguments to the point? Zero. If Emerenko and Grinberg are so eager to defend the truth, they should consider sticking to the facts, abstain from distorting other people's statements, nurture some fairness, and use logic even when expressing an opinion outside their expertise.

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(Received July 5, 2013)

The Incorrect DNA Structures and Mathematicians' Contribution to DNA Topology

2013 marks the sixtieth anniversary of Watson and Crick's publication of the double helix DNA structure [1]. It is worth emphasizing that arguments against the intertwined helical structure also played important roles in making it firmly accepted. And the establishment of a rigorous mathematical foundation of circular DNA topology further supports the helix structure.

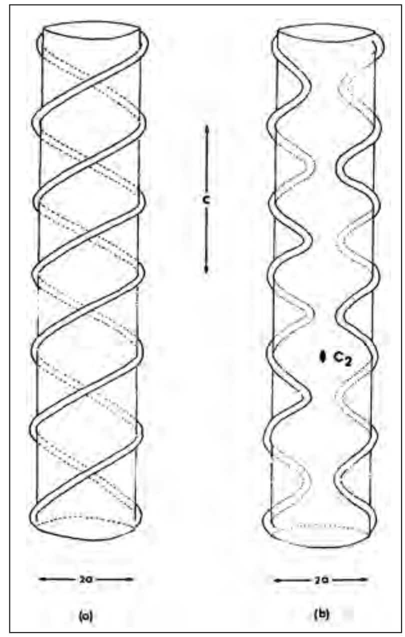
Pauling and Corey proposed a triple helix DNA structure in 1953, which turned out to be wrong. Watson and Crick had considered an incorrect DNA model before the double helix; in their earlier incorrect model, the negatively charged phosphate groups of two strands of DNA interact by binding with the magnesium ion between two phosphates, and four bases (adenine and thymine; guanine and cytosine) have no interaction.

The double helix is intertwining and topologically constrained for circular DNA. A big difficulty is the separation of strands during replication. Therefore the double helix was challenged even after Watson and Crick had been awarded the Nobel Prize in 1962, and the side-by-side model of DNA was proposed (see accompanying figure) [2, 3]. The exclusion of the side-by-side model was recalled by Crick [4]:

"At about this time Bill Pohl, a pure mathematician, got into the act. He pointed out, quite correctly, that unless something very special happened, the most likely result of replicating a piece of circular DNA would be two interlocked daughter circles rather than two separate ones. From this he deduced that the DNA chains could not be intertwined, as we had suggested, but had to lie side by side.

"Fortunately some brilliant work by Walter Keller and by Jim Wang on the 'linking number' of circular DNA molecules proved that all these side-by-side models must be wrong."

In addition to William F. Pohl, the mathematical relationship of the linking number L of a circular DNA with the twist T and the writhing number W was mainly accomplished by two mathematicians, F. Brock Fuller and James H. White [5, 6, 7]. The equation $L = T + W$ is not a derivative of known mathematical or physical laws; it is unique for DNA topology and geometry. This equation is one more example of Eugene Wigner's "unreasonable effectiveness of mathematics in the natural sciences."



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(Received June 12, 2013)

The Calculus Concept Inventory—Measurement of the Effect of Teaching Methodology in Mathematics

Jerome Epstein

Introduction

The Calculus Concept Inventory (CCI) is a test of conceptual understanding (and only that—there is essentially no computation) of the most basic principles of differential calculus. The idea of such a test follows the Mechanics Diagnostic Test (MDT, Halloun and Hestenes [11], [12]) and its successor the Force Concept Inventory (FCI) in physics (Hestenes, Wells, and Swackhammer [14]; Halloun et al. [13]; Hake [7], [8]), the last a test which has spawned a dramatic movement of reform in physics education and a large quantity of high quality research. The MDT and the FCI showed immediately that a high fraction of students in basic physics emerged with little or no understanding of concepts that all faculty assumed students knew at exit and that a semester of instruction made remarkably little difference. More dramatic, the pre-to-post test average normalized gains g on the MDT and FCI in Hake's ([7], [8]) meta-analysis showed a strong correlation with teaching methodology: the average g for "interactive engagement" (IE) courses exceeded the average g for "traditional" (T) courses by about two standard deviations. No other variable, including the pretest score, had anywhere near this correlation with the gain.

Mathematics education is often mired in "wars" between "back-to-basics" advocates and "guided-discovery" believers. There seems to be no possibility of any resolution to this contest without hard, scientific evidence of what works. Such evidence requires widespread agreement on a set of very basic concepts that *all* sides agree students should—must—be expected to master in, for example, first semester calculus. The CCI is a first element in such a development and is an attempt to define such a basic understanding.

Jerome Epstein was a faculty member of the Department of Mathematics at Polytechnic University. He continues to be affiliated with the Department of Mathematics at the same institution, now known as Polytechnic Institute of New York University. His email addresses are `jerepst@att.net` *and* `jepstein@poly.edu`.

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The CCI has undergone extensive development and validation, funded by the National Science Foundation (Epstein and Yang [4]). It was developed by a panel of respected calculus educators and a consultant, nationally known for development and validation of standardized tests. The test shows good performance characteristics (see below) and exposes exactly what the FCI in physics showed. From the fall semester of 2006 through the fall semester of 2008, the test was given to approximately 5,000 students at test sites with many traditional programs as well as programs using alternative teaching methodologies. Test sites were in colleges and universities in the United States and about fifteen other countries. Comparison of gain from two widely divergent methodologies then becomes possible and is discussed in this paper. This paper also discusses the development and validation process in some detail. Those interested in using the test should contact this author (Epstein, email addresses in the footnote on the first page of this article). While this paper was being prepared, additional requests for the test have come in, typically one or two per week, but results received after 2006 are not included in this paper. All the more recent results seem to follow the pattern described below.

The CCI is the second in an anticipated series of Basic Conceptual Understanding instruments for various levels in mathematics (including high school and earlier) that can hopefully serve to provide a scientific basis for discussions about teaching methodology and curricula. The first is the Basic Skills Diagnostic Test (BSDT), which has already been used quite widely nationally. We are currently seeking funding for an Elementary Algebra Concept Inventory.

Concept Inventories

The production of "concept inventories" has become a small cottage industry. There does not seem to be a universally accepted definition of what constitutes a concept inventory, and the term is being used now quite widely. We use the following, taking the example of the FCI in physics: These are tests of the *most basic* conceptual comprehension of foundations of a subject and not of computation skill. They are quite different from final exams and make no pretense of testing everything in a course. All of them trace their roots to the MDT and FCI in physics, and there is general agreement that physics education is ahead of other disciplines in the use of concept tests as measures of teaching effectiveness and in the development of programs that show much improved gain. The FCI consists of multiple-choice items that test understanding of the basic foundations of Newtonian mechanics. The questions are carefully designed to test one's ability to use fundamental physical laws and principles in simple, qualitative, yet profound situations, where calculations are neither needed nor helpful. The FCI is designed to measure conceptual understanding that is considered to be absolutely fundamental for any useful understanding of physics. Halloun and Hestenes [11] say in their abstract:

> An instrument to assess the basic knowledge state of students taking a first course in physics has been designed and validated. Measurements with the instrument show that the student's initial qualitative, common sense beliefs . . . have a large effect on performance in physics. But conventional instruction induces only a small change in those beliefs.

Both the FCI in physics and the CCI in calculus show that traditional instruction has remarkably little effect on basic conceptual understanding, and this has been the greatest shock to faculty. Research dating back more than thirty years has shown that most students emerge from standard introductory courses without a solid grasp of the basic concepts. This was clearly documented in physics by Arnold Arons ([1], [2]). But, prior to the development of the FCI/MDT, there was no generally accepted measure of how well students understood the basic foundations. It was thus difficult, if not impossible, to convince faculty of a need to consider changing the way they taught.

Results from research using the FCI have caused a dramatic transformation in a modest, but rapidly increasing, number of physics programs in the last twenty years. There are two main reasons why the FCI has been so effective in changing views, and these are instructive for mathematics also. First, faculty recognize in the FCI questions that arise in any practical use of basic principles, *including* those requiring standard computations. All acknowledge that the concepts measured are absolutely necessary (but not sufficient) for any useful understanding. Second, Hake ([7], [8], [9]), and subsequently many others (shown in Hake [10]), has shown that the FCI provides a *reproducible* and *objective* measure of how a course improves *comprehension* of principles, not merely how bright or prepared the students are nor what they have memorized. In a study of some 20 institutions, 100 classes, and 6,000 students, Hake compared FCI scores at entry with scores at exit. Patterns found in the data led to a performance measure that Hake calls the *normalized gain*, $<g>$. The FCI is administered once at the start and once at the end of a first course in physics. The class performance is measured by the *normalized gain*, defined to be

$$< g >= \frac{\mu_f - \mu_0}{100 - \mu_0},$$

where μ_0 is the mean score of the *class* (not of individuals, hence the angle brackets) at the start and μ_f is the mean score at the end (in percent correct). This measures the gain in the class's performance on the FCI as a fraction of the maximum possible gain. Few of the groups studied had a normalized gain much less than 0.15. On the other hand, the best performing classes in more recent studies in physics have a normalized gain up to about 0.70. The question of calculating g for individual students is quite tricky; we do not consider it here.

Hake's findings are striking. They show that g is independent of the level μ_0 of the class at entrance (the correlation of g with μ_0 for the sixty-two courses surveyed was +0.02) and largely independent of instructor and text. It is, however, strongly dependent on the teaching methodology used. Classes that used a Traditional (T) approach, depending on "passive-student lectures, predefined laboratories and algorithmic homework and tests" (Hake's choice of words), had an average normalized gain of 0.23 (standard deviation 0.04). In contrast, classes that used an Interactive Engagement (IE) approach had an average normalized gain of 0.48 (standard deviation = 0.14), roughly two standard deviations above that of the T classes. The consistency and predictability, and the strong correlation with teaching methodology, make this difficult to ignore. The need for similar information in calculus, and math in general, is the prime motivation for this project. New data from calculus (see below) show exactly the same pattern. An increasing number of departments use FCI results to measure the effectiveness of physics courses, and this movement, while still small, is growing rapidly. The data and analysis have provided *objective* evidence, which convinced many to attempt changes in the way they teach and to seek validation from the test. The growth in this movement in physics has been impressive, and there are now concept tests in more advanced parts of physics and new concept inventories in biology, astronomy, mathematics (the CCI), chemistry, and others. The new results on the CCI match those on the FCI (scores are even a bit lower, though the same pattern is seen); the gains are in the range 0.08—0.23.

Many, particularly in mathematics, are skeptical, believing that students taught with IE are less able to do standard computational problems. There is, however, much physics research that appears to show otherwise. Studies by Mazur [15], Redish [17], Redish and Steinberg [18], and Saul [20] have found IE students solving standard problems are no worse than those in T courses. When he introduced Peer Instruction, Mazur expected—and looked for—a decline on standard "end-of-chapter" problems. In Peer Instruction the instructor spends much less time lecturing and working examples. Still, Mazur found no difference between T students and those using Peer Instruction. He did find the latter performed significantly better on tests of concept understanding. The mission of this project is to see if the same pattern holds for calculus instruction.

The studies in more basic mathematics (often back to elementary school) seem to show the same thing. Schoenfeld [21, p. 16] says:

> Now, more than a decade after the publication of the *[NCTM] Standards*, hard data on large-scale implementations of these curricula are beginning to come in. To briefly summarize
>
> 1. On tests of basic skills, there are no significant performance differences between students who learn from traditional or reform curricula.
>
> 2. On tests of conceptual understanding and problem solving, students who learn from reform curricula consistently outperform students who learn from traditional curricula by a wide margin.
>
> 3. There is some encouraging evidence that reform curricula can narrow the performance gap between whites and underrepresented minorities.

History of the CCI—What Defines IE?

In 2004, Epstein and Yang obtained NSF funding for the development and validation of a Calculus Concept Inventory (CCI). Howard Everson became consultant on that project in 2005 and has done validation studies on the test and the student data. More schools become involved on a regular basis (this author gets new requests for the test on a weekly basis), but we give the basics below. There has been no difficulty in getting T data from a good many schools. However, it has not been easy at all to find adequate numbers of clearly IE teaching sections in Calculus I to allow comparison with the T sections and thus get a handle on the effect of the different methodology, at least as measured by the CCI. In order to do this, one needs an *independent* definition of what IE means in practice. Clearly, simply lumping all of the high gain sections into IE will not be very convincing. We use as a definition essentially what was used by Richard Hake in his foundational paper (Hake, [8]).

> "Interactive Engagement" (IE) methods are those designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors.

Our data in calculus indicate that the "immediate feedback" part of this is crucial, and the mere avoidance of lecture in favor of some alternative methodology does not *ipso facto* produce any change in <g>. The importance of immediate formative assessment has been emphasized by Black and Wiliam (1998) and Shavelson (2008). The feedback may be from an instructor or from other students or some combination of these. Feedback in this context means that students check the extent to which their answers are sensible and check for consistency with other concepts they already understand. The class structure must allow *time* for them to back up, revise strategy, and try again *immediately*. Programs based on computerized instruction have, so far, shown the same gain as the lecture sections. What is critical, and the great advantage conferred by an instrument like the CCI, is that one has a consistent measure of outcome, on which nearly all faculty will agree that students *should* succeed, to check what is making a difference and what is not.

Development of the CCI

A panel of expert faculty[1] with decades of experience was assembled and produced the first form for pilot testing in the spring semester of 2005. This was preceded by extensive discussion to agree on a small set of basic constructs (behaviors we believed the test should measure) and content domains to be covered (limited to Calculus I, differential only). From these, the writing of items began and a pilot test was given first in February 2005 as a pre-test. There were about 250 students at six institutions. It showed results mostly at the random guess level, even though substantial numbers of students had taken calculus previously. This was actually not a surprise. At the end of the semester we found that there was *no gain anywhere*, and some classes scored lower than at pre-test (though not by a significant amount). We had shown, at least as measured by that pilot test, the same thing that was shown by Halloun and Hestenes: a semester of instruction had essentially no effect at all. We rather expected that, but "no gain anywhere" was clearly a shock, even to us.

A reappraisal was in order. We were coming to the conclusion that, as basic as the items were, they were too hard for the purposes for which the test was intended. One department head said the questions needed to be at a level of "point to your foot" and there will still be students who will get it wrong. We came to the conclusion that the items needed to be at a level where most faculty would believe the items were utterly trivial, and we would be about right. A revised field test was developed for administration in the fall of 2006. Except for two items (see below), this is the form in which the CCI now exists. It was given in the fall of 2006 to 1,100 students at fifteen institutions in the U.S. and one in Finland (no difference between Finland and the U.S.). Pre-test scores were now significantly above random guess levels, and at semester's end there was some gain everywhere (not much at most places). We seemed to be, at least on the surface, where the FCI had arrived after some years of development.

Dr. Everson came on board the team in the summer of 2005 and began with his graduate student to do evaluations of the results with the intent of ascertaining the validity of the instrument from the psychometric point of view. We discuss this below. A set of Cognitive Laboratories was done (also see below) to give us a better window into the student mental process when faced with the test items, and then a second field test was given in the fall of 2007. We have attempted to keep the project going after the ending of the grant, in order to obtain adequate data from IE sections to appropriately test the fundamental hypothesis of a connection between gain and teaching methodology. Some quite dramatic results were obtained in the fall 2008 semester.

Results on the CCI through 2007

Early on, we made an attempt to survey instructors in a self-administered survey on the degree of "interactive engagement" in teaching. This showed—not surprisingly—no correlation with gain score. Instructors' own views of their interactivity are generally just not a satisfactory measure (however, see below on the results from the University of Michigan), and it was clear to us that all sections were predominantly lecture. During the field tests of the fall semesters of 2006 and 2007, of most interest were obviously any sections that could be viewed as clearly alternative teaching methods. This is a critical issue. We got data from Uri Treisman at the University of Texas, from a strongly IE-based instructor at Oregon State University (through Tevian Dray, along with several traditional sections), and from two sections at St. Mary's College of Maryland, of clearly IE methodology (David Kung). The absence of lectures is not sufficient. Assigning conceptual homework problems and going over them in class the next day is not sufficient. Real IE sections are not so easy to find.

All of these IE sections showed g between 0.30 and 0.37. While this gain does not seem very high, especially when compared with results from physics, it is well outside the range of what we

[1] *D. Yang (Polytechnic), C. Shah (Polytechnic (deceased)), D. Flath (Macalester), M. Terrell (Cornell), K. Vincent (Washington State) and M. Robinson (Seattle).*

were seeing for T sections. This was enticing and optimistic but simply not enough data, we felt, to make any broad conclusions. But very recent data have improved matters dramatically. In the fall semester of 2008, there was more data from Oregon State and once again the same instructor had dramatically better gain than the lecture-based sections. But most important we obtained a large amount of data from the University of Michigan. We discuss this next. These results were reported at the Joint National Meetings in Washington (Rhea [19]).

University of Michigan Calculus Program

In the fall of 2008, the CCI was administered to all sections of Calculus I at the University of Michigan (U-M). Introductory mathematics courses at U-M are taught in sections of thirty-two (or fewer) students (though this is by no means unique to U-M). In the fall of 2008, there were fifty-one sections of Calculus I, with 1,342 students. Homework assignments and all exams (two midterms and a final) are uniform, but instructors have full responsibility for teaching their individual section(s)—delivery of material, preparing and grading in-class quizzes, and grading collected homework. All sections of the course used the Harvard Project Calculus text (Hughes-Hallett et al., 1998).

Eighteen of the fifty-one sections (35 percent) were taught by instructors new to the course. For many years, U-M has trained its instructors to teach in an IE style. All new instructors attend a week-long presemester training workshop and weekly coursewide meetings to support this instruction. Experienced instructors are also encouraged to attend weekly meetings, and most do. The new instructors were new postdocs and graduate students, either new to teaching or new to the course. In order to preserve the integrity of the test, the CCI was administered online in a proctored lab. No instructors had access to the test. Students took the pretest during the first week of class and the post-test during the last week of class. Students were allowed thirty minutes and one attempt on each test. As incentives, the pre-test counted as credit for an in-class quiz grade. The post-test counted for 5 percent of the final exam grade. Of the 1,342 students who completed the course, 1,284 students (96 percent) took both the pre- and post-tests. This alone is *quite extraordinary* and, we think, an important independent result. Generally, drop-out rates from pre-test to post-test have been much higher in other schools. The g values at all schools have been calculated only with students who completed both tests, but we have checked that the drop-outs are randomly distributed among the pre-test scores.

We were interested in the students' perception of whether the class was taught in an interactive classroom style, so students were asked two questions on a preface page to the CCI post-test. Instructors were asked corresponding questions on an anonymous survey. These questions were:

• If an interactive classroom is one in which students actively work on underlying concepts and problems during the class and receive feedback from the instructor or other students on their work in class, how would you describe your class this semester: Very Interactive; Interactive; Somewhat Interactive; Not Interactive?

• On average, about what percent of your time in class would you say was spent with you working on problems and receiving feedback from your instructor and/or your classmates: 76–100 percent; 51–75 percent; 26–50 percent; 1–25 percent; 0 percent?

Tabulation of Results at U-M:

The results of the CCI at U-M include the following:

- The average gain over all fifty-one sections was 0.35.
- Ten sections had a gain of 0.40 to 0.44.
- The range of the gain scores was 0.21 to 0.44.
- Assignments to "interactivity" responses were 4 = very interactive; 3 = interactive; 2 = somewhat interactive; and 1 = not interactive.
- Coursewide, the average student perception of "interactivity" was 2.7; range 1.8 to 3.7.
- For the ten sections with a gain over 0.40, the average interactivity score was 3.02.
- Percent of time in class spent on "interactive engaged" activities was defined by taking the midpoint of the percent range chosen (e.g., 51–75 percent was scored as 63 percent, etc.). Student perception of the percent of time spent on these activities showed the following:
- Average for the overall course: 48 percent; range 30 percent to 74 percent.
- Average percent time in the ten high gain sections: 55.1 percent.

We note that the *lowest* gain at U-M was 0.21, which was about the *highest* gain among the T sections. The lowest gain section at U-M contained twelve students, all known to be at risk for failure. That this section had the same gain as the *highest* T section seems to be quite dramatic. The next lowest section at U-M had a g of 0.27, significantly above *all* the T sections at *all* schools. There are still questions of interpretation, and we claim no final conclusions. We discuss at the end some of the possible alternate explanations.

Follow-up and Analysis: Students at U-M and the other institutions who have contributed to the study were all given the same test. The analysis of gain, <*g*>, was determined using the same measure at all institutions, and this definition models the measure used in physics. Previous calculus sections showing gain at or above 0.30 have been from sections taught in a clearly IE style (based on self-descriptions of how the class is run). The fact that over one-third of the sections at U-M were taught by instructors new to the course demonstrates that this style of teaching can be fostered and developed.

This follows the history of the FCI quite well. However, the results thus far indicate that, as a community, this is surely worthy of pursuit. There are numerous ways that the FCI has changed the face of physics instruction. (Most recently, see the *NY Times* article regarding physics instruction at MIT: `http://nytimes.com/2009/01/13/us/13physics.html?emc=eta`.) Physics has led the way, but we now have a means to pursue this analysis in mathematics. We are happy to see more schools use the CCI and contribute to the data and the dialog. Please inquire with this author.

Recent Results

In recent years, the CCI has been given outside the United States in three provinces of Canada and about a dozen other countries. The results will surprise many. While there are small variations between countries, and between those countries and the United States, the results are generally very much the same, with a few striking exceptions, and there is no dramatic difference between these countries and the U.S. overall. In spite of the common mythology, the problem of basic conceptual understanding is extremely widespread. This result has been a source of some distress not only in the U.S., but also in almost all the other countries—except one.

The results in China (Shanghai) looked very much like the results from Michigan. They were a reasonably normal distribution, but two standard deviations above the general U.S. results, except for the clearly Interactive-Engagement sections in Michigan, the sections with Uri Treisman (Texas), David Kung (St. Mary's College, MD), and I think two other small sections. The size of the difference is enormous—two Gaussians with no overlap. Clearly we know about the Interactive-Engagement methods in the U.S., but some explanation is needed for the results in China. We have no conclusive explanation for this and hope to do more investigation at some point.

There is a common (mis-)conception that Chinese students do well only because they have been drilled hard and have become very good at memorized, low-level tasks. The data from the CCI clearly indicate that this view is insupportable, and the Chinese are doing something much more fundamentally right. It looks like the conclusion will be that the rest of the world has a great deal to learn from China in mathematics education, and almost certainly, one needs to go back to much earlier stages than calculus. We hope that we, or others, can pursue this further in the future.

Validation of the CCI

Cognitive Laboratories (Garavaglia 2001, Ericcson and Simon 1993) are of great help in knowing what test items are really measuring in the student mind, and they were used in the validation of the CCI. Scores on items and on tests can tell a lot when properly analyzed, but it is surely true that students get right answers for wrong reasons and can get wrong answers that are at least in part the fault of the item. Cognitive Labs (sometimes called "analytic interviews") are a marvelous technique in discovering this phenomenon. They are a highly structured interview technique where individual students (only a modest number of course) are asked to think out loud as they work on a problem. Probing questions are then used to access the student's mental process (*not* to tutor the student!). These probing questions for each item are contained in a carefully designed protocol. It is subtle to design this protocol. We utilized consultant services to do this for the CCI. Cognitive Labs are helpful on an item with poor discrimination (good students got it wrong and/or poor students got it right), but also on a few items that perform well, to be sure that students are not getting right answers for wrong reasons, or getting wrong answers due to wording of the item.

A set of Cognitive Labs was done with students from the fall semester of 2006 early into the following spring semester. These confirmed that all of the test items except one were indeed hitting the misconceptions they were designed to hit. Students were not being tripped up by confusing wording, or on some other unanticipated issue. The panel stripped out this item and one other, where we were not satisfied that we had found an item to measure the construct of "the derivative as a measure of the sensitivity of the output to change in the input"—that is, essentially the tangent line approximation. This left a final test of twenty-two items. Dr. Everson presented to us a detailed psychometric analysis, which looked pretty good. Discrimination numbers were all acceptable. There seemed to be two "dimensions" to the exam, which correlate well internally, but not as well with each other. These were roughly (a) "Functions" and (b) "Derivatives", and a smaller third dimension on limits, ratios, and the continuum. Of interest from the psychometric point of view was the reliability coefficient, which came in at 0.7—considered modestly respectable, given the wide variety of testing circumstances. Professional test developers like to see 0.8, and the SAT consistently comes in around 0.85. But Dr. Everson assured us that our results were respectable. There is much more data analysis possible with the data we already have, and more comes in on a regular basis. We expect a further report on validation and on the deeper meaning in future years.

Interpretation and Conclusions—the Future

On the surface the results do look good, but caution is always in order. Are there alternative explanations for the results seen? The data sets for T and IE sections are widely spread apart, essentially two Gaussians with no overlap, so an explanation on the basis of random statistical fluctuation seems quite unlikely. The effect size is about 2.0, highly significant. The question remains of whether there might be an unanticipated *systematic* error, some variable which might be skewing the results. We have made an attempt to think of any variables that might be hidden in this data which could distort the results in apparent favor of the IE sections. We make no claim that these results are final. We have every expectation that many institutions will be using the test in the coming years and their results will independently either verify or call into question these results.

We have considered the following possible confounding variables:

- Class size,
- Instructor experience,
- Assignment to IE or T categories,
- Textbook,
- Time spent in calculus class,
- Student preparation at entrance.

Class size: We have little data from large IE sections. It is no small feat to do Interactive Engagement in a large class. The only approach to doing this that we know of is (for ordinary faculty) the use of Personal Response Systems (so-called "Clickers"). This is also a development that comes from physics. We are not aware of any implementation of this methodology in large calculus classes but would be happy to know of results if any such exist. We do, however, have lots of data from small calculus classes. The class sizes at U-M where most of the IE data come from are all less than or equal to thirty-two. But that is also the case for the Polytechnic data, Cornell, and most of the other T sections. The small classes do not appear to have made any difference in those cases. There is one case of a relatively large IE class. Uri Treisman at the University of Texas, Austin, had a class of eighty-five and did not expect good results. His gain of 0.30 falls into the IE range and corresponds with his well-known commitment to interactive teaching.

Instructor experience: It seems very clear that this variable has no effect. A large fraction of the teachers at Michigan were brand new to the course or brand new to teaching entirely, whereas all at Polytechnic had many years of experience. Yet the g values at Polytechnic were much lower.

Assignment to IE or T categories: We have done the best we could to make this assignment based on independent information on how the class runs, and not on the gain score after the fact. The largest body of IE data is from Michigan, and they have had a strong program of training and supervising IE teaching for more than ten years (described above). The other cases of IE are also clearly within the definition, although this is based on self-reporting. One interesting case is a school with a long-time program in calculus using Mathematica. This course produced the same range of gain scores as the T sections. The lack of lectures alone seems to make no difference.

Textbook: Both Michigan and Polytechnic (and we suspect others as well) used the CCH book from Harvard and had done so for many years. The results are dramatically different. We made no systematic attempt to investigate this, and more data on this possible variable will appear in the future.

Time spent in calculus class: As far as we know, all of the sections at all schools were in the typical range of 4±1 hours per week in class (including some recitation). We saw no pattern indicating a significant effect. We have seen anecdotal reports that schools who immerse students for much longer hours (as many as ten per week, largely working with student peer tutors) have shown clear improvements in pass rates. We have no further information on this, and we note that multiple hours of one-on-one or one-on-few teaching might qualify as IE methods anyway.

Student preparation at entrance: We can examine any correlation of the normalized gain with the pre-test score. Such a correlation, if significant, would indicate that the normalized gain is in part predicted by the level of the student at entrance. The information we have indicates that, just as in physics, there is no significant correlation between the entry level score and the normalized gain. For example, at the University of Michigan, this correlation turns out to be +0.04. A similar result (no correlation) is also found by Hake for the FCI in physics. The correlation is quite small. One would expect that a reasonable measure of preparation, especially for this test, would be the pre-test score. We also asked on the test whether the student had previously taken calculus, either in high school or college. In general, no effect was seen on g from the student taking calculus previously. The data from Michigan seem to show actually that those who have taken calculus previously have somewhat smaller gain. At this point, we do not attribute any significance to this, though it might turn out later to be interesting.

We expect that, with the continuing accumulation of more data, the possible effect of any confounding variables will become clearer, and again we strongly encourage others to join the project and make use of the test.

How is the future of the CCI likely to evolve? Can we learn something of this from the history of the FCI? The explosion of physics education reform arose *after* the publication of the FCI, and use of the test did in fact feed back into improved education. The dramatically improved gain scores (up to 0.70) arose over a period of thirteen years between Halloun and Hestenes's publication of the original test and Hake's analysis. We expect something quite similar to happen with the CCI.

Richard Hake has communicated the following to me:

> I agree with your view of the dissemination history as outlined in your proposal. I think the papers by Halloun and Hestenes [11], [12] were virtually unknown outside the tiny and nearly invisible Physics Education Research community until Mazur, Redish, and Hake gave them wider publicity.

The real explosion began following Hake's work of 1998. This showed rather conclusively that the effects of IE programs were not due to enrollment of better students, nor to smaller classes, nor to better instructors who would have fared equally well with T programs. It was the *teaching methodology* that made a two standard-deviation difference. The experience at Michigan strongly supports this conclusion, as we see from the uniformly improved results across a large group of instructors, many with no prior experience in the methodology or even in teaching at all.

The need for a CCI or something similar was already very clear in 2004 when this project began. As of the date this is written (June 2012), further requests for the test come in on a regular basis (one or two each week). In the coming years, we will attempt to assemble the large mass of data, item by item, that should be out there. It should be a very worthwhile repository of valuable information on mathematics education in general. There had already been two decades of papers and articles making clear that some sort of evaluation of reform programs was critical. Presentations at conferences have consistently led to requests for the test and in particular postings on the Web at sites frequented by people in mathematics education research have spread wide interest and greatly increased demand for the test. Those who know about it are now doing presentations themselves at meetings on calculus instruction, and that is how the department leader at the University of Michigan (Rhea) heard about it (we have made a consistent attempt to have everyone requesting the test agree to a set of nondisclosure requirements). The consciousness that some sort of scientific means of "deciding what works" is needed in all of mathematics. The Web gives an immediate means of propagating information that such an instrument exists and has already produced many requests for the test and one request to use it in Ph.D. thesis research. It is our hope that the CCI and other instruments to follow will provide a research tool that can begin to provide answers to issues that have been around for a very long time.

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DML-CZ: The Experience of a Medium-Sized Digital Mathematics Library

Miroslav Bartošek and Jiří Rákosník

Introduction

The Czech Digital Mathematics Library (DML-CZ) [6] is one of the national initiatives that emerged in the past decade when technical and social circumstances allowed making mathematicians' dreams of a global digital mathematics library (DML) come true. Following the vision approved by the International Mathematical Union [3], taking lessons from the successful French project *NUMDAM* [11], and using the financial support from the Academy of Sciences of the Czech Republic, we started the DML-CZ project [4] in 2005, which after five years ended up in the fully functional DML-CZ [5].

The original goal was to build up a sound basis for a digital archive comprising the relevant mathematical literature published in the territory of today's Czech Republic, endowed with all conceivable features and services, making it a comprehensive, topical, and living DML, generally respected and used by the local as well as the global mathematical community. From the very beginning we had in mind that the DML-CZ should constitute a building block for the envisioned global DML.

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In this note we want to look back upon the original goals compared to actual achievements, share the experience, and demonstrate how such a medium-scale project can serve the community and contribute to the global vision. We shall discuss various features of the DML-CZ: its content, purpose and usage, system, functionality, access and sustainability, readiness for integration into global structures, and possible further development.

Content

Mathematical literature that has been published by Czech publishers is fairly varied. Our ambition was to build an open comprehensive library for a wide range of users rather than a mere archive of specialized literature for researchers in mathematics. Of course, the research journals, selected conference proceedings, and monographs form the core of the library with emphasis put on validity, topicality, and currency.

The DML-CZ contains virtually all research journals that have been published by Czech publishers since the nineteenth century. Ten of them are still publishing and contributing their new content to the DML-CZ on a regular basis. Research journals represent not only the most important section of research literature but also the easiest one to handle in a DML.

Conference proceedings constitute a little more complex issue requiring more careful selection and laborious processing. Every year there are many different meetings, and the proceedings have different technical and content quality. Therefore only six series have been included so far.

Digitizing research monographs and providing free access to them requires a particularly careful assessment of the copyright. This is why only a very few recent books have been included so far. The monographs section primarily contains a valuable collection of twenty-five mathematical works by the famous Bernard Bolzano. Then there is the ever-growing number of books devoted to the history of mathematics, both Czech and international. The rest ranges over a selection of historical scripts from the collection of the Royal Czech Society of Sciences, some popular undergraduate textbooks, and a couple of specialized monographs for which the copyright was easy to obtain.

At the public's request, a special section called *Eminent Czech Mathematicians* was established two years ago. At the moment it contains the private archive of Otakar Borůvka; additional ones (of Vojtěch Jarník, Matyáš Lerch, and Eduard Čech) are in preparation. The peculiarity of such collections is in the large variability of the content: research works scattered in a variety of journals, most of which are not included in the DML-CZ; monographs; textbooks; lecture notes and even manuscripts in multiple editions; newspaper articles; and other people's works about a mathematician. Even though the extreme heterogeneity of such personal collections goes far beyond the standard DML structure, their value is unquestionable. The same idea has been independently adopted by the Biblioteca Digitale Italiana di Matematica [2], which presents the collected works of the eminent Italian mathematician Salvatore Pincherle.

Certain technical complications might be connected with other relevant literature, notably theses, which for various reasons (extremely diverse form and technical quality, copyright, necessity of cooperation by universities) still remains in the realm of contemplation.

DML-CZ content growth in the post-project phase

	December 2009	June 2011	December 2012
Journals	11	12	13
Conference series	6	6	6
Monographs	32	65	108
Pages	275,220	313,707	349,988
Articles/Chapters	25,784	30,475	33,179
Issues/Volumes	2,223	2,619	2,846

Purpose and Usage

The DML-CZ has been built to serve a variety of users. The needs of the main group of users—the community of researchers—are met by the access provided to scientific journals, proceedings, and monographs. The general policy guarantees that these exclusively represent validated items published by authorized publishers and that all of them can be freely accessed after a certain fixed period elapses. This is secured by formal contracts with publishers, all of which are not-for-profit entities: universities, research institutes, and learned societies.

Researchers particularly take advantage of the set of specialized services which in addition to standard browsing and searching comprise browsing by MSC codes, links to Zentralblatt and MathSciNet, searching for similar articles, and recently—through the European Digital Mathematics Library (EuDML) [8]—also the search for mathematical formulae. The response from users shows that the rare possibility to access all back volumes of the journals and conference proceedings from one place is highly valued.

Another important target group is historians of mathematics and science. They benefit from the centralized access to the retrodigitized serials (the oldest one, *Časopis pro pěstování mathematiky a fysiky*, started in 1872), the specialized monograph series *History of Mathematics* (published mostly in Czech), the already-mentioned Bolzano collection and other old scripts, the series of almanacs documenting the 150-years history of the Union of Czech Mathematicians and Physicists, and the section of collected works of eminent Czech mathematicians.

Teachers and students will find not only textbooks and scientific and historical articles in the DML-CZ, but also a wealth of instructive texts, collections of solved problems, and educational materials that were published regularly in special appendices to *Časopis pro pěstování mathematiky a fysiky* until the 1950s and which would be forgotten otherwise.

The library is also of merit for physicists as four of the periodicals also used to publish or still publish articles about physics and astronomy as well as mathematics.

An important kind of user is publishers. For them DML-CZ means a reliable archive independently preserving their collections, enhancing the content with special tools, services, and upgraded metadata. Publishers and their products gain better visibility through the DML-CZ and, subsequently, increased citation rates. The DML-CZ set up a workflow for each publisher which complies with the typesetting system used and enables a more-or-less automatic production of inputs to the DML-CZ [12].

System

What turns a mere heap of documents into a library is metadata and services. One of the crucial tasks in the DML-CZ project was to create a comprehensive software system which would facilitate the production of the DML's content (production system) and provide users with access to the DML (presentation system). It is made of a combination of specialized tools developed in the project and freely available open-source systems adapted to the needs of the DML-CZ.

In the core of the *production system* is Metadata Editor [1]—the extensive Web application integrating all activities related to processing the digital content, creating metadata, and interconnecting information sources. Generally, materials to be incorporated in a DML are of three types and have to be processed in three different ways:

(1) *Printed* documents pass through standard digitization workflow involving scanning the printed originals, recognition of characters considering specifics of mathematical texts, grouping page images into digital documents, creating and adjusting descriptive, structural, and administrative metadata, etc.

(2) *Partly digital* documents whose digital form is incomplete or unsatisfactory (for instance, if only the final presentation form is available without the digital source files) are processed in a series of semiautomatic transformations and manually completed into a full digital form according to DML standards.

(3) *Born-digital* documents often also have to be converted into the standardized form, but this can usually be done automatically, including creation of all necessary metadata. This highly effective procedure is typically applied to new-born journal issues generated by suitably adapted editorial workflows for direct ingestion of digital data with a minimum of manual work.

Metadata Editor in combination with other tools including various validation procedures and the module for disambiguation of authors proved to be a very useful and efficient device that significantly reduces the work and facilitates creation of the digital library. It is the fundamental production tool for populating the DML with quality data.

For *presentation* of the content and the DML-CZ interface, DSpace software [7] was chosen, a general open-source tool for implementation of digital libraries and documentary repositories. Being largely adapted for the DML-CZ needs [10], DSpace offers most of the basic functions of digital libraries and services for the end users, which thus need not be carried out by the DML designers: user interface, indexing, document search, browsing information sources, persistent document identification, providing metadata for harvesting through the OAI-PMH protocol, support for long-term preservation of digital data, etc.

Separation of the production and presentation systems into two independent parts enabled designing and implementing the system in a more efficient way.

Features and Functionality

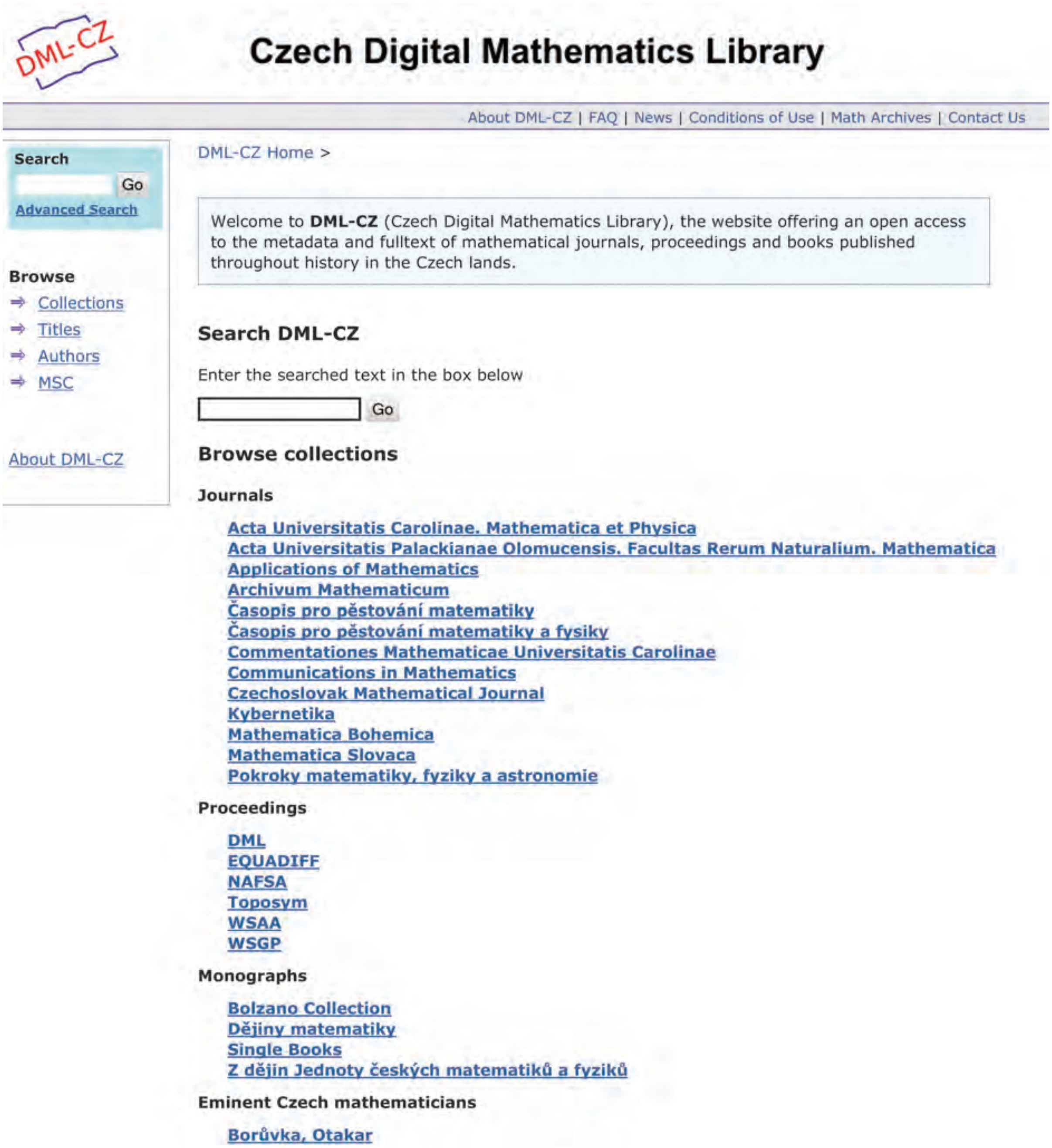
As mentioned above, end users employ the DML-CZ through the suitably modified DSpace repository software. The vision was to not only offer basic functions which belong to the standard repertoire of today's digital libraries but also to provide a certain added value in view of the possibilities, foreseen needs, and expectations of the mathematical community. The basic functionality is grounded in the native services of DSpace: searching, browsing, interlinking, communication with users, system functions. The unique services with added value implemented by the project team are represented by the search for similar articles based on machine text analysis and by experimental search for mathematical expressions using the $\TeX$ recording or MathML representation.

Among the basic functions, the key one is searching. The user can choose either a simple Google-style search in both the metadata and the full texts or an advanced search in metadata by selected fields and/or by a specified scope of data. Browsing offers the possibility of information "discovery" by going through available collections, hierarchically structured documents (e.g., journal volumes and issues), or specific indexes (author index, title index, Mathematical Subject Classification).

In addition to a simple intuitive access to chosen segments of scholarly literature, the browse functionality provides an illustrative insight into the overall content and structuring of a digital library.

A particular challenge is represented by the multilinguality of the DML-CZ content—a typical feature for the Central European region and for the literature fifty years old and older. The DML-CZ comprises documents in no less than twelve different languages, including such less-known ones as Czech, Slovak, Polish, Croatian, Latin, and Greek. There are no feasible tools for reasonable translations into English, especially if mathematical rigor is required. The DML-CZ's general policy is to provide translations of all titles in English and in many cases also in German or French. Providing higher-level multilingual services (e.g., multilingual key words) is a difficult problem which should be solved on a larger platform than the small national DML.

The important advantage from which the DML-CZ users benefit is the rich interconnection of available information both inside the DML-CZ and to the outside environment. The inner linkage



The DML-CZ main page.

allows the browsing user to easily move from one entity to another in the DML-CZ, for instance from an article to the author's record with the list of all his/her works, to a list of articles with the identical MSC code, or to a possible continuation of that article. The external links offer connections from an article to its records in the reference databases Zentralblatt and MathSciNet, and this holds even on the level of individual bibliographical references. The persistent identifiers based on the Handle system [9] enable easy building of reliable connections in the opposite direction too—from the outside into the DML-CZ, e.g., from an EuDML record or from the reference databases to the parent record and corresponding full text in the DML-CZ. As the vast majority of the DML-CZ content is open access, this is a step towards the envisioned global broadly interconnected network of mathematical information resources. In 2012 we started implementing interconnection with

CrossRef through DOI identifiers, the pilot journal being *Archivum Mathematicum*.

In this way, the DML-CZ plays an important role in the national community as a pioneer and intermediary of global infrastructure and modern technologies which would otherwise be much harder for local publishers, universities, and research institutes to adopt individually.

Access and Sustainability

The DML-CZ has been built with public support to form a specialized open access digital library. Its content ranges from immediate open access content to materials which would eventually be freely accessed after a certain period that depends on a publisher's policy, with the maximum being twenty-four months.

The general rule is that the DML-CZ owns the created metadata, while the ownership of the digital content (full texts) remains with the content provider or IPR owner, and the DML-CZ (the Institute of Mathematics of the Academy of Sciences of the Czech Republic (AS CR)) is licensed to archive and possibly enhance the content and to make it freely accessible online for strictly noncommercial purposes. This includes the license for re-serving the content through higher structures like the European Digital Mathematics Library. The Institute, as the public research institution, guarantees that the DML-CZ remains a service representing the public interest.

Access to the DML-CZ content

	Articles/Chapters Total	Articles/Chapters Open Access	Open Access (%)
Journals	28,759	28,349	98.6
Conference series	2,452	2,452	100.0
Monographs	1,968	1,968	100.0
Total	33,179	32,769	98.8

Building the digital library was exciting work for a team encouraged by the project task and necessary funding. At the project's end, there is the DML-CZ as a functional prototype with a critical core content and an open future. However, to assure its long-term viability and further development, it was necessary to take measures in advance, during the project phase. The core of the project team expressed their explicit interest in continuing. The Institute of Mathematics AS CR as the project coordinator and DML-CZ owner assumed the overall responsibility for the maintenance and resources, acquisitions, intellectual property rights issues, and publicity. Mathematicians' expert supervision is provided in collaboration with the Charles University in Prague and the Czech Mathematical Society. The team from the Masaryk University in Brno, where the DML-CZ core technology was developed, maintains both the digital library and system and secures further technological development. Retrodigitization is carried out in the Digitization Centre of the Academy Library with the use of workflow and tools developed during the project phase.

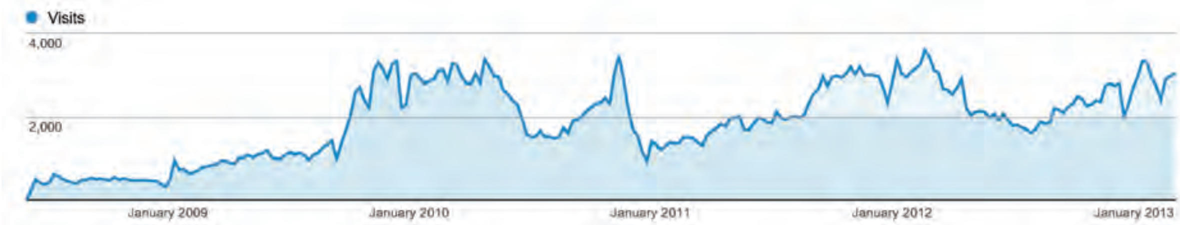
This is the DML-CZ sustainability model. In the future, we shall concentrate on continuous content growth and data improvement while for further technological development we shall mostly rely on joint efforts within the EuDML structure to which the DML-CZ wants to actively contribute. For instance, the search for semantically similar documents which was originally developed in the DML-CZ can be enhanced using the much larger reference corpus associated with the EuDML. Some features like mathematical formulae search will be better left on the common EuDML portal.

Even though DML-CZ is a not-for-profit activity, there occur certain expenses which require a sustainable plan. The basic costs related to system maintenance and ingestion of new-born journal issues do not exceed the equivalent of one IT developer's FTE and are proportionally shared by the main and regular content providers—journal publishers. Additional costs connected with special development or integration of irregular or new-type content are covered by the Institute of Mathematics AS CR or by the ordering party. Needless to say, all these obligations are based on long-term contracts which regulate operational and financial conditions as well as the IPR issues.

Conclusions and Future Work

The DML-CZ technology, experience, and expertise already found their application in various external activities. They helped to develop the Digital Library of the Faculty of Arts at Masaryk University. Some tools developed in the project were used to enhance the library system Kramerius, widely used by the Czech public libraries. Preparatory works are ongoing to apply Metadata Editor and other tools for several EuDML partners. This includes enhancement of the Bulgarian Digital Mathematics Library (Bul-DML) and upgrading the metadata of journals in the Spanish Digital Mathematics Library (DML-E) and *Journal of the EMS* published by the European Mathematical Society Publishing House. For the latter, still subject to further negotiation, the DML-CZ may serve as a mediator content provider to the EuDML.

During the two years of independent operation following the project phase, the DML-CZ proved beyond any doubt its viability and general utility. This is well documented by the stable rate of more than 100,000 visitors per year with a day peak of 600. Most of the visitors come from the Czech Republic (19.7 %), followed by the USA (8.5 %), India (6.1 %), Germany (5.4 %), and China (4.8 %).



Visits per week to the DML-CZ (source: Google Analytics).

Through the Institute of Mathematics AS CR and Masaryk University, the DML-CZ became a partner in the large consortium for a three-year project aiming at the EuDML, supported by the European Commission.

Cooperation with the EuDML partners and integration of the DML-CZ into the EuDML portal provided the occasion for enhancement of the data, substantial DSpace OAI-PMH system reconfiguration, and—last but not least—interlinking with a large number of documents distributed in a network of other DMLs and thus increasing the visibility and utility of the DML-CZ content. This provides a great challenge as well as opportunity to contribute to the further development of the EuDML, which has been recognized as a basis for the envisioned global DML.

Acknowledgments

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Fingerprint Databases for Theorems

Sara C. Billey and Bridget E. Tenner

"*Fingerprint*, in the anatomical sense, is a mark made by the pattern of ridges on the pad of a human finger. The term has been extended by metaphor to anything that can uniquely distinguish a person or object from another" [26].

Suppose that M is a mathematician and that M has just proved theorem T. How is M to know if her result is truly new, or if T (or perhaps some equivalent reformulation of T) already exists in the literature? In general, answering this question is a nontrivial feat, and mistakes sometimes occur.

Certain mathematical results have canonical representations, or *fingerprints*, and some families of fingerprints have been collected into searchable *databases*. If T is such a theorem, then M's search will be greatly simplified. Note that the searchable nature of a database is important here. An analogue of "alphabetical order" does not exist for all structures, and so it is important that M be able to query the fingerprint of T instead of needing to browse through all existing catalogued results.

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A revolutionary mathematical tool appeared online in 1996—Neil Sloane's collection of integer sequences, along with mathematical interpretations of the numbers, formulas for generating them, computer code, references, and relevant links. This was the On-Line Encyclopedia of Integer Sequences (OEIS) [22], originally hosted on Sloane's website at AT&T Labs. Anyone with access to the Internet could peruse the database, and anyone could submit a sequence or supplemental data to the database. All for free. Thanks to Sloane's tireless efforts and a worldwide community of contributors, the collection has grown to well over 200,000 sequences to date, drawing results from all areas of mathematics. The sequences in the OEIS act as fingerprints for their associated entries, the majority of which encode mathematical statements. While the fingerprints in the OEIS have a specific input structure, the sequences can arise in many contexts, including arrays of data, coefficients of polynomials, enumeration problems, subway stops, and so on. The OEIS itself is the database for these fingerprints. The impact on research is clearly established by over 3,000 articles to date citing the OEIS [23].

Fingerprinting has made an impact in many scientific fields. For example, fingerprinting documents is crucial in computer science for reducing duplication in Web search results, isotopic fingerprints are used in fields ranging from chemistry to archaeology, and there is of course extensive use of fingerprinting in forensic science.

There are other families of mathematical results that have their own identifying fingerprints, not in the form of integer sequences. Searchable catalogues are already in use for some of these families, while no such directories yet exist for others. The aim of this article is to give these resources greater exposure and also to encourage the community to create and support new fingerprint databases for other mathematical structures. Note that what we propose is not simply enhanced digital mathematical resources. Rather, a fingerprint database of theorems should be a searchable, collaborative database of citable mathematical results indexed by small, language-independent, and canonical data.

Every day new tools for searching the scientific literature are established. To be clear, this article will be out of date the moment it is published. In fact, active research at the intersection of mathematics, computer science, and linguistics is devoted to organizing mathematics into more searchable formats, including the Mathematical Knowledge Management and Intelligent Computer Mathematics conferences. An example outside of mathematics is biomedical natural language processing, known as BioNLP [11]. We expect that, one day, natural language processing will be applicable to theorems and will significantly facilitate M's search through the literature. The question is, what can we do until then?

Rod Brooks and his group at MIT used the phrase

"fast, cheap, and out of control"

to describe an emphasis on building small, cheap, and redundant robots instead of overly complex single machines [6]. We suggest that a similar approach to fingerprinting theorems can make a big impact in the near future, while more finessed tools are being developed in the background. It is better to start a theorem collection now—with an imperfect but efficient fingerprint—than to waste time awaiting an epiphany about the perfect mechanism for encoding this data.

In a sense, we are proposing a new line of research for mathematicians to address: what are the fingerprintable theorems within each discipline of mathematics, and what might those fingerprints look like?

Known Results Can Be Hard to Find

Theorems are usually written in human-readable language. They employ specialized vocabulary, functions, and layers of hypotheses and implications. A theorem in one branch of mathematics can resurface in another context, and the two statements may bear little superficial resemblance to each other. Search engines can help uncover a result if it is accessible online and there is a name associated with it, such as for a solution to a famous conjecture, in which case the name, or names, would be the fingerprint. For example, one can easily ask a search engine for information about Fermat's Last Theorem, which would lead M to discover that her result T was already proved by Wiles [28].

Formulas are prevalent in mathematical research but are inherently difficult to query. For example, M would have to make decisions about notation, variable names, and formatting. Moreover, even if search engines did have a good mechanism for querying formulas, it might not be especially useful—a given formula can often be stated in a variety of ways. For example, the following basic trigonometric identities are equivalent:

$$\sin^2\theta + \cos^2\theta = 1,$$
$$2\tan^2\theta + 2 = 2\sec^2\theta,$$

and

$$3 + 3\cot^2\theta = 3\csc^2\theta.$$

If our mathematician M has discovered a new statement of an existing formula, a search engine might have difficulty detecting that her result is equivalent to the known one.

There have been many ideas put forth for improving the search tools for formulas in the literature. In fact, search tools themselves can contribute to mathematical results. Notably, Gödel invented a numerical encoding of formulas as a step toward proving his famous Incompleteness Theorem [12]. However, the procedure is not unique and it is certainly not efficient. For example, the Gödel number of the formula "0 = 0" is $2^6 \times 3^5 \times 5^6 = 243{,}000{,}000$. More recently, Borwein and Macklem addressed the question of how best to add hyperlinks to electronically available textbooks [4].

Of course, M's search through existing literature for any hint of her theorem T would have been much harder prior to the Internet. There are examples throughout mathematical history of theorems having been discovered, and subsequently rediscovered independently—sometimes over and over again. For example, the characterization of higher-dimensional regular polytopes, attributed to Schläfli, had been recovered at least nine other times by the end of the nineteenth century [9].

Benefits of a Good Fingerprint Database

We wish to proselytize for the accumulation of theorem fingerprints into databases. We urge the reader to become a collector—a connoisseur, even!

First, though, we must explain how the OEIS encodes *theorems*—after all, its primary purpose is to collect and catalogue integer sequences. In fact, the theorems can be found within the architecture of this database—namely, by the inclusion of other fields associated with each sequence such as "name", "comments", "formula", and so on.

If our mathematician M is going to make use of the OEIS, it is because she has encountered a sequence of integer data within her work. Then M runs a query against the OEIS, using her data. Even a relatively small subsequence—perhaps just two numbers—can sometimes determine a unique entry in the OEIS. The responses from M's search enable her to connect her data to known literature, to find formulas, to make conjectures, and so on.

For example, if M enters $0, 1, 1, 2, 3, 5, 8, 13, 21$ into the OEIS, the first option it returns is sequence A000045, the Fibonacci numbers. Two of the comments for this entry are

- $F(n+2)$ = number of subsets of $\{1, 2, \ldots, n\}$ that contain no consecutive integers, and
- $F(n+1)$ = number of tilings of a $2 \times n$ rectangle by 2×1 dominoes.

Thus this entry encodes a variety of results, including the following.

Theorem ([22, A000045]). *The subsets of $\{1, 2, \ldots, n\}$ containing no consecutive integers are in bijection with the tilings of a $2 \times (n+1)$ rectangle by 2×1 dominoes, and these are each enumerated by the $(n+2)$nd Fibonacci number.*

In this way, each entry in the OEIS chronicles a mathematical theorem, and the integer sequence associated with the entry is that theorem's fingerprint. The OEIS is arguably the most established fingerprint database for theorems to date.

Other Fingerprint Databases

Depending on the structure of theorem T, the OEIS is not the only tool of its kind available to the curious M. We will describe some of the fingerprint databases for theorems that already exist in this section. These databases augment the classical approach to finding theorems in the literature, including books, journals, MathSciNet, the arXiv, and the World Digital Mathematics Library.

Permutation Patterns

The Database of Permutation Pattern Avoidance (DPPA) [24] contains collections of permutations—thought of as patterns—whose avoidance exactly characterizes particular phenomena. The second author started this database in 2005, and it has grown to more than forty sets of patterns so far. In addition to the patterns themselves, each entry in the DPPA includes the phenomenon (or phenomena) being characterized, references to existing literature, and a link to the OEIS whenever possible. The DPPA is searchable both by permutation (pattern) and by keyword.

For example, if theorem T involves permutations avoiding the two patterns 3412 and 4231, then the DPPA would have directed M to entry P0005, for the set $\{3412, 4231\}$. The two descriptions for this entry are

- permutations with rank symmetric order ideals in the Bruhat order and
- permutations indexing smooth Schubert varieties,

as described in [7], [17].

Each entry of the DPPA represents a characterization theorem. The theorem for the entry just described would be as follows.

Theorem ([24, P0005]). *The permutations with rank symmetric order ideals in the Bruhat order are exactly those that index smooth Schubert varieties, and they are precisely the permutations that avoid the patterns* 3412 *and* 4231.

The fingerprint for each DPPA theorem is its associated set of patterns, and the DPPA itself is the database for these fingerprints.

FindStat

FindStat [3] is a database of statistics on combinatorial objects. It was created in 2011 by Berg and Stump and currently catalogues over one hundred statistics. If M has obtained some data about one of these objects, then she could enter her data into FindStat, and it would tell her if this particular statistic is included in the database. If so, FindStat would identify the standard vocabulary used for that statistic. This would equip M with searchable terminology, allowing her to discover any relevant existing literature.

Hypergeometric Series

Every hypergeometric series can be written in a canonical form, and this form serves as the fingerprint for these objects. It has long been common to store identities for these series in tables, listed in a given order by these canonical forms. For example, Bailey published such a collection in 1935 [2]. Perhaps this book is the original fingerprint database for theorems.

The modern approach has taken research in hypergeometric identities one step further. The WZ method for finding identities involving hypergeometric series has been described in the book $A = B$ by Petkovšek, Wilf, and Zeilberger [19]. Using these algorithms, one can determine definitively if a hypergeometric series has a closed form or not. If there is a closed form, then the WZ method will produce it, given enough computational time and memory. Furthermore, this procedure will give a proof certificate that can be used to check the identity. Many new identities and new proofs of known identities have been found using the WZ method, for example [10]. What this resource currently lacks is a way to connect results to existing literature, pointing our mathematician M to what is already known about each identity.

The National Institute of Standards and Technology's (NIST) Digital Library of Mathematical Functions (DLMF) also includes many hypergeometric identities indexed by canonical form and some references. We should point out, however, that neither the WZ method nor the DLMF form a fingerprint database for theorems themselves in their current form. Perhaps there could be a collaborative effort to catalogue all known hypergeometric identities with extensive references and entries searchable by their canonical forms. If so, all new identities found by the WZ method could include their proof certificate as a comment. This could provide a useful place to "publish" proof certificates.

Constructing a Fingerprint Database Is Not Always Easy

An important asset of the OEIS, the DPPA, FindStat, and the WZ method is that the fingerprints they use are *language independent*. More precisely, their input is entirely numerical and canonical—free from specialized vocabulary. This seems to be a necessary feature of a good fingerprint database for theorems.

Another desirable feature of a productive fingerprint database is that it should *reference* existing literature whenever possible. Cross-references within a single database and between different databases can only enhance the state of knowledge. Features like computer code and external links can be highly beneficial when relevant. For example, any integer sequence associated with a theorem in a new fingerprint database should reference the relevant OEIS entry.

Because mathematics is so broad and develops so quickly, a fingerprint database for theorems should be *collaborative*—publicly available and welcoming additions from anyone, subject to editorial standards. The Wikipedia model for an open database is a highly successful model of this idea. However, one does not need to learn MediaWiki before starting a collection of theorem fingerprints; rather, one could simply ask for new database entries to be submitted in some kind of standard format which can easily be added to the database.

Finally, it is most convenient for the fingerprint to be encoded in a *small* amount of data. There is a natural conflict between keeping fingerprints small and uniquely identifying each object in the database. Certainly some compromises to one or both of these might be necessary. An efficient fingerprint encryption may be permitted to return some false positives, but it should never return a false negative. The possibility of false positives is all the more reason for additional fields within the database entries, to distinguish the true from the false positives. For example, querying the first nine Fibonacci numbers will return many false positives in the OEIS, but M can weed through them by reading through their full records.

There are certainly some challenges to creating a fingerprint database for theorems. These include identifying the right data structure as the fingerprint, determining a canonical format, addressing structures that have no obvious numerical data, and compactly encoding a given fingerprint. We hope these obstacles will not be too daunting, though, because an imperfect resource is still better than no resource at all. Two examples are given below.

Example: Fingerprinting Graphs

Theorems about finite graphs deserve a fingerprint database. There exist numerous classification theorems in graph theory that equate graph containment with important properties. One of the monumental results of the twentieth century is the Graph Minor Theorem by Robertson and Seymour [21]:

> Any family $\mathcal{F}$ of graphs that is closed under taking minors can be characterized as the set of all graphs whose minors avoid a finite list $L(\mathcal{F})$.

This result certainly suggests that graphs can fingerprint theorems. The Wagner formulation of Kuratowski's Theorem is an example of this situation [16], [25]:

> A simple graph G is planar if and only if G has no minor isomorphic to the graphs known as $K_{3,3}$ and K_5.

Graphs arise as classification tools in many fields of mathematics, including Hales's proof of Kepler's Conjecture [14] and the classification of finite Coxeter groups [15, Chapter 2 and Section 6.4].

One could enumerate the results of a graph theorem, say, by counting the graphs of each size possessing a certain property. The resulting sequence could be an entry in the OEIS. However, a graph theorem database would still be relevant because it could track more specific graph properties through further refinement and cataloguing. Moreover, and perhaps more persuasively, counting graphs is not an easy computational problem, so this partial enumerative fingerprint would not uniquely identify the appropriate entry in the OEIS. For example, the linklessly embeddable graphs in Euclidean space are characterized by avoiding the Petersen family of graphs, which include seven graphs having between six and ten vertices each. It is computationally infeasible to compute the number of linklessly embeddable graphs on six, seven, eight, nine, and ten vertices, which would be the first few times at which this sequence differs from the sequence enumerating all graphs.

There currently exist many online resources for graph data, such as House of Graphs [5] and the tools listed at [27]. However, none of these resources is a database of theorems (at present). It is inherently difficult to fingerprint graph theorems using searchable, canonical, and concise numerical data. In particular, there is not an obvious choice for the best way to fingerprint a graph.

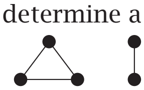
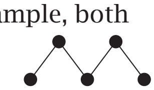
The adjacency matrix of a graph describes the graph uniquely in numerical data. Often in graph theory, a classification theorem depends only on isomorphism classes. This could pose a problem if the fingerprint of a graph is its adjacency matrix, because isomorphic graphs can have different adjacency matrices. For example, the graph with two adjacent vertices and one isolated vertex could be represented by any of

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \quad \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}, \quad \text{and} \quad \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}.$$

We can, of course, handle this difficulty by choosing a canonical representative in each isomorphism class, such as the adjacency matrix whose row reading word is smallest in lexicographic order. However, finding such a canonical adjacency matrix is no easy task: there is no known polynomial time algorithm for testing graph isomorphism. In fact, it is an open question whether the graph isomorphism problem is NP-complete.

Degree sequences are an attractive choice for fingerprints because they are much easier to encode than adjacency matrices. If one were to fingerprint graph families by lists of degree sequences written in lexicographic order, then $K_{3,3}$ and K_5 would be encoded as the list $[[3,3,3,3,3,3],[4,4,4,4,4]]$. Querying this list in a database of graph theorems, the mathematician M would learn that these two graphs are related to planar graphs via Kuratowski's Theorem.

On the other hand, a degree sequence does not determine a unique graph. For example, both

 and 

have degree sequence $[2,2,2,1,1]$.

Theorems about specific graphs or families of graphs may be rare enough that the compromises one makes when fingerprinting by degree sequences might not result in too many false positives. Indeed, as we have said before, it is better to have a collection of theorems with an imperfect fingerprint than to have no collection at all!

Example: Finite Groups

The finite simple groups have been completely classified [29]. These groups fall into six families, and the title for each group is given by a combination of letters and numbers. For example, one group is denoted ${}^3D_4(q^3)$. These groups, and various details about them, are collected in the *ATLAS of Finite Group Representations* [1]. To date, this resource includes more than $5,000$ representations of more than 700 groups.

The current implementation of the *ATLAS* does not allow users to search the database by numerical invariants of the groups; thus it is not a fingerprint database as we have defined it. To find the details of a group, one must know its title or something about where it fits into the classification.

To make the *ATLAS* into a fingerprint database, one would have to add a feature where groups could be detected by some numerical invariant(s). For example, an additional search box could be added to the main webpage to access the database by entering the order of a group. Then the order would act as the fingerprint. There are groups of the same order already in the database, but perhaps the number of coincidences is small enough that a user could prune the results via the many other entries available. Additional invariants might also be used to refine the search.

What Should Happen Next

We believe that many families of theorems can be fingerprinted—some identified by obvious data structures, others perhaps by less obvious structures. We encourage everyone in the mathematical community to look at their own work for results that can be identified by some form of compact data. In fact, any structure that has a canonical parameterization merits this attention. Additionally, a long-term benefit of having these databases is that structures amenable to fingerprinting may also be amenable to computer proof verification systems and learning algorithms, as with the Four Color Theorem [13], [20] and permutation patterns [18].

Clever insight, beyond what is currently common practice, might be necessary to find an appropriate fingerprint. In fact, the need to find theorem fingerprints can drive future research.

Many disciplines of mathematics would benefit from the greater context of a theorem database. The accessibility of mathematical research in the last few decades has flourished. In the past few years alone, we have seen substantial growth as measured in mathematics articles posted on the arXiv, increasing from 4,654 articles in 2002 to 24,176 articles in 2012 [8]. With this level of productivity, fingerprint databases are even more valuable. These resources—both the ones that currently exist and those that we hope the readers will create—enhance experimental mathematics, help researchers make unexpected connections between areas of mathematics, and even improve the refereeing process. We encourage everyone to follow Neil Sloane's lead and to take up such a collection.

Hats off to Neil!

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A History of the Arf-Kervaire Invariant Problem

Victor P. Snaith

> "I know what you're thinking about," said Tweedledum; "but it isn't so, nohow." "Contrariwise," continued Tweedledee, "if it was so, it might be; and if it were so, it would be; but as it isn't; it ain't. That's logic."
>
> —*Through the Looking Glass*, by Lewis Carroll (aka Charles Lutwidge Dodgson) [8]

Typing "Invariant theory" into Wikipedia yields the theory of functions like $x_1x_2+x_1x_3+x_2x_3$ which are unaltered by permuting the variables. In algebraic topology, particularly post-1950, a different notion of "invariant" emerged. This use of invariant (e.g., Hopf invariant, Arf-Kervaire invariant, λ-invariant) denotes an algebraic quantity that gives a partial answer to a topological question.

Often invariants in this sense are very technical, both in their context and in their construction. However, a very simple invariant occurs in the game of Nim ([31], pp. 36–38). In the 1960s this game was popular among students due to its enigmatic appearance in Alain Resnais's 1961 avant-garde movie *L'Année Dernière à Marienbad*.

A set of matchsticks is divided arbitrarily into several heaps. Two players play alternately. A play consists of selecting a heap and removing from it any (nonzero) number of matchsticks. The winner is the player whose move leaves no remaining matchsticks. The question which the Nim invariant answers is, If my opponent and I play out of our skins, will I win?

Suppose there are k heaps of matchsticks of sizes $n_1, \ldots, n_k$. Recall that every positive integer n can be written in one and only one way as the sum of distinct powers of 2. This is called the binary or dyadic formula for n. For example, $17 = 1 + 2^4$, $35 = 1 + 2 + 2^5$, and $60 = 2^2 + 2^3 + 2^4 + 2^5$. The binary formula may be depicted as a string of 0's and 1's that records in the i-th place whether or not 2^i appears in the binary formula for n. Here is a sample table of binary strings:

17	10001
35	110001
60	001111

If we express each of $n_1, \ldots, n_k$ as a row in a similar table of binary strings, we define the Nim invariant to be the string of integers given by the column sums. The Nim invariant of $17, 35, 60$ is $(2, 1, 1, 1, 2, 2)$. If every entry in the Nim invariant is even (which we shall call the Nim condition) after a player's turn, then the answer to the question is yes; otherwise it is no.

If the Nim condition holds after Player A's turn, then either A has won or any move by Player B destroys the Nim condition. In particular, Player B has not won! Conversely, if the Nim condition does not hold after Player B's turn, then Player A can restore it by the following algorithm: Player A inspects the string of column sums from right to left to find the first odd column sum. Suppose this is the column corresponding to 2^i. Then Player A chooses a row in which there is a 1 in the i-th column. Player A takes some matchsticks from the pile corresponding to this row. There is always a number of matchsticks which Player A can remove from this pile in order to restore the Nim condition. For example, in the table above, the 2^3-column has an odd sum, and Player A finds a 1 in the bottom row. Subtracting $2^3 + 2 = 10$ from 60 changes the table to:

17	10001
35	110001
50	010011

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whose column sum is $(2,2,0,0,2,2)$. With this algorithm Player A has restored the Nim condition and reduced the total number of matchsticks. Since Player B cannot win, playing perfectly, Player A must do so.

The Arf invariant, which occurred first in algebra [5], requires a little more mathematical background. Let V be the n-dimensional vector space over the field $\mathbb{F}_2$ of two elements. In more concrete terms, let V be the set of n-tuples $\underline{x} = (x_1, x_2, \ldots, x_n)$ in which each x_i is equal to 0 or 1. Recall that "addition" on V is defined by setting $\underline{x} + \underline{y}$ equal to the n-tuple whose j-th entry equals 0 if $x_j + y_j$ is even and equals 1 otherwise. $\mathbb{F}_2$ is the example in which V consists of 1-tuples.

A quadratic form is a function $q : V \longrightarrow \mathbb{F}_2$ such that $q((0,\ldots,0)) = 0$ and the associated function $Q : V \times V \longrightarrow \mathbb{F}_2$ given by $Q(\underline{x},\underline{y}) = q(\underline{x}+\underline{y}) - q(\underline{x}) - q(\underline{y})$ satisfies $Q(\underline{x},\underline{y}+\underline{z}) = Q(\underline{x},\underline{y}) + Q(\underline{x},\underline{z})$. This function of two V-variables is called an $\mathbb{F}_2$-bilinear form. It is symmetric and symplectic, which means $Q(\underline{x},\underline{y}) = Q(\underline{y},\underline{x})$ and $Q(\underline{x},\underline{x}) = 0$ for all $\underline{x},\underline{y}$ in V. The function q is called a quadratic refinement of Q. Three examples when $n = 2$ are given by $q(x_1,x_2) = x_1x_2$, $q'(x_1,x_2) = x_1^2 + x_1x_2 + x_2^2$, and $q''(x_1,x_2) = (x_1 + x_2)x_2$. For larger, even values of n, further quadratic forms may be made by applying one of q, q', or q'' to (x_{2i-1}, x_{2i}) for $i = 1, 2, \ldots, n/2$ and adding the results in $\mathbb{F}_2$.

Two quadratic forms q_1 and q_2 on V are called equivalent if there is a bijective, linear change of coordinates which transforms q_1 into q_2. For example, when $n = 2$, q'' is equivalent to q via the coordinate transformation $(x_1,x_2) \mapsto (x_1 + x_2, x_2)$.

A nonsingular quadratic form q_1 is one for which n is even and is equivalent either to the sum of $n/2$ copies of q or to q' plus the sum of $(n-2)/2$ copies of q. Hence, for each even integer n, there are just two equivalence classes of q_1's. The Arf invariant $c(q_1)$ lies in $\mathbb{F}_2$ and answers the question: To which equivalence class does the nonsingular quadratic form q_1 belong?

The definition of $c(q_1)$ given in [5] involves a complicated algebraic formula, which at first sight is not even well defined. In [7] Bill Browder used an amusing equivalent definition of the Arf invariant as the following "democratic invariant". The elements of V "vote" for either 0 or 1 by the function q_1. The winner of the election (which is never a tie) is $c(q_1)$. Here is a table illustrating this for the three possibilities q, q', q'' when $V = \{(0,0),(0,1),(1,0),(1,1)\}$. Having equal Arf invariants, q'' and q are equivalent, as we observed earlier, the vote being three to one in each case.

x	$(0,0)$	$(0,1)$	$(1,0)$	$(1,1)$	value of c
values of q	0	0	0	1	0
values of q'	0	1	1	1	1
values of q''	0	1	0	0	0

The Nim and Arf invariants fortuitously give a necessary and sufficient answer to their mathematical questions. As the mathematical subtlety of the question deepens, one must often settle for invariants which give only partial information. Algebraic topology is littered with examples of the calculational device known as a spectral sequence. A spectral sequence is an invariant (some poetic license may be needed here) whose output can often be highly ambiguous. Spectral sequences, like Marmite, are either loved or hated, and in the 1960s, graduate courses about them were regularly inflicted on unwilling students in a variety of research areas. One of the most famous is the Adams spectral sequence, invented in the 1950s by Frank Adams [1] (unfortunately universally abbreviated to ASS), which turns cohomological algebra into calculational information about stable homotopy groups. Typically a spectral sequence comprises an infinite family of abelian groups, calculable by an algebraic algorithm, together with maps between them called differentials. The ambiguity arises from the fact that. even if one knew the identity of all the differentials, the algorithm for their use yields information concerning only a filtration of the abelian groups which the spectral sequence is said "to compute". In algebraic topology, information squeezed from invariants may be hard won. One's motto should be "Do not expect too much of an invariant." We shall return to the ASS later.

Algebraic topology is generally believed to have begun with Poincaré in [26], which initiated the study of differentiable manifolds. Poincaré posed problems (e.g., the Poincaré Conjecture [24]) of generalizing to higher dimensions the success of the nineteenth-century geometers in classifying surfaces. His interest in manifolds stemmed partly from his study of the global properties of solution curves to differential equations on orientable surfaces and partly from his use of the method of Riemann surfaces in connection with complex function theory.

A differentiable manifold is a set of points in which each point lies in a coordinate patch modelled on the Euclidean space $\mathbb{R}^n$ consisting of n-tuples of real numbers, which is familiar from several-variable calculus courses. Where two coordinate patches overlap, the change-of-coordinates function is required to be highly differentiable in terms of the two sets of local coordinates. A differentiable map between two manifolds is a function $f : M \longrightarrow N$ that is differentiable in terms of the local coordinates, and f is a diffeomorphism if it is one-one and onto and has a differentiable inverse map.

Poincaré gave sample methods for the construction of manifolds. Among the methods for studying manifolds up to diffeomorphism which he introduced are homology, the fundamental group, and the relation of cobordism. His successes include Poincaré duality for compact, closed, and oriented manifolds.

To appreciate the need for invariants in algebraic topology, consider the n-dimensional sphere S^n consisting of the points $\underline{x} = (x_0, x_1, \ldots, x_n)$ in R^{n+1} such that $x_0^2 + x_1^2 + \cdots + x_n^2 = 1$. Hence S^n with two coordinate patches consisting of slightly enlarged upper and lower hemispheres is the simplest differentiable manifold after Euclidean space. In professional jargon, it is a smooth compact manifold without boundary. The simplest problem one might pose is the classification of continuous maps $f : S^n \longrightarrow S^m$. Clearly we have the identity map when $n = m$, and in all cases we have the constant maps. In order to render the problem a little more tractable, we introduce the notion of based homotopy classes of maps. Suppose that each manifold M that we shall consider comes equipped with a base point within it, usually denoted by $* \in M$. Henceforth we shall consider only based continuous maps between manifolds, meaning that base point is mapped to base point. Two continuous, based maps $f_0, f_1 : M \longrightarrow N$ are homotopic if there is a continuous map $H : [0,1] \times M \longrightarrow N$ such that $H(0, \underline{x}) = f_0(\underline{x})$, $H(1, \underline{x}) = f_1(\underline{x})$, and for all t we have $H(t, *) = *$. In order to ensure that invariants involving based homotopy classes of maps do not depend on the choice of $*$, we shall assume from now on that each of our manifolds M is path connected so that there is a continuous path between any two choices of $*$. Of course, S^n is path connected if $n \geq 1$.

Ever optimistic, we would like an invariant that gives an answer to the question: Is a continuous, based map $f : S^n \longrightarrow S^m$ not homotopic to a constant map? When $m = n$, Poincaré already had the answer: the degree of f must be nonzero. More precisely, in this case the homology group $H_n(S^n)$ is equal to $\mathbb{Z}$, the integers, and f induces a homomorphism f_* from the group $H_n(S^n)$ to itself, which must be multiplication by an integer, the degree of f. When $n < m$, approximation theorems allow us to replace f by a based map h which is homotopic to f while also being highly differentiable. The differential techniques of Poincaré show that the image of h misses a point, which easily implies that h (and therefore f) is homotopic to a constant map. The case when $m < n$ is considerably harder and remains unsolved in general for want of sufficiently powerful invariants.

Prior to the 1950s, although there had been some wonderful post-Poincaré discoveries during the intervening years (e.g., fixed point theorems), it seems to me that algebraic topology was in a state analogous to that of calculus in 225 B.C. Recall that, in a series of essays ([4]; for example, see [25]), Archimedes had successfully used ingenious ad hoc arguments, which prefigure integral and differential calculus, in order to calculate ratios of curve lengths, areas and volumes, and to find centers of gravity of selected geometrical shapes. His methods included dissecting the shapes in the style of integral calculus, then calculating the ratio under consideration up to an error which was assumed infinitesimally small. However, the method did not amount to a theory, since Archimedes could make it work only for a small set of judiciously chosen shapes. Similarly, for example, in algebraic topology prior to [13], the search for a continuous dimension-lowering map between spheres which is not homotopic to the constant map had drawn a blank.

In retrospect, finding an example was rather easy. Consider a point P in S^3 given by a pair (z_1, z_2) of complex numbers whose squared absolute values add up to 1. Then the point $(e^{\theta\sqrt{-1}} z_1, e^{\theta\sqrt{-1}} z_2)$ draws a circle on the 3-sphere passing through P. The set which has one point for each of these circles is $\mathbb{CP}^1$, the space of complex lines through the origin in the space of pairs of complex numbers, which is homeomorphic to the 2-sphere. Sending P to the circle through it gives a differentiable map between manifolds $h : S^3 \longrightarrow S^2$. On the other hand, the problem of showing that this map is not homotopic to the constant map is far from easy. In fact, Heinz Hopf originally established this by ad hoc ingenuity based on the observation that the inverse images of any two distinct points on S^2 are linked circles.

What was needed in order to systematize this sort of result was a calculable invariant—in the above case, the Hopf invariant. The Hopf invariant is an integer that is associated to any continuous, based map of the form $f : S^{2n-1} \longrightarrow S^n$ for $n \geq 1$. Later, with the construction of cohomology operations by Norman Steenrod, it became possible to define the parity of the Hopf invariant for any $g : S^m \longrightarrow S^n$ (with $n \gg 0$) and to show that the only possibilities for odd Hopf invariants occur when $m - n + 1$ is a power of two ([35], p. 12). The full story is the famous result, due originally to Frank Adams ([2]; see also [3], [32]), which shows that only the cases $m - n = 1, 3, 7$ admit homotopy classes with odd Hopf invariant. As we shall see later, the Arf-Kervaire problem is the next natural obstacle after [2].

The mid-1950s was an exciting time for algebraic topology, ushering in a golden age of the construction of invariants and the development of methods for their calculation. Sociologically, one can see what was to come by looking for the presence of mathematical luminaries in the photograph of the 1956 International Symposium on Algebraic Topology held in Mexico City in honor of Solomon Lefschetz. Alternatively, one may reflect that sixty years after [26] there was still precious little known about the differential structure of manifolds—even the sphere. Then, in [21], enters the first of the exotic spheres. An exotic sphere is a smooth manifold that is homeomorphic to, but not diffeomorphic to, a sphere. At that time such manifolds were very hard to find. In fact, in dimension three, Munkres, Smale, and Whitehead independently had shown that there were no nontrivial exotic spheres. It is worth going into some detail at this point to get the flavor of just how adventurous the construction of invariants was destined to become.

To get any further we shall need to collect mathematical objects in groups, and usually we prefer abelian groups. For example, every manifold has abelian homology groups $H_s(M)$ and cohomology groups $H^s(M)$ of various flavors, as well as homotopy groups $\pi_r(M)$ for $r \geq 1$. The latter is the set of homotopy classes of continuous, based maps $f : S^r \longrightarrow M$. Addition of g_1 and g_2, which is abelian if $r \geq 2$, is accomplished by pinching S^r to a point at the equator to form two copies of S^r (joined at one common point, the base point) and using g_1 and g_2 to map the two S^r's to M.

A compact smooth n-dimensional manifold without boundary (i.e., closed and, by our convention, path connected) M^n is orientable if its top-dimensional integral homology group $H_n(M^n)$ is isomorphic to the integers and is oriented if a generator has been chosen.

There are some closed orientable M^7s which are easy to describe, whose construction was discovered by John Milnor [21]. One starts with a continuous, based map $f : S^3 \longrightarrow SO(4)$. Here $SO(4)$ is the group of 4×4 orthogonal matrices of determinant one with the identity matrix as base point. If $\underline{x} = (x_1, x_2, x_3, x_4)$ is a point of $\mathbb{R}^4$ which is in S^3 and Y is a 4×4 matrix in $SO(4)$, then the matrix product $\underline{x}Y$ is again a point on S^3. The 4-dimensional disk is the set of points in $\mathbb{R}^4$ such that $x_1^2 + x_2^2 + x_3^2 + x_4^2 \leq 1$ with boundary equal to S^3. Take two copies of the product $D^4 \times S^3$ and glue them together along the boundary $S^3 \times S^3$ according to the recipe $(\underline{x}, \underline{y}) \mapsto (\underline{y}, \underline{x}f(\underline{y}))$. This process is called "plumbing". When f sends each point to the identity we see that plumbing results in the space S^7. In addition, f may be replaced by a homotopic map that is highly differentiable, in which case Milnor showed that the plumbing space is a 7-dimensional differentiable manifold M^7. Potentially there are lots of homotopy classes of f's for use in the above construction, since it is known that the homotopy group $\pi_3(SO(4))$ is equal to $\mathbb{Z} \oplus \mathbb{Z}$. Finally, in order to show that some of these M^7's are exotic spheres, Milnor had to construct an entirely new type of invariant, the λ-invariant. By the calculations of [36], there exists an 8-manifold B^8 whose boundary is M^7, $\partial B^8 = M^7$. An ingenious argument involving B^8 was used in [21] to construct the λ-invariant which identified some of these M^7s as exotic 7-spheres.

The construction of [21] was streamlined and systematized in [23] using the homotopy groups of larger special orthogonal groups to construct M^{4k-1}s which were the boundary of a B^{4k}. The original strategy is generalized by applying the full force of Hirzebruch's signature theorem, which appeared in 1956 ([11]; see also [12]), to the manifold B^{4k} to extend the λ-invariant and thereby count the number of distinct exotic spheres. For example, the method showed that S^{31} has more that 16×10^6 differentiable structures!

In [17], diffeomorphism classes of n-dimensional exotic spheres were used to define a finite abelian group denoted by Θ_n. If M_1 and M_2 are smooth oriented manifolds, each homeomorphic to S^n, then their connected sum $M_1 \# M_2$ is the space formed by removing a small n-dimensional disk from each and pasting together the resulting boundaries. Clearly $M_1 \# M_2$ is homeomorphic to S^n. In [17] it is shown that it can be given the structure of a smooth oriented manifold. Connected sum gives the "addition" operation in the group Θ_n such that $M_1 \# S^n$ is diffeomorphic to M_1. In Θ_n the negative of the class of M_1 is represented by $(-M_1)$, the manifold M_1 but with the opposite orientation.

The improved λ-invariant gives a homomorphism that takes its values in the abelian quotient group $\mathbb{Q}/\mathbb{Z}$ whose elements are the rational numbers q in the range $0 \leq q < 1$. This group has an infinite number of finite abelian groups within it, making it an ideal target for estimating the size of Θ_n. For example, from [17], for low values of k we have the following table:

k	7	11	15
$\lvert\Theta_{4k-1}\rvert$	28	992	16256

Before leaving exotic spheres (to which we shall return later) it should be pointed out that the methods of [17] successfully computed the order of Θ_n for many dimensions, not just those of the form $n = 4k - 1$, and their results essentially metamorphosed the problem into questions about the stable homotopy groups of spheres. As it happened, fortunately, the 1950s and 1960s saw considerable advances in the calculational techniques of homotopy theory.

Next we turn to stable homotopy groups of spheres. For $t \geq 2$ there is a homomorphism of abelian groups $\Sigma : \pi_t(S^n) \longrightarrow \pi_{t+1}(S^{n+1})$ called the *suspension homomorphism*. One considers each latitudinal level in S^{r+1} (resp. S^{n+1}) as a copy of S^r (resp. S^n) and defines $\Sigma(f)$ to be the homotopy class of the map which maps levelwise via f. The map Σ is a bijection provided that $t \le 2n-2$ and the stable homotopy group $\pi_r^S(S^0)$ is defined to be $\pi_{r+m}(S^m)$ for $m \gg 0$. Notice that $\pi_r^S(S^0)$ makes sense even when the integer r is negative and, in fact, this group is zero for $r < 0$, finite for $r > 0$.

There are two famous constructions which land in the abelian group $\pi_r^S(S^0)$. The J-homomorphism $J : \pi_r(SO) \longrightarrow \pi_r^S(S^0)$ is simple to describe. Recall that multiplication by a matrix Y in the special orthogonal group $SO(n)$ maps the sphere S^{n-1} to itself. A continuous map $h : S^r \longrightarrow SO(n)$ induces a map $\tilde{h}$ from $S^r \times S^{n-1}$ to S^{n-1} via the formula $\tilde{h}(\underline{x}, \underline{y}) = \underline{y}h(\underline{x})$. The following construction due to Heinz Hopf applied to $\tilde{h}$ produces a continuous map $J(h) : S^{r+n} \longrightarrow S^n$. Let $(\underline{x}, \underline{y})$ be a point in $\mathbb{R}^{r+n+1}$ with $\underline{x} = (x_1, \ldots, x_{r+1}) \in \mathbb{R}^{r+1}$ and $\underline{y} = (y_1, \ldots, y_n) \in \mathbb{R}^n$. The standard norm of $|\underline{x}|$ is the positive square root of $x_1^2 + \cdots + x_{r+1}^2$ and similarly for $|\underline{y}|$. If $(\underline{x}, \underline{y}) \in S^{r+n}$, then $|\underline{x}|^2 + |\underline{y}|^2 = 1$ and $(|\underline{x}|, \tilde{h}(\underline{x}/|\underline{x}|, \underline{y}/|\underline{y}|)$ is (almost) a point of the cylinder $[0,1] \times S^{n-1}$. The problems occur when $|\underline{x}| = 0, 1$. In these cases the formula gives $(0, h(?, \underline{y}))$ and $(1, h(\underline{x}, ??))$ where ? and ?? indicate an unspecified point of S^r and S^{n-1} respectively. However, if we compose with the map from the cylinder to S^n which sends $(t) \times S^{n-1}$ by the identity map to the S^{n-1} at latitudinal level t when $0 < t < 1$ and sends every point with level $t = 0$ or $t = 1$ to the south or north poles respectively, we obtain a well-defined continuous map $J(h)$.

The homotopy groups of $SO(n)$ for large n were famously calculated by Raoul Bott [6]. By work (in the 1960s and 1970s) of J. F. Adams, M. F. Atiyah, M. Mahowald, D. Sullivan, D. G. Quillen, and others, the image of J is known.

The second famous construction, due to Lev Pontrjagin [27], [28] and René Thom [36], describes $\pi_r^S(S^0)$ in terms of (framed) manifolds. Interestingly, Pontrjagin introduced this construction in order to compute stable homotopy groups via the geometry of manifolds, while Thom generalized the construction in order to reduce the analysis of the cobordism relation between manifolds to the calculation of stable homotopy groups.

We shall require only the special case in which the manifold Σ^k is a k-dimensional exotic sphere. Consider the circle S^1 embedded as a subset of $\mathbb{R}^2$ in the usual manner as the subset of points whose norm is equal to one. The normal to the circle at $\underline{x} = (x_1, x_2)$ comprises all the scalar multiples $\lambda\underline{x}$ where λ is any real number. The normal unit disk bundle comprises the union, as $\underline{x} \in S^1$ varies, of the points in the normal at $\underline{x}$ within (a chosen small) unit distance of $\underline{x}$. In this example the unit disk bundle may be realized by the subset of $\mathbb{R}^2$ consisting of points $\lambda\underline{x}$ where $\underline{x} \in S^1$ and $1/2 \le \lambda \le 1$. Hence $\lambda\underline{x} \mapsto (\underline{x}, \lambda)$ gives a homeomorphism of the normal unit disk bundle with $S^1 \times [1/2, 1]$. Identify S^1 with the space obtained from $[1/2, 1]$ by gluing its endpoints together. Sending $(\underline{x}, \lambda)$ to λ induces a continuous map from the disk bundle to S^1 that sends each point on the boundary of the disk bundle to the base point. Considering S^2 as the union of $\mathbb{R}^2$ with a point at infinity (as in the classical stereographic projection used by cartographers), the map extends continuously to all of S^2 by sending "∞" and all points of $\mathbb{R}^2$ outside or on the boundary of the disk bundle to the base point.

More generally, if we embed an exotic sphere Σ^k as a differentiable submanifold of $\mathbb{R}^{k+m}$ for $m \gg 0$, there is a homeomorphism, called a framing, of the normal disk bundle with $S^k \times D^m$. In this case the Pontrjagin-Thom construction yields a continuous map $S^{k+m} \longrightarrow S^m$. Remarkably, the Pontrjagin-Thom construction gives a well-defined element of $\pi_k^S(S^0)$ depending only on the cobordism class of the framed manifold Σ^k. I shall skip the definition of cobordism of manifolds and other manifold-related structures—suffice it to repeat that the notion was introduced by Poincaré and to add that the efficacy of the Pontrjagin-Thom construction is intimately related to Poincaré's observation that the inverse image of a regular point is a manifold.

However, the manifold Σ^k does not know about embeddings and framings, so we do not receive a homomorphism from Θ_k to $\pi_k^S(S^0)$. On the other hand, it can be shown that varying the framing changes the element of $\pi_k^S(S^0)$ only by the addition of an element $J(z)$ in the image of the J-homomorphism. Therefore we obtain a homomorphism $\tau_k : \Theta_k \longrightarrow \pi_k^S(S^0)/\mathrm{Im}(J)$ where the elements of the latter abelian group are the subsets of $\pi_k^S(S^0)$ of the form $\{x + J(z)\}$ as z varies through $\pi_k(SO(t))$ for $t \gg 0$ and x is an element of $\pi_k^S(S^0)$. In algebraic topology this is a very important homomorphism about which almost everything is now known. Some of the final missing pieces of the jigsaw are provided by the Arf invariant in a topologically embellished form known as the Arf-Kervaire invariant.

Using the Arf invariant, Kervaire [16] defined an $\mathbb{F}_2$-valued invariant for certain compact, topological manifolds and applied it to exhibit a 10-dimensional topological manifold that does not admit any differentiable structure!

The following construction from [7] extends this definition to any framed, closed $(4l-2)$-manifold. It hinges on the ingenious construction of a quadratic form that takes values in a stable homotopy group. For any space X with a base point, the stable homotopy groups $\pi_k^S(X)$ are defined in an analogous manner to the case $X = S^0$, which we met earlier.

The Eilenberg-MacLane space $K(\mathbb{Z}/2, k)$ is characterized up to homotopy equivalence by having only one nontrivial homotopy group, namely, $\pi_k(K(\mathbb{Z}/2, k))$, which has precisely two elements. The mod 2 singular cohomology group of M, denoted by $H^k(M; \mathbb{Z}/2)$, is the group of homotopy classes of continuous, based maps from M to $K(\mathbb{Z}/2, k)$.

Suppose we are given a framed manifold M^{2k} and a cohomology class $a \in H^k(M; \mathbb{Z}/2)$. In this case the Pontrjagin-Thom map takes the form $S^{2k+N} \longrightarrow \frac{S^N \times M}{* \times M}$, whose target is the product $S^N \times M$ with any point whose S^N-coordinate is equal to the north pole identified with the base point. Composing this with any map whose homotopy class represents a yields a stable homotopy class $q_{M,t}(a) \in \pi_{2k}^S(K(\mathbb{Z}/2, k))$. This stable homotopy group is isomorphic to $\mathbb{F}_2$.

This gives a nonsingular quadratic form $q_{M,t}$ on $V = H^k(M; \mathbb{Z}/2)$, depending on the framing t, and the Arf-Kervaire invariant of (M, t) is $c(q_{M,t}) \in \mathbb{F}_2$. A celebrated result of Browder [7] asserts that the Arf-Kervaire invariant of a framed manifold M^{4l-2} is trivial unless $l = 2^s$ for some s. Via the Pontrjagin-Thom construction, the Arf-Kervaire invariant may be considered as a homomorphism $\mathrm{Arf}_n : \pi_{2^n-2}^S(S^0) \longrightarrow \mathbb{Z}/2$ for $n \geq 2$. Since 1969 one of the major questions in stable homotopy theory has been: Is Arf_n nonzero?

The Arf-Kervaire invariant has a very important influence on the behavior of τ_k in the following manner:

Theorem. *If* $\mathrm{Arf}_{4l+2} = 0$*, then* τ_{4l+2} *is surjective and the kernel of* τ_{4l+1} *consists of two elements. If* $\mathrm{Arf}_{4l+2} \neq 0$*, then the cokernel of* τ_{4l+2} *is a group with precisely two elements.*

In view of the Pontrjagin-Thom result, the last part of the above theorem may be rephrased geometrically as the fact that, in dimension $4l + 2$, the Arf-Kervaire invariant is the only obstruction to finding an exotic sphere in a framed cobordism class. This is the sort of manifold-theoretic statement that would have appealed to Poincaré; in particular, he would have surely been delighted to see the problem resolved. In 2009, Mike Hill, Mike Hopkins, and Doug Ravenel (or HHR for short) posted a proof of a result which almost completely did just that.

Theorem ([10]; see also [9] and [20])**.** *The homomorphism* Arf_n *is zero for* $n \geq 8$.

This result leaves open only dimension 126, and my personal opinion would be that there is no element in $\pi_{126}^S(S^0)$ having odd Arf-Kervaire invariant. In fact, settling the problem in this dimension might be within the scope of a computer-assisted computation such as that of [18]; see also [19].

When the dust settled following the appearance of [10], the outcome was "mostly, framed manifolds of odd Arf-Kervaire invariant do not exist," as predicted by Tweedledum and Tweedledee in the opening quotation!

To get even the vaguest feel for what goes into the HHR result (the argument is analogous to Doug Ravenel's odd primary result [29]) it is necessary to return to the promised account of Adams spectral sequences and their intrinsic ambiguities. The classical ASS [1] begins with the discovery of the Steenrod algebra $\mathcal{A}$ of natural operations on the $\mathbb{F}_2$-cohomology of spaces. This is an infinite-dimensional abelian group which comes as a direct sum of finite-dimensional pieces, each indexed by a cohomological dimension. Thus far, $\mathcal{A}$ is an example of a graded abelian group. Composing two operations gives another one, and this "product" turns $\mathcal{A}$ into a graded ring. In fact, Milnor showed that $\mathcal{A}$ has the additional structure of a graded Hopf algebra [22]. One may perform elaborate, algorithmic homological algebra calculations with a graded Hopf algebra, and the classical ASS begins with the bigraded (like a graded one, but the pieces come indexed by pairs of integers) Ext-ring $\mathrm{Ext}_{\mathcal{A}}^{s,t}(\mathbb{F}_2, \mathbb{F}_2)$. The precise definition need not concern us, but here is a picture of $\mathrm{Ext}_{\mathcal{A}}^{s,t}(\mathbb{F}_2, \mathbb{F}_2)$ for small values of s and t ([30], Theorem 3.2.11).

For the range $t - s \leq 11$ and $s \leq 7$ the group $\mathrm{Ext}_{\mathcal{A}}^{s,t}(\mathbb{Z}/2, \mathbb{Z}/2)$ is a copy of $\mathbb{F}_2$ wherever an element is depicted in the following table and is zero elsewhere. The vertical coordinate is s and the horizontal is $t - s$.

7	h_0^7									$P(h_1^2)$
6	h_0^6								$P(h_1^2)$	$P(h_0 h_2)$
5	h_0^5							$P(h_1)$		$P(h_2)$
4	h_0^4					$h_0^3 h_3$		$h_1 c_0$		
3	h_0^3			h_1^3		$h_0^2 h_3$	c_0	$h_1^2 h_3$		
2	h_0^2		h_1^2	$h_0 h_2$	h_2^2	$h_0 h_3$	$h_1 h_3$			
1	h_0	h_1		h_2		h_3				
0	1									
	0	1	2	3	6	7	8	9	10	11

The differentials in the ASS are homomorphisms $d_2, d_3, \ldots$ from bigrading (s, t) to $(s+r, t+r-1)$. Inductively the differentials are used to compute new tables of homology groups $E_3^{s,t}, E_4^{s,t}, \ldots$. Eventually the group in bigrading (s, t) stabilizes and can then tell us something about the 2-Sylow subgroup of $\pi_j^S(S^0)$ for $t - s = j > 0$ consisting of those elements whose order is a power of 2. The simplest case occurs when the differentials are zero, which is the case in the range of dimensions in our table.

For example, the occurrence of four $\mathbb{F}_2$'s when $t - s = 7$ tells us that the 2-Sylow subgroup of $\pi_7^S(S^0)$ has 16 elements, but it does not tell us that the subgroup is cyclic of order 16. On the other hand, when $t - s = 1, 2$ there is only one $\mathbb{F}_2$, and in fact $\pi_1^S(S^0)$ and $\pi_2^S(S^0)$ are both isomorphic to $\mathbb{F}_2$. For the record, the 2-Sylow subgroups of $\pi_8^S(S^0)$ and $\pi_9^S(S^0)$ are $\mathbb{F}_2$-vector spaces with 4 and 8 elements, respectively.

The appearances of h_1, h_2, h_3 and $h_1^2, h_2^2, \ldots$ in the table correspond respectively to the existence of maps of Hopf invariant one [2] and Arf-Kervaire invariant one [7].

I have included this excessive computational detail involving the classical Adams spectral sequence in low dimensions in order to impress on the reader just how badly the ambiguities ramify when one is trying to show, for example, that h_7^2 in dimension 254 (and bidegree $(2, 2^8)$) survives despite the effect of all the differentials.

Since the 1960s the fans of ASS developed supercharged models [30] for which the input was a generalized cohomology theory. It is not possible here to go into the formidable technical details of the HHR theorem. Suffice it to say that the HHR result is based on the very ingenious discovery of a new generalized cohomology theory, which we shall denote by $L^*(-)$. It has the property that L^* gives rise to a generalized Adams spectral sequence that comes with a map from the classical ASS and is sufficiently simple to compute so that one can show that a map $\theta : S^{r+2^j-2} \longrightarrow S^r$ with Arf-Kervaire invariant one induces a nonzero homomorphism $L^r(S^r) \longrightarrow L^r(S^{r+2^j-2}) \cong L^0(S^{2^j-2})$. This amounts to choosing L^* so that the differentials in its generalized Adams spectral sequence are simple enough to control. Incredibly, HHR manage to accomplish all this and in addition find L^* which satisfies $L^{r+2}(S^r) = 0$ and $L^{m+256}(S^n) \cong L^m(S^n)$ for all m, n. This is curtains for the Arf-Kervaire invariant, because, for example, $L^0(S^{254}) \cong L^{256}(S^{254}) = 0$!

A result of Stewart Priddy and Dan Kahn enables one to give equivalent rephrasings of the Hopf invariant and the Arf-Kervaire invariant problems. Recall that real projective space $\mathbb{RP}^n$ is the topological space whose points consist of the antipodal pairs $\{\underline{x}, -\underline{x}\}$, where $\underline{x}$ is a point on S^n. The Kahn-Priddy theorem [15] permits one to restate properties of $\pi_k^S(S^0)$ in terms of $\pi_k^S(\mathbb{RP}^n)$ for $n \gg 0$. For example, the Kahn-Priddy reformulation implies Browder's original result that framed manifolds of Arf-Kervaire invariant one can occur only in dimensions of the form $2^j - 2$ [34]. Collapsing $\mathbb{RP}^{2n}$ to the base point gives a continuous map $\pi : \mathbb{RP}^{2n+1} \longrightarrow S^{2n+1}$. The existence of maps of odd Hopf invariant, together with the Kahn-Priddy theorem, implies that, for any generalized cohomology or homology theory, π behaves as if there is a map f in the opposite direction such that the degree of $\pi \cdot f$ is odd. In [3] K-theory, which is a generalized cohomology theory, is used to give a simpler proof of Adams's original theorem about the nonexistence of maps of odd Hopf invariant [2]. To each generalized cohomology theory there corresponds a generalized homology theory, which for K-theory is called connective K-homology. The connective K-homology proof in terms of the above Hopf invariant reformulation is so simple that I gave it in the midst of a book review [32]!

The Arf-Kervaire invariant problem is equivalent to posing the analogue of the above with $\mathbb{RP}^{2n+1}$ replaced by $\mathbb{RP}^{2n}$ ([33], [34]). In this sense, as I mentioned earlier, the Arf-Kervaire invariant is the next natural obstacle after the Hopf invariant.

Constructing elements of $\pi_k^S(S^0)$ in terms of continuous maps between spheres or in terms of framings on manifolds is a hard way to make a living.

As an alternative, I shall conclude by sketching a method that constructs a few elements of odd Arf-Kervaire invariant using manifolds that are known to be frameable but for which no specific framing need be given [33]. The infinite-dimensional projective space $\mathbb{RP}^\infty$ is just the union of all the $\mathbb{RP}^n$s. It is also the classifying space $BO(1)$ of the group of 1×1 orthogonal matrices (aka the group with two elements). The group of $m \times m$ orthogonal matrices $O(m)$ has a classifying space $BO(m)$. A manifold M^{2t} together with a continuous map $E : M^{2t} \longrightarrow BO(m)$ for $m \geq 2$ possesses a second Stiefel-Whitney class $w_2(E)$ in $H^2(M^{2t}; \mathbb{Z}/2)$ and a fundamental class $[M]$ which is the only nonzero element of the top-dimensional homology group $H_{2t}(M; \mathbb{Z}/2)$. Cohomology has a product that allows one to define an element $w_2(E)^t$ in $H^{2t}(M; \mathbb{Z}/2)$. The pairing between top-dimensional cohomology and homology yields an element of $\mathbb{F}_2$, denoted by $\langle w_2(E)^t, [M^{2t}] \rangle$. In [33] it is shown that if M^{2t} is frameable and $\langle w_2(E)^t, [M^{2t}] \rangle$ is odd, then there exists an element of $\pi_{2t}^S(S^0)$ with odd Arf-Kervaire invariant.

This result applies to each of the manifolds $M^{2t} = \mathbb{RP}^t \times \mathbb{RP}^t$ for $t = 1, 3, 7$ because $\mathbb{RP}^1, \mathbb{RP}^3$ and $\mathbb{RP}^7$ are Lie groups (hence frameable) and each M^{2t} is a subspace of $BO(2)$. In fact, there are nonstandard framings on these three Lie groups that give rise to the Hopf invariant one elements which are depicted by h_1, h_2, and h_3 in the classical ASS. Taking the Cartesian product of each of these with itself gives another construction of the Arf-Kervaire invariant one elements in dimensions $2, 6$, and 14, depicted by h_1^2, h_2^2, and h_3^2 in the classical ASS.

Let C denote the Riemann surface obtained by putting a thin tube around each edge of a cube. The natural action of D_8, the dihedral group of order 8, on the cube induces a free D_8-action on C. Since D_8 is the 2-Sylow subgroup of the permutations on four objects, D_8 also acts on $(\mathbb{RP}^7)^4$. Let D_8 act simultaneously on the two factors of $C \times ((\mathbb{RP}^7)^4)$. This is a free action with eight points in each orbit. Form the manifold $M^{30} = C \times_{D_8} ((\mathbb{RP}^7)^4)$, which has one point for each D_8-orbit. A simple calculation in K-theory [33] shows that M^{30} is frameable (first noticed by John Jones [14]) and M^{30} is a subspace of $BO(4)$.

Each of these examples gives an odd value for $\langle w_2(E)^t, [M^{2t}]\rangle$ and hence shows the existence of odd Arf-Kervaire invariants in dimensions $2, 6, 14$, and 30.

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W H A T   I S . . .

the p-adic Mandelbrot Set?

Joseph H. Silverman

Before attempting to answer the title question, we must first answer two preliminary questions: "What are the p-adic numbers?" and "What is the (classical complex) Mandelbrot set?" We start with the former.

A standard characterization of the real numbers $\mathbb{R}$ is as the smallest field containing $\mathbb{Q}$ that is complete with respect to the "usual" absolute value $|r|_\infty = \max\{r, -r\}$ on $\mathbb{Q}$, where we recall that a field is complete if every Cauchy sequence converges. But there are other absolute values on $\mathbb{Q}$. Ostrowski showed that, up to a natural equivalence, there is one absolute value for each prime number p. Writing a rational number r as $r = p^k \frac{a}{b}$ with p not dividing ab, the p-adic absolute value of r is defined by $|r|_p = p^{-k}$. Intuitively, two rational numbers r and s are p-adically close if the numerator of their difference is divisible by a large power of p. Then the field of p-adic numbers $\mathbb{Q}_p$ is the smallest field containing $\mathbb{Q}$ that is complete with respect to the p-adic absolute value $|\cdot|_p$. The p-adic numbers were invented by Hensel in the nineteenth century. They are analogous in many ways to $\mathbb{R}$. For example, the field $\mathbb{Q}_p$ is locally compact for the topology induced by $|\cdot|_p$, and one can do p-adic analysis with p-adic power series. A significant difference between $\mathbb{R}$ and $\mathbb{Q}_p$ is that the p-adic absolute value satisfies the "ultrametric" triangle inequality $|r+s|_p \le \max\{|r|_p, |s|_p\}$. This implies that the unit disk $\{x \in \mathbb{Q}_p : |x|_p \le 1\}$ is a compact sub*ring* of $\mathbb{Q}_p$, which is nice, but it also implies that $\mathbb{Q}_p$ is totally disconnected, which is not so nice. Also, although the fields $\mathbb{R}$ and $\mathbb{Q}_p$ are complete, they are not algebraically closed; so just as it is often better to work with the complete algebraically closed field of complex numbers $\mathbb{C}$, it is also often better to work with the field $\mathbb{C}_p$, the smallest complete algebraically closed field containing $\mathbb{Q}_p$. But we note that $\mathbb{C}_p$ is a monster of a field; it is not even locally compact!

The classical (degree 2 complex) Mandelbrot set $\mathcal{M}_\infty$ arises in studying the dynamics of the simplest family of nonlinear functions, which is the set of quadratic polynomials $f_c(x) = x^2 + c$. Dynamicists study the effect of repeatedly applying the map f_c to an initial point $a \in \mathbb{C}$; i.e., they study how the points in the orbit $\mathcal{O}_{f_c}(a) = (a, f_c(a), f_c^2(a), \ldots)$ move around $\mathbb{C}$, where $f_c^n = f_c \circ f_c \circ \cdots \circ f_c$ denotes the nth iterate of f_c. Of particular interest is the *Julia set* $\mathcal{J}(f_c)$ *of* f_c, which is the set of initial points where the iterates of f_c behave chaotically. The Julia set may also be described as the boundary of the set of initial points $a \in \mathbb{C}$ whose orbit $\mathcal{O}_{f_c}(a)$ is bounded. Surprisingly, the geometry of $\mathcal{J}(f_c)$ is heavily influenced by the orbit of the single point 0. For example, a famous theorem of Fatou and Julia (discovered independently) says that if $\mathcal{O}_{f_c}(0)$ is bounded, then $\mathcal{J}(f_c)$ is connected (although generally quite fractal-like), and otherwise $\mathcal{J}(f_c)$ is totally disconnected. This dichotomy divides the parameter space of c values into two pieces. The *Mandelbrot set* $\mathcal{M}_\infty$ is the set of parameters $c \in \mathbb{C}$ such that the orbit $\mathcal{O}_{f_c}(0)$ is bounded, or equivalently, such that $\mathcal{J}(f_c)$ is connected. You have undoubtedly seen pictures of the incredibly complicated and beautiful Mandelbrot set. It has become one of the most ubiquitous images in all of mathematics, and

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the study of its geometry has occupied generations of mathematicians.

The modern theory of complex dynamics dates from the fundamental work of Fatou and Julia around 1920. The study of p-adic dynamics is more recent, where initial investigations in the 1980s by Herman, Yoccoz, and others led to an explosion of interest starting in the 1990s with groundbreaking results by Benedetto, Bézivin, Hsia, and Rivera-Letelier. The classical Mandelbrot set is defined in terms of whether $|f_c^n(0)|$ is bounded or goes to infinity as $n \to \infty$. We can use exactly the same definition to define the p-adic Mandelbrot set $\mathcal{M}_p$. Thus $c \in \mathbb{C}_p$ is in $\mathcal{M}_p$ if and only if $|f_c^n(0)|_p$ is bounded as $n \to \infty$. The only change is that we've replaced the usual absolute value on $\mathbb{C}$ with the p-adic absolute value on $\mathbb{C}_p$. However, using the ultrametric property of $|\cdot|_p$, it is very easy to see that $|f_c^n(0)|_p$ is bounded if and only if $|c|_p \le 1$, so $\mathcal{M}_p = \{c \in \mathbb{C}_p : |c|_p \le 1\}$ is the closed unit disk, which really is not very interesting.

If that were the end of the story, then we'd have wasted a lot of ink, since the title question would have a single word answer: boring. Luckily, matters become more interesting when we look at Mandelbrot sets associated with polynomials of higher degree. But first we ask why it is that the orbit of the particular point 0 for $f_c(x) = x^2 + c$ has such a profound influence on the dynamics of f_c. What makes the point 0 so important? The answer is that 0 is the (unique) critical point of f_c, i.e., the derivative $f_c'(x)$ vanishes at 0, and thus there is no neighborhood of 0 on which f_c is one-to-one. We now fix $d \ge 2$, and for each $(d-1)$-tuple $\boldsymbol{c} = (c_1, \dots, c_{d-1}) \in \mathbb{C}^{d-1}$, we define a (normalized) degree-d polynomial

$$f_{\boldsymbol{c}}(x) = x^d + c_1 x^{d-2} + c_2 x^{d-3} + \cdots + c_{d-2}x + c_{d-1}.$$

(Every degree-d polynomial can be put into this form by conjugating by a linear polynomial. This conjugation does not materially affect the dynamics.) The polynomial $f_{\boldsymbol{c}}(x)$ has $d-1$ critical points $\gamma_1, \dots, \gamma_{d-1}$ (counted with multiplicity) whose orbits similarly have a profound influence on the dynamics of $f_{\boldsymbol{c}}$. We say that $f_{\boldsymbol{c}}$ is *critically bounded* if the orbits $\mathcal{O}_{f_{\boldsymbol{c}}}(\gamma_i)$ of all of the critical points are bounded. Then the *degree-d Mandelbrot set* $\mathcal{M}_{\infty,d}$ is the set of $\boldsymbol{c} \in \mathbb{C}^{d-1}$ whose associated polynomials $f_{\boldsymbol{c}}$ are critically bounded. If we work over $\mathbb{C}$, then these higher degree analogues of $\mathcal{M}_{\infty,2}$ are extremely complicated, with higher-dimensional fractal-like boundaries.

It's clear how we should define the p-adic analogue of the degree-d Mandelbrot set; it is the set

$$\mathcal{M}_{p,d} = \{\boldsymbol{c} \in \mathbb{C}_p^{d-1} : f_{\boldsymbol{c}}(x) \text{ is } p\text{-adically critically bounded}\},$$

where of course we now use the p-adic absolute value to determine whether the orbits $\{f_{\boldsymbol{c}}^n(\gamma_i)\}$ of the critical points are bounded. If p is large, then $\mathcal{M}_{p,d}$ is again boring, as shown by the following result that has long been "well known to the experts," but seems to have first been written down in [1].

Theorem 1. *If $p \ge d$, then $\mathcal{M}_{p,d}$ is a polydisk,*

$$\mathcal{M}_{p,d} = \{\boldsymbol{c} \in \mathbb{C}_p^{d-1} : |c_i|_p \le 1 \text{ for all } 1 \le i \le d-1\}.$$

The fact that $\mathcal{M}_{p,2}$ is a disk for all p, combined with Theorem 1, seems to have discouraged people from studying p-adic Mandelbrot sets, but recent work by Anderson has shown that when $p < d$, the p-adic Mandelbrot set $\mathcal{M}_{p,d}$ has a complicated geometric structure that may rival the geometry of the classical complex Mandelbrot sets.

Example 2. Consider the action of the polynomial $g(x) = x^3 - \frac{3}{4}x - \frac{3}{4}$ on $\mathbb{C}_2$. The critical points of $g(x)$ are $\pm\frac{1}{2}$, and they both have finite orbits, since

$$-\frac{1}{2} \xrightarrow{g} -\frac{1}{2} \quad \text{and} \quad \frac{1}{2} \xrightarrow{g} -1 \xrightarrow{g} -1.$$

Hence $(-\frac{3}{4}, -\frac{3}{4}) \in \mathcal{M}_{2,3}$, so $\mathcal{M}_{2,3}$ is not contained in the unit polydisk. (Note that $|\frac{3}{4}|_2 = 4 > 1$.)

More generally, consider the one-parameter family of polynomials $g_t(x) = x^3 - \frac{3}{4}t^2x - \frac{1}{4}(t^3 + 2t)$, so $g(x) = g_1(x)$. The critical points of $g_t(x)$ are the fixed point $\gamma_1 = -\frac{1}{2}t$ and the point $\gamma_2 = \frac{1}{2}t$, so g_t is critically bounded if and only if the orbit of $\frac{1}{2}t$ is bounded. One can show that $g_t(x)$ is critically bounded for the sequence of parameter values $t = 1 + 2^{2k}$ converging 2-adically to 1, while it is critically unbounded for the sequence of parameter values $t = 1 + 3 \cdot 2^{2m+1}$, also converging 2-adically to 1. Thus $(-\frac{3}{4}, -\frac{3}{4})$ is on the boundary of $\mathcal{M}_{2,3}$. Computations in [1] show that the geometry of $\mathcal{M}_{2,3} \cap \mathbb{Q}_2$ in a 2-adic neighborhood of $(-\frac{3}{4}, -\frac{3}{4})$ is extremely complicated, and they further suggest that this neighborhood is geometrically equivalent (in some not yet precisely defined sense) to a 2-adic neighborhood of the critical point $\frac{1}{2}$ in the Julia set $\mathcal{J}(g_1) \cap \mathbb{Q}_2$. This is our first inkling of a potential p-adic analogue of a famous classical result over $\mathbb{C}$ that says that a Misiurewicz point c in $\mathcal{M}_{\infty,2}$ has a neighborhood that is quasi-similar to a neighborhood of the critical point 0 in the complex Julia set $\mathcal{J}(f_c)$.

If $p < d$, then the p-adic Mandelbrot set $\mathcal{M}_{p,d}$ is (generally) not contained in the unit polydisk, so it is an interesting problem to compute or estimate the p-adic radius of $\mathcal{M}_{p,d}$. For this purpose, we define the *p-adic critical radius* $R_{p,f}$ of a polynomial $f(x)$ to be the maximum of $|\gamma - \alpha|_p$ as γ ranges over the critical points of $f(x)$ (roots of $f'(x)$) and α ranges over the fixed points of $f(x)$ (roots of $f(x) - x$).

Then the *critical radius of* $\mathcal{M}_{p,d}$, denoted $R(\mathcal{M}_{p,d})$, is the maximum of $R_{p,f}$ for $f \in \mathcal{M}_{p,d}$.

Example 3. It is an easy consequence of Theorem 1 that $R(\mathcal{M}_{p,d}) = 1$ for $p \geq d$. On the other hand, the polynomial from Example 2 satisfies

$$g'(x) = 3x^2 - \frac{3}{4} = 3(x - \frac{1}{2})(x + \frac{1}{2})$$

and

$$g(x) - x = (x+1)(x - \frac{3}{2})(x + \frac{1}{2}),$$

so $R_{2,g} = 2$. Hence $R(\mathcal{M}_{2,3}) \geq 2$.

Theorem 2 (Anderson [1]). *Let p be a prime satisfying $\frac{1}{2}d < p < d$. Then $R(\mathcal{M}_{p,d}) = p^{p/(d-1)}$. Further, $R(\mathcal{M}_{p,2p}) = 1$.*

To prove the lower bound for $R(p,d)$, it suffices to exhibit a single polynomial in $\mathcal{M}_{p,d}$. Explicitly, one can show that the polynomial $x^{d-p}(x-\beta)^p$ has critical radius $p^{p/(d-1)}$ for the carefully chosen value $\beta = [(-p/d)^p(1-p/d)^{d-p}]^{-1/(d-1)}$. The upper bound in Theorem 2 is more difficult and requires an elaborate calculation with Newton polygons. It's possible that the argument in [1] can be extended to compute $R(\mathcal{M}_{p,d})$ for $\frac{1}{3}d < p < \frac{1}{2}d$, but it appears to be a difficult problem to evaluate $R(\mathcal{M}_{p,d})$ when, say, $p < \sqrt{d}$.

Returning now to the classical complex Mandelbrot set $\mathcal{M}_{\infty,2}$, we consider the collection $\mathcal{H}_{\infty,2}$ of *hyperbolic maps*, which is the set of parameter values $c \in \mathcal{M}_{\infty,2}$ such that the orbit of the critical point 0 of $f_c(x) = x^2 + c$ converges to an attracting cycle. In other words, $c \in \mathcal{H}_{\infty,2}$ if and only if $\lim_{n\to\infty} f_c^n(0)$ converges to a point $\alpha \in \mathbb{C}$ satisfying $f_c^m(\alpha) = \alpha$ and $|(f_c^m)'(\alpha)| < 1$ for some $m \geq 1$. It is known that $\mathcal{H}_{\infty,2}$ is an open subset of $\mathcal{M}_{\infty,2}$, and the Lebesgue measures satisfy $1.503 \leq \mu(\mathcal{H}_{\infty,2}) \leq \mu(\mathcal{M}_{\infty,2}) \leq 1.562$. The famous Hyperbolicity Conjecture asserts that $\mathcal{H}_{\infty,2}$ equals the entire interior of $\mathcal{M}_{\infty,2}$.

The p-adic analogue $\mathcal{H}_{p,2}$ is defined similarly; we simply replace $\mathbb{C}$ with $\mathbb{C}_p$ and use $|\cdot|_p$ in place of the complex absolute value. Then, although $\mathcal{H}_{p,2}$ is a subset of the (boring) closed unit disk $\mathcal{M}_{p,2}$, it turns out that $\mathcal{H}_{p,2}$ itself is quite complicated. A first reduction is to note that $\mathcal{H}_{p,2}$ is the full inverse image under the "reduction mod p map" of the set

$$\overline{\mathcal{H}}_{p,2} = \{c \in \overline{\mathbb{F}}_p : f_c^m(0) = 0 \text{ in } \overline{\mathbb{F}}_p \text{ for some } m \geq 1\}.$$

(Here $\overline{\mathbb{F}}_p$ denotes an algebraic closure of the finite field $\mathbb{F}_p$.) It is conjectured that $\overline{\mathcal{H}}_{p,2}$ is quite small, in contrast to the complex hyperbolic set $\mathcal{H}_{\infty,2}$, which has positive Lebesgue measure.

Conjecture 3. *Let $p \geq 3$. Then*

$$\lim_{k\to\infty} \frac{\#(\overline{\mathcal{H}}_{p,2} \cap \mathbb{F}_{p^k})}{p^k} = 0.$$

A beautiful and deep result of Jones [3] says that Conjecture 3 is true if $p \equiv 3 \pmod 4$ and that a slightly weaker statement with an alternative notion of density is true for all $p \geq 3$. Jones's proof begins by using the function field Chebotarev density theorem to reduce the problem to properties of the action of the Galois group of $\overline{\mathbb{F}_p(t)}/\mathbb{F}_p(t)$ on the iterated preimage tree of 0. He next constructs a stochastic process that encodes information about the group action and shows that this process is a martingale. Finally, additional information about the group action is combined with a martingale convergence theorem to complete the proof.

Acknowledgment

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Invisible in the Storm: The Role of Mathematics in Understanding Weather

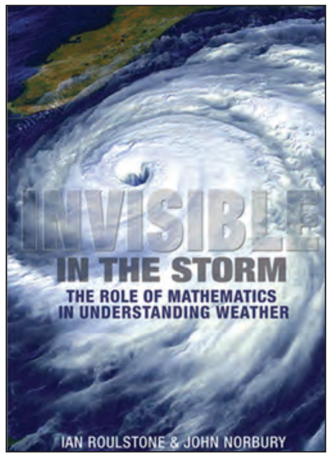
Reviewed by Peter Lynch

Invisible in the Storm: The Role of Mathematics in Understanding Weather
Ian Roulstone and John Norbury
Princeton University Press, 2013
US$35.00, 346 pages
ISBN-13: 978-0691152721

The development of mathematical models for weather prediction is one of the great scientific triumphs of the twentieth century. Accurate weather forecasts are now available routinely, and quality has improved to the point where occasional forecast failures evoke surprise and strong reaction among users. The story of how this came about is of great intrinsic interest.

General readers, having no specialized mathematical knowledge beyond school level, will warmly welcome an accessible description of how weather forecasting and climate prediction are done. There is huge interest in weather forecasting and in climate change, as well as a demand for a well-written account of these subjects. In this book, the central ideas behind modeling and the basic procedures undertaken in simulating the atmosphere are conveyed without resorting to any difficult mathematics.

The first chapter gives a good picture of the scientific background around 1900. It opens with an account of the circulation theorem derived by the Norwegian meteorologist Vilhelm Bjerknes. This theorem follows from work of Helmholtz and Kelvin but makes allowance for a crucial property of the atmosphere: that pressure and density surfaces do not usually coincide. This is what is meant by the term baroclinicity. The theorem specifies how the circulation can change when baroclinicity is present. It enables us to calculate how vortices in the atmosphere and oceans behave, giving a holistic, but quantitative, description. Bjerknes's circulation theorem initiated the study of geophysical fluid dynamics.



The basic mechanical and physical laws governing the atmosphere were in place by 1900. Bjerknes developed a vision of how weather forecasting could be put on solid theoretical foundations and drew up what amounted to a manifesto for scientific prediction. He considered how precise, long-range predictions of astronomical events were possible and tried employing a similarly systematic approach in meteorology. He recognized the intractability of the governing equations and realized that analytical solution of them was impossible. But even an approximate solution, which would have required many months to carry out, might eventually lead to more practical methods.

The authors give an excellent account of developments over the first two decades of the twentieth century. The discovery by Henri Poincaré of sensitive dependence on initial conditions arose in the context of studying the three-body problem but had much wider implications. It meant that unavoidable errors in the specification of the initial state of the atmosphere would grow over time, ultimately rendering the forecast useless. It imposed an inherent limit on prediction of future weather. A central aim of the book is to explain how rational prediction of weather is possible at all in the presence of chaos.

Predicting the weather is vastly more complex than predicting the return of a comet. The authors

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show how the problem can be reduced to the solution of a system of seven equations (coupled nonlinear partial differential equations) in seven variables: pressure, temperature, density, humidity, and three components of the wind. The mathematical details are very sketchy, even in the "Tech Boxes" (boxes separate from the running text, with additional technical details), but the overall ideas are well conveyed.

Most of the key meteorologists are recognized in the narrative. In particular, William Ferrel's work in formulating the equations on a rotating Earth is given due prominence. But a description of the important work of the scientists working in Vienna, specifically Max Margules and Felix Exner, is omitted. Margules anticipated the problems that would arise if the continuity equation were used for prediction, and Exner carried out several numerical forecasts using a highly simplified set of equations.

The method of solving a complicated system of equations by reducing them to a manageable, algebraic form is given good treatment. The consequences of discretization are described by a nice analogy with pixelation of a painting, Constable's *Hay Wain*. Unfortunately, the indifferent quality of the illustration on page 34 detracts somewhat from the presentation. Overall, the diagrams in the book are good, but some of the photographs are poorly reproduced.

Bjerknes's original idea was to use mathematical equations to forecast the weather. However, the complexity of this task convinced him and his team to follow a more empirical line, which turned out to be enormously fruitful. The conceptual models of warm and cold fronts and of the life cycles of frontal depressions that emerged from the Bergen School dominated synoptic meteorology for most of the twentieth century and were of great practical benefit to humankind. More quantitative methods had to await scientific and technical developments in mid-century.

During the First World War, an extraordinary numerical experiment was carried out by Lewis Fry Richardson, who, using the best data set he could find, calculated changes in pressure and wind using the basic equations of motion. However, he was unaware that errors in the initial data could completely spoil the forecast, and his results were completely unrealistic. Richardson's attempt at practical forecasting by numbers was so unsuccessful and so impractical at the time that it had a deterrent effect on other meteorologists. But of course, Richardson's approach was ultimately the right one, and the causes of the error in his forecast are now well understood and quite avoidable. The authors provide a clear description of what Richardson achieved and of the remarkable prescience of his work.

In a chapter entitled "When the Wind Blows the Wind", the authors attempt to convey the ideas of nonlinearity, a phenomenon that "makes forecasting so difficult and weather so interesting." This is a key idea, and I feel that the attempt can at best be described as a qualified success. Some of the discussion is lacking in clarity and may not provide readers with the desired level of understanding.

Part 2 opens with a chapter in which the brilliant work of Carl Gustaf Rossby is described. Rossby had the capacity to reduce a problem to its essentials and to devise conceptual models that elucidated the mechanism of atmospheric phenomena, unencumbered by extraneous details. In a landmark paper published in 1939, he explained the basic dynamics of the large wavelike disturbances in the atmosphere by using a simple model based on conservation of absolute vorticity. Linearizing this, he produced an expression for the phase speed of the waves, thereby explaining the mechanism of propagation and also providing a means of predicting the propagation of wave disturbances. Some mathematical details of Rossby's model are presented in a Tech Box.

Rossby's model assumed a wave disturbance of a fluid with uniform depth. When the fluid depth varies, the conserved quantity is the ratio of absolute vorticity to depth, the potential vorticity (PV) in its simplest form. This can be used to explain the effect of a mountain chain on the flow. The authors describe a flow over the Andes but do not mention that in the Southern Hemisphere the configuration of troughs and ridges is reversed. Thus, their account and their Figure 5.12 are likely to be a source of confusion to readers.

Rossby's formula was of limited value in practical forecasting. The atmosphere is complex, and its behavior cannot be reduced to a simple travelling wave on a uniform background flow. A much more complete understanding of how midlatitude disturbances develop from small beginnings was provided by Jule Charney when he showed that they grow through baroclinic instability. Charney's work is rightly given prominence in the book. Having explained the mechanism of wave growth, he went on to produce a system of equations that could be used for practical numerical prediction while avoiding the problems encountered by Richardson. Charney then led the team that carried out the first successful prediction on the ENIAC computer in 1950. This was the beginning of real numerical weather prediction. The story is very well told in the book.

The limitations on prediction imposed by the chaotic nature of the atmosphere are then discussed. The work of Edward Lorenz was crucial to our understanding of what can and cannot be achieved. With our growing appreciation of the inherent limitations on weather forecasting, the emphasis has shifted from deterministic to probabilistic prediction, and the method of ensemble forecasting is now at the forefront of operational practice. All this is well described, including the application of probability forecasts to loss/cost models that can be used for rational decision making with great economic benefits.

The authors have an interest in symplectic geometry, the mathematical framework underlying Hamiltonian mechanics. They include a description of the main ideas of symplectic geometry, but this is as likely to mystify as to inspire readers, especially as the link with PV is not clarified. More practical is the account of Lagrangian advection schemes, which have led to substantial increases in numerical efficiency of forecasting models. The components of climate models are also described. In general, more schematic diagrams showing, for example, the components of an earth system model and the principal physical processes parameterized in models would have been welcome.

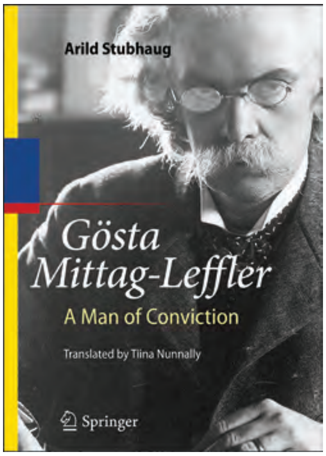
The book concludes by considering a number of outstanding issues. One of these is how best to represent moving surfaces of discontinuity. It is interesting that in the preface of his 1922 book, Richardson asked, "How are we to deal with discontinuities by finite differences?"

Recognizing that many readers are strongly discouraged by the appearance of even a few mathematical equations, the authors have endeavored to elucidate the key ideas of modern weather prediction without explicit mathematical material. This is quite a difficult task. The attempt has been reasonably successful, and readers without advanced scientific knowledge but with an interest in scientific matters should get an accurate, if incomplete, impression of how modern weather forecasts are made.

In the main text the authors strive to avoid mathematics and relegate details to Tech Boxes. I feel that more extensive use of mathematics in these boxes would have been appropriate and would have enabled mathematically inclined readers to get a more concrete understanding of the various technicalities discussed in the boxes (without frightening away more general readers). Readers with more extensive mathematical knowledge may be frustrated by the absence of fuller quantitative detail.

In summary, this is a well-written book giving a generally clear and accessible account of how weather forecasts are prepared. The historical detail enlivens the narrative and makes for an enjoyable read. The authors have considerable knowledge and expertise, and the book is scientifically sound. It can be warmly recommended to anyone who wishes to understand, in broad terms, how modern weather forecasts are made and how we may use models of the atmosphere to anticipate changes in the earth's climate.

Book Review



Gösta Mittag-Leffler. A Man of Conviction

Reviewed by Sigurdur Helgason

Gösta Mittag-Leffler. A Man of Conviction
Arild Stubhaug
Springer-Verlag, 2010
US$79.95, 810 pages
ISBN-13: 978-3642116711

The author of this book, Arild Stubhaug, is well known among mathematicians for his superb biographies of Abel and Lie. Being a *cand. mag.* in mathematics as well as in literature, he was in fact singularly qualified for such undertakings. He managed to convey the flavor of the mathematics involved without discouraging the nonmathematician reader.

It is therefore a matter of great interest that Stubhaug has undertaken the job of writing a biography of Mittag-Leffler. While Mittag-Leffler does not compare to Abel and Lie in mathematical output or creativity, the mathematician G. H. Hardy in 1927 maintained that no one had done more for mathematics during the preceding fifty years. And in fact many consider Mittag-Leffler to be the father of mathematics in Sweden. Most mathematicians know his name from the Mittag-Leffler theorem in complex analysis. It is a counterpart to Weierstrass's theorem about constructing a holomorphic function with prescribed zeros; in Mittag-Leffler's theorem the poles and the singular part at each end pole are prescribed.

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Stubhaug's book traces Gösta Mittag-Leffler's life from childhood on. However, the first chapter starts with a kind of an appetizer, "Journey at the Turn of the Century", which describes a trip Mittag-Leffler took to Egypt with his wife, Signe, accompanied by his personal physician. This is one example of many extensive trips he took during his life for health reasons. In fact, he suffered from serious health problems throughout his life. As a child he suffered from serious pneumonia of a kind where the survival prospects were 0.1 percent. He credited his mother's care for his survival and kept very warm contact with her all her life. He added her name, Mittag, to his father's name, Leffler.

After his professorship in Helsingfors, 1877–1881, Mittag-Leffler accepted a professorship at Stockholm's Högskola. His principal activities can be divided into four parts: (i) reforming Stockholm's Högskola toward a more research-oriented program in mathematics; (ii) founding in 1882 and developing the journal *Acta Mathematica*, which even today is a highly respected mathematical journal; (iii) investing in highly varied enterprises, carbide factories, railroads, waterfalls for hydroelectric production, etc.; and (iv) founding the Mathematical Institute in Djursholm in 1916 jointly with his wife: "The married couple Signe and Mittag-Leffler".

At the time of the founding of the institute their fortune was estimated at four million krona, down from seven million two years earlier. This would decline even further after the First World War. Toward the end of his life he had little left, partly because Signe's inheritance (she died six years before him) had been in large part diverted elsewhere due to another inheritor whom Mittag-Leffler called "The Witch [Hexan] W". After his death the institute was rather dormant except for the continued publication of *Acta Mathematica*.

However, around 1970 Lennart Carleson managed to obtain funding whereby the institute could function in the way Mittag-Leffler had planned, and Carleson served for sixteen years as the scientific director.[1]

Activities (ii) and (iii) were connected with very extensive travels all over Europe (and Egypt and Algeria). Many of these trips were taken for reasons of health and necessitated the company of a doctor.

Clearly Mittag-Leffler expected his biography would be written after his death. He always kept a diary, finally totalling ninety-three volumes. He wrote about 20,000 letters to about three thousand correspondents, collected hundreds of articles and drafts thereof, as well as records of business dealings. Every item involved was kept. The "Nachlass" filled about seventy-five shelf-meters. At the Mittag-Leffler Institute one can find series of leather-bound volumes filled with nothing but visiting cards. The list of his *Vitenskapelige Utmerkelser* (honorary degrees and memberships in scientific academies) fills two pages.

After defending his doctoral thesis in Uppsala in 1872 he got a stipend to travel to Berlin and Paris for two to three years. He started in Paris and dutifully attended Hermite's lectures. These turned out to be a real challenge to Mittag-Leffler's familiarity with French, because Hermite had difficulty walking so he did not use a blackboard. He just stood at the lectern and read the lectures from his manuscripts, most of which consisted of formulas for elliptic functions. He lectured 9:00–10:00 p.m. on Christmas Eve and continued Christmas Day at the same time. But Mittag-Leffler was clearly a dashing, charming fellow, and Hermite took a great liking to him, inviting him to dinner *en famille* with his two unmarried daughters present. But he advised Mittag-Leffler to go to Berlin and learn from Weierstrass ("he is the master of us all"). In Berlin Mittag-Leffler had a very productive time and established contact with members of the brilliant Berlin school, particularly Weierstrass. While Weierstrass would have liked to keep him in Berlin, Mittag-Leffler instead applied successfully for a professorship in Helsingfors. From Weierstrass he had heard about his brilliant student, Sonja Kowalevski. Shortly before taking the position at Helsingfors, Mittag-Leffler met her on a trip to St. Petersburg. To his mother he wrote: "Som quinna är hun forjusande. . . .Denne dag er en af de márkligsta i mitt liv. (As a woman she is enchanting. . . .This day is one of the most remarkable of my life.)" Through Mittag-Leffler's efforts Sonja was appointed professor at Stockholm's Högskola, and he did his best to make a pleasant life for her. This was often a difficult task.

Another woman scientist receiving significant support from Mittag-Leffler was Marie Curie. As a member of the Royal Swedish Academy he knew that Pierre Curie was a likely candidate for the Nobel Prize and was aware that her name had not been mentioned. Mittag-Leffler then wrote to Pierre Curie and asked whether she was not a fully worthy partner in his work. Curie answered quite positively that if such a prize was contemplated she would be equally deserving. So they did indeed share the Nobel Prize in physics in 1903. A couple of years later Pierre Curie died in a traffic accident, and in 1911 the chemistry prize was accorded to Marie Curie. At that time the Nobel committee was unaware of the scandal circulating in Paris concerning Marie Curie and Paul Langevin. Arrhenius, another member of the Swedish Academy, then wrote to Marie Curie expressing his opinion that it would be best if she did not come to Stockholm to receive the prize. Mittag-Leffler took quick action and in several telegrams to Langevin insisted that she should come to Stockholm. She followed his advice with deep gratitude. Thus Mittag-Leffler has the honor of arranging the first female professorship in mathematics and the first Nobel Prize to a female.

Stubhaug's description of these scientific political matters makes for fascinating reading. One also gets a clear image of Mittag-Leffler's business and investment affairs, which during some difficult times caused him much grief and criticism. A marital crisis around 1897 caused by jealousies is described with great tact and sensitivity. While reading this book three times I often felt that I was back in Djursholm wandering through the institute or along the paths near the seashore. The book is thoroughly captivating.

While Mittag-Leffler might have thought that his diaries could make an account of his life easy for a biographer, it took almost a century until Stubhaug had the courage to tackle this enormous challenge with reasonable completeness. The result is a fascinating account of Mittag-Leffler's life which at the same time gives a vivid picture of the European mathematical milieu and activities during the period 1887–1920.

[1] *Information about the Mittag-Leffler Institute and its history may be found in "The dream of a Swedish mathematician: The Mittag-Leffler Institute", by Allyn Jackson,* Notices, *October 1999.*

Reconsidering the Mathematics Preparation of Pre-service Secondary Mathematics Teachers

Mary Beisiegel, Josh Chesler, Dana Cox, Rachael Kenney, Jill Newton, and Jamalee Stone

Secondary mathematics teacher preparation programs typically require pre-service teachers to complete an undergraduate degree in mathematics, or the equivalent [1, 3], along with education coursework and some type of field experience. There has been substantial discussion in the mathematics education community about the mathematics coursework required of pre-service secondary mathematics teachers. Many have questioned the value of traditional undergraduate mathematics programs for future high school mathematics teachers. Hodgson [5] noted that, within such programs, pre-service secondary mathematics teachers "have no explicit occasion for making connections with the mathematical topics for which they will be responsible in school, nor of looking at those topics from an advanced point of view" (p. 509). He endorsed the inclusion of undergraduate coursework that would help pre-service teachers develop "deep conceptual understanding of the school mathematics content" (p. 512).

In 2001 the Conference Board of the Mathematical Sciences (CBMS) [3] recommended that pre-service secondary mathematics teachers complete "a 6-hour capstone course connecting their college mathematics courses with high school mathematics" (p. 8). Recently, the CBMS has released an updated version of these recommendations [4] and, rather than suggesting a specific capstone course, now proposes that pre-service secondary mathematics teachers complete the equivalent of a mathematics major "that includes three courses with a primary focus on high school mathematics from an advanced viewpoint" (p. 18). The call for pre-service secondary mathematics

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teachers to interact with high school mathematics content at a deeper level is particularly salient in light of Monk's [6] influential large-scale, longitudinal study of the effects of teachers' mathematics subject matter preparation on their students' performances. Monk declared that "having a mathematics major has no apparent effect on student performance" and suggested that training which is not directly relevant to secondary school content "cannot be counted on to have positive collateral effects" (p. 132). There is a continual call for pre-service secondary mathematics teachers to interact with high school mathematics content at a deeper level

Against this backdrop of recommendations and concerns about secondary mathematics teacher preparation, we conducted a survey [2] of universities to investigate the prevalence and nature of capstone courses one decade after the CBMS recommendations. We found that just over one third of survey respondents reported having a capstone course that aligned with the CBMS by linking high school and university mathematics content. Further, only 27 percent of these CBMS-aligned capstones (9.6 percent of all respondents) comprised at least six credit hours, as recommended.

Though the generalizability of our survey is limited by a convenience sample of 73 institutions, it is apparent that relatively few programs have a capstone course that aligns with the 2001 CBMS recommendations. Moreover, only 23 percent of these courses were intended exclusively for students seeking licensure. This seemingly limited impact of the CBMS recommendations for capstone courses is amplified by the fact that, even among institutions that have such courses, less than one third of respondents described the 2001 CBMS document as being influential in the design of the capstone course.

The CBMS-aligned capstones investigated through our study are very diverse in terms of mathematical content, course materials, and methods of assessment. A large majority of instructors for these courses indicated that they have a great deal of freedom and very few departmental (or other) guidelines for teaching this course. In terms of instructor control, course descriptions indicated that the capstones ran the gamut from independent study opportunities to lecture-driven mathematics courses. In terms of content, there was also great variability in terms of how content was selected. In some courses, it was specified entirely by the instructor and in others, negotiated between instructor and student. The instructors' backgrounds were in either mathematics (50 percent), mathematics education (15 percent), or both (35 percent).

Our survey shows that a decade after the CBMS recommendation for capstone courses, there are very few actual implementations of the recommendations. Moreover, the variety of capstone courses we found through the study is perhaps a reflection of the capstone being tailored to fit the needs of individual departments. In particular, if a capstone course is offered by the mathematics department, it is most likely designed to fit the general needs of a mathematics major and addresses advanced mathematical topics in lieu of making connections to high school mathematics. Despite recommendations, pre-service secondary mathematics teachers still have few occasions for thinking deeply about high school-level content. The current required coursework appears to be the same formal mathematics that Monk said did nothing to improve student performance [6] and does not help pre-service teachers to benefit from a deep examination of the content they will someday teach.

It is an important time to be considering recommendations put forth by national organizations. In addition to the CBMS [3] renewing and increasing the suggested focus on high school mathematics content for pre-service secondary mathematics teachers to focus on, that very content is changing on a national basis. Any programmatic changes that are responsive to K–12 content need to be made in light of the adoption of the *Common Core State Standards for Mathematics* (CCSSM). Meeting these recommendations could place additional pressure on departments to develop separate sections of established courses for pre-service teachers or to offer an alternative program of study for this population in order to better prepare teachers for teaching the new content included in CCSSM.

Our study indicates that it is unlikely that the new CBMS recommendations will inspire widespread departmental change on their own. However, against the backdrop of major changes in K–12 mathematics education, it is an opportune time for departments to uncover and question the assumptions which underlie their teacher preparation programs and to identify potential opportunities for improvement. As a community, we must put to work the practices that we know are needed to help the future students of these pre-service teachers. In particular, we and others (for example, [3] and [4]) believe that pre-service secondary mathematics teachers benefit from a deep examination of high school content. By no means do we wish to insinuate that there is no value for future teachers to take traditional upper division mathematics courses, but future teachers also stand to benefit from an equally rigorous examination of high school mathematics and statistics. Shulman [7] reminds us of our role in teaching mathematics to pre-service teachers:

> Whether we call ourselves professors of education or professors of mathematics, to the extent that in our classrooms day after day sit men and women

> who subsequently go out and teach youngsters, we are teacher educators. To the extent that they are likely to teach both *what* and *as* they have been taught, unlike any other students in your classes, the future teachers are, if you will, carriers. Whatever understandings or misunderstandings you infect them with, both about the content and regarding the pedagogy, they will carry to generations of young people whom they will subsequently teach, and who themselves will eventually appear at your doorstep. (p. 406; emphasis in original)

Mathematics and statistics departments have the responsibility to ensure that future mathematics teachers have deep and connected understandings of the mathematics they will teach.

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Mathematics People

AMS Menger Awards at the 2013 ISEF

The 2013 Intel International Science and Engineering Fair (ISEF) was held May 12–17, 2013, at the Phoenix Convention Center in Phoenix, Arizona. This year, more than 1,600 students in grades nine through twelve (selected from 433 affiliate fairs in more than seventy countries, regions, and territories) participated in the world's largest precollege science research competition. The first fair was held in Philadelphia in 1950. In 1958, the fair became international, when Japan, Canada, and Germany joined the competition.

Student finalists who competed at this year's Intel ISEF went through a multistep process to qualify and won an all-expense-paid trip to the fair. They qualified by winning local, regional, and state fairs in the United States or national science fairs abroad. In addition to numerous grand awards presented by ISEF, more than sixty federal agencies, professional and educational organizations, including the American Mathematical Society (AMS), participated by giving special awards. Prizes given by the AMS included cash, certificates, and a booklet about Karl Menger, given to each award winner.

For the AMS, this was the twenty-fifth year of participation and it was the twenty-third year of the presentation of the Karl Menger Awards.

The members of the 2013 AMS Menger Prize Committee and AMS special awards judges were Jonathan King, University of Florida (chair); Mihai Stoiciu, Williams College; and John Milton, Claremont McKenna College. The panel of judges initially reviewed all seventy-two projects in mathematics: sixty-three by individuals, and nine by teams. From these entries they selected a subset of students who were interviewed for further consideration for a Menger Prize. The AMS gave awards to one first-place winner, two second-place winners, four third-place winners, and honorable mentions to five others.

The Karl Menger Memorial Prize winners for 2013 are listed below, together with each student's high school and project title.

First Place Award (US$1,000): Colin Aitken, Leland High School, San Jose, California, "Dots and lines: A combinatorial interpretation of the homotopy groups of finite topologies".

Second Place Awards (US$500): Stanislav I. Atanasov, Model High School of Mathematics "Academician Kiril Popov", Plovdiv, Bulgaria, "Rational fixed points of polynomial involutions"; Hannah Larson, South Eugene High School, Eugene, Oregon, "Classification of dome fusion categories of rank 4".

AMS Menger Awards. Back row: (l-r): Jonathan King (chair), Maksim Bezrukov, Ilya Kirillov, Asbjorn Nordentoft, Colin Aitken. Front row (l-r): Stanislav Atanasov, Aliasksandr Stadolnik, Hannah Larson, Simanta Gautam.

Third Place Awards (US$250): Asbjorn C. Nordentoft, Aurehoj Gymnasium, Gentofte, Denmark, "Applications of Dirichlet series"; Simanta Gautam, Albemarle High School, Charlottesville, Virginia, "A novel approach to the spherical codes problem"; Ilya Kirillov, Lyceum 1303, Moscow, Russia, "Configuration spaces of 4-bar linkages"; Maksim L. Bezrukov, Gymnasium #41, and Aliasksandr O. Stadolnik, Gymnasium #13, Minsk, Belarus (team entry), "Percolation games on Cayley graphs of groups".

Honorable Mention Awards: Rumen R. Dangovski, Sofia High School of Mathematics, Sofia, Bulgaria, "On Weitzenboeck derivations of free metabelian associative and Lie algebras"; Yu-Fang Hsu, National Nanke International Experimental High School, Taiwan Chinese Taipei, "Resolving an open problem related to figurate numbers by Pell equations"; Sarah Shader, Laramie High School, Laramie, Wyoming, "Intercalates galore"; Akhil Nistala, Novi High School, Novi, Michigan, "Matching preclusion and conditional matching preclusion for dual-cubes"; David Pan, Canterbury School, Fort Wayne, Indiana, "A maximum principle and its applications".

As indicated by these project titles, student research covered a wide swath. The judges were impressed by the quality, breadth, and originality of the work, as well as the dedication and enthusiasm shown. Many projects contained original research that one would expect from graduate students. For the second time in recent history, one of the prize-winning entries was from a team (Maksim Bezrukov and Aliasksandr Stadolnik, third place). In the mathematics section, there were two entries from fourteen-year-olds, and the youngest Menger finalist was sixteen (Yu-Fang Hsu, Honorable Mention).

The Society for Science and the Public (http://www.societyforscience.org/), a nonprofit organization based in Washington, DC, owns and has administered the ISEF since 1950, first sponsored by Westinghouse and then, since 1998, by Intel.

The Intel ISEF finals for next year will be held May 11–16, 2014, in Los Angeles, California, at the Los Angeles Convention Center. (See http://www.societyforscience.org/intelisef2014).

The AMS's participation in ISEF is supported in part by income from the Karl Menger Fund, which was established by the family of the late Karl Menger (http://www.ams.org/profession/prizes-awards/ams-awards/menger-award). The income from the donation by the Menger family covers less than the amount of the awards. The balance, including the travel expenses of the judges, comes from the AMS's general fund. For more information about this program or to make contributions to this fund, contact the AMS Development Office, 201 Charles Street, Providence RI, 02904-2294: or send email to development@ams.org; or telephone 401-455-4103.

—Jonathan King
Associate Professor of Mathematics
University of Florida, Gainesville, FL

Mathematical Sciences Awards at ISEF

The 2013 Intel International Science and Engineering Fair (ISEF) was held May 12–17, 2013, at the Phoenix Convention Center in Phoenix, Arizona. The Society for Science and the Public, in partnership with the Intel Foundation, selects a Best in Category contestant, who receives a cash award of US$5,000. The student chosen this year in the Mathematical Sciences category was Vinay S. Iyengar, seventeen, of Oregon Episcopal School, Portland, Oregon, for his project titled "Efficient characteristic 3 Galois field operations for elliptic curve cryptographic applications". Iyengar also received a First Award, which carries a cash prize of US$3,000. He was also chosen as the recipient of a Grand Award from the European Union Contest for Young Scientists, which consists of an all-expenses-paid trip to attend the European Union Contest for Young Scientists. The Oregon Episcopal School was awarded a grant of US$1,000. More award winners and the titles of their projects follow.

First Award (US$3,000): Vinay Iyengar, seventeen, Oregon Episcopal School, Portland, "Efficient characteristic 3 Galois field operations for elliptic curve cryptographic applications"; Katherine L. Cordwell, seventeen, Manzano High School, Albuquerque, New Mexico, "Lower central series quotients of finitely generated algebras over the integers".

Second Award (US$1,500): Salahaldeen I. Abu-Alshaikh, sixteen, Jubilee School, Amman, Jordan, "Closed-form volumes of a wide family of astroidal ellipsoids and the hyperbolic octahedron"; Akhil Nistala, seventeen, Novi High School, Novi, Michigan, "Matching preclusion and conditional matching preclusion for dual-cubes"; Simanta Gautam, seventeen, Albemarle High School, Charlottesville, Virginia, "A novel approach to the spherical codes problem"; Niranjan Balachandar, sixteen, and Nirali K. Thakor, fifteen, Shepton High School, Plano, Texas, "Simulation of protein folding using Monte Carlo methods in a triangular lattice".

Third Award (US$1,000): Asbjorn C. Nordentoft, nineteen, Aurehoj Gymnasium, Gentofte, Denmark, "Applications of Dirichlet series"; Yu-Fang Hsu, sixteen, National Nanke International Experimental High School, Taiwan, Chinese Taipei, "Resolving an open problem related to figurate numbers by Pell equations"; Daniel M. Hanover, fifteen, John L. Miller Great Neck North High School, Great Neck, New York, "Kaprekar's constant: A journey to new bases"; Ashwin P. Ramachandran, seventeen, Randolph School, Huntsville, Alabama, "A novel mathematical model of cellular apoptosis under the influence of Hsp70"; Kevin K. Lee, sixteen, University High School, Irvine, California, "Electromechanical modeling of the heart in moving domains using the phase-field method"; Andres J. A. Colon, seventeen, and Edwin S. Torres-Cuevas, seventeen, Centro Residencial de Oportunidades Educativas de Mayaguez, Mayaguez, Puerto Rico, "Study of integrals of parametric functions for Fermat's curve of third degree".

Fourth Award (US$500): Retselisitsoe E. Monyake, seventeen, Harmony High School, Virginia, South Africa, "An alternative proof of the Pappus chain theorem using the method of circle inversion"; Hannah K. Larson, eighteen, South Eugene High School, Eugene, Oregon, "Classification of some fusion categories of rank 4"; Colin C. Aitken, seventeen, Leland High School, San Jose, California, "Dots and lines: A combinatorial interpretation of the homotopy groups of finite topologies"; Shashwat Kishore, sixteen, Unionville High School, Kennett Square, Pennsylvania, "Analysis of novel clustering algorithms for gene expression patterns"; Rishi S. Mirchandani, sixteen, Fox Chapel Area High School, Pittsburgh, Pennsylvania, "Superadditivity and subadditivity in fair division"; Evan Z. Liu, seventeen, Albuquerque Academy, Albuquerque, New Mexico, "A mathematical analysis of set variants"; Rohan B. Banerjee, sixteen, and Archis R. Bhandarkar, seventeen, Thomas Jefferson High School for Science and Technology, Alexandria, Virginia, "On the stability of lung parenchymal lesions with applications to early pneumothorax diagnosis"; Nayana R. Koravatti, sixteen, and Aishwarya C. Ashok, sixteen, Amrita Vidyalayam, Davangere, India, "Dissection of square into 'N' congruent squares".

—From an ISEF announcement

Mathematics Opportunities

American Mathematical Society Centennial Fellowship

Invitation for Applications for Awards for 2014–2015
Deadline December 1, 2013

Description: The AMS Centennial Research Fellowship Program makes awards annually to outstanding mathematicians to help further their careers in research. The number of fellowships to be awarded is small and depends on the amount of money contributed to the program. The Society supplements contributions as needed. One fellowship will be awarded for the 2014–2015 academic year. A list of previous fellowship winners can be found at `http://www.ams.org/profession/prizes-awards/ams-awards/centennial-fellow`.

Eligibility: The eligibility rules are as follows. The primary selection criterion for the Centennial Fellowship is the excellence of the candidate's research. Preference will be given to candidates who have not had extensive fellowship support in the past. Recipients may not hold the Centennial Fellowship concurrently with another major research award such as a Sloan Fellowship, NSF Postdoctoral Fellowship, or CAREER award. Under normal circumstances, the fellowship cannot be deferred. A recipient of the fellowship shall have held his or her doctoral degree for at least three years and not more than twelve years at the inception of the award (that is, received between September 1, 2002, and September 1, 2011. However, for any program, fellowship, prize, or award that has a maximum period of eligibility after receipt of the doctoral degree, the selection committee may use discretion in making exceptions to the limit on eligibility for candidates whose careers have been interrupted for reasons such as family or health). Applications will be accepted from those currently holding a tenured, tenure-track, postdoctoral, or comparable (at the discretion of the selection committee) position at an institution in North America. Applications should include a cogent plan indicating how the fellowship will be used. The plan should include travel to at least one other institution and should demonstrate that the fellowship will be used for more than reduction of teaching at the candidate's home institution. The selection committee will consider the plan, in addition to the quality of the candidate's research, and will try to award the fellowship to a person for whom the award would make a real difference in the development of his or her research career. Work in all areas of mathematics, including interdisciplinary work, is eligible.

Deadline: The deadline for receipt of applications is **December 1, 2013**. The award recipient will be announced in February 2014 or earlier if possible.

Application information: Centennial information and the application form may be found via the Internet at `http://www.ams.org/ams-fellowships/`. For paper copies of the form, write to the Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; send email to `prof-serv@ams.org`; or call 401-455-4105.

—AMS announcement

Call for Nominations for the Ostrowski Prize

The Ostrowski Foundation is seeking nominations for the 2013 Ostrowski Prize. This international prize is awarded for recent outstanding achievements in pure mathematics or the theoretical foundations of numerical mathematics. The 2013 prize carries a cash award of 100,000 Swiss francs (approximately US$106,500).

Nominations should include a CV of the candidate, a letter of nomination, and three letters of reference. Nominations should be sent by **September 15, 2013**, to the jury chair, Cameron Stewart, at `cstewart@uwaterloo.ca`. For more information, see the website `http://www.ostrowski.ch/index_e.php?ifile=home`.

—Cameron Stewart, University of Waterloo

AWM Travel Grants for Women

The National Science Foundation (NSF) and the Association for Women in Mathematics (AWM) sponsor travel grant programs for women mathematicians.

AWM Travel Grants for Women Researchers enable women to attend research conferences in their fields, thereby providing scholars valuable opportunities to advance their research activities and their visibility in the research community. A Mathematics Travel Grant provides full or partial support for travel and subsistence for a meeting or conference in the grantee's field of specialization, awarding funds of up to US$1,750 for domestic travel and of US$2,300 for foreign travel.

The Mathematics Education Research Travel Grants provide full or partial support for travel and subsistence in math/math education research for mathematicians attending a math education research conference or math education researchers attending a math conference. The grants provide up to US$1,750 for domestic travel and of US$2,300 for foreign travel.

AWM Mathematics Mentoring Travel Grants are designed to help junior women develop long-term working and mentoring relationships with senior mathematicians. A mentoring travel grant funds travel, subsistence, and other expenses for an untenured woman mathematician to travel to an institute or a department to do research with a specified individual for one month. Up to seven grants will be awarded in amounts up to US$5,000 each.

Mathematics Education Research Mentoring Travel Grants encourage collaboration between mathematicians and researchers in education and related fields in order to improve the education of teachers and students. Women mathematicians who wish to collaborate with an educational researcher or to learn about educational research may use the mentoring grants to travel to collaborate with or be mentored by a mathematics education researcher. Up to seven grants will be awarded in amounts up to US$5,000 each.

The final deadline for the Travel Grants program for 2013 is **October 1, 2013**. The deadlines for 2014 are **February 1, 2014**; **May 1, 2014**; and **October 1, 2014**. For the Mathematics Education Research Travel Grant program, the deadlines are **October 1, 2013**; **February 1, 2014**; **May 1, 2014**; and **October 1, 2014**. For the Mathematics Mentoring Travel Grants program, the deadline is **February 1, 2014**. For the Mathematics Education Research Mentoring Travel Grants program, the deadline is **February 1, 2014**. For further information and details on applying, see the website `https://sites.google.com/site/awmmath/programs/travel-grants`; telephone: 703-934-0163; or email: `awm@awm-math.org`; or contact the Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

—From an AWM announcement

AIM Workshops

The American Institute of Mathematics (AIM) seeks proposals for workshops in all areas of the mathematical sciences. Proposals should include (1) a plan for the workshop, including a description of the workshop focus and goals; (2) a list of at least two and at most four organizers; (3) a list of potential participants; and (4) the mathematics subject classification and a list of references. Workshops generally last four or five days and can support up to twenty-eight participants.

Proposals for workshops may be submitted online at `www.aimath.org`; the deadline for submissions is **November 1, 2013**. The AIM workshop format is designed to encourage new collaborations to make plans or progress toward a research goal: there are two talks each morning of the workshop and structured group activities each afternoon, including research in small groups.

Further details and a list of upcoming workshops are available at `www.aimath.org`.

—From an AIM announcement

Call for Nominations for Clay Research Fellowships

The Clay Mathematics Institute (CMI) solicits nominations for its competition for the 2014 Clay Research Fellowships. Fellows are appointed for a period of two to five years. They may conduct their research at whatever institution or combination of institutions best suits their research. In addition to a generous salary, the fellows receive support for travel, collaboration, and other research expenses.

The selection criteria are the quality of the candidate's research and promise to become a mathematical leader. All those selected are recent Ph.D.'s, and most are selected as they complete their thesis work. Selection decisions are made by CMI's Scientific Advisory Board.

To nominate a candidate, please send the following items by **October 30, 2013**: (1) letter of nomination; (2) names and contact information of two other references; (3) curriculum vitae for the nominee; and (4) publication list for the nominee. Nominations should be sent to the attention of Nick Woodhouse, Clay Mathematics Institute, 10 Memorial Boulevard, Suite 902, Providence, RI 02903. Electronic submissions are also accepted at `nominations@claymath.org`.

Information about the Clay Research Fellows is available on the CMI website at `http://www.claymath.org/research_fellows`.

—From a Clay Mathematics Institute announcement

News from MSRI

The Mathematical Sciences Research Institute (MSRI) is accepting applications for residencies in 2014–2015 and preproposals for scientific programs.

Research Program Residencies

Forty research professors, 200 research members, and thirty postdoctoral fellows will be selected for residencies in the following programs:

New Geometric Methods in Number Theory and Automorphic Forms, August 11, 2014–December 12, 2014.

Geometric Representation Theory, August 18, 2014–December 19, 2014.

Dynamics on Moduli Spaces of Geometric Structures, January 12, 2015–May 22, 2015.

Geometric and Arithmetic Aspects of Homogeneous Dynamics, January 19, 2015–May 29, 2015.

Research professorships are intended for senior researchers who will make key contributions to a program, including the mentoring of postdoctoral fellows, and who will be in residence for three or more months. Research memberships are intended for researchers who will make contributions to a program and who will be in residence for one or more months. Postdoctoral fellowships are intended for recent Ph.D.'s who will be in residence for one semester. Interested individuals should carefully describe the purpose of their proposed visit and indicate why a residency at MSRI will advance their research program. To receive full consideration, the application must be completed, including all letters of support, by the following deadlines: research professorships, **October 1, 2013**; research memberships, **December 1, 2013**; postdoctoral fellowships, **December 1, 2013**. For more information see the website `https://www.msri.org/web/msri/scientific/member-application`.

Preproposals for Scientific Programs

MSRI invites the submission of preproposals for full- or half-year programs to be held at MSRI. Such programs are generally planned about three years in advance. A scientific program at MSRI generally consists of up to one year (ten months) of concentrated activity in a specific area of current research interest in the mathematical sciences. MSRI usually runs two programs simultaneously, each with about thirty mathematicians in residence at any given time. The most common program lengths are for one year and for five months (typically in the form of a fall or spring semester program).

For more complete information see the website `https://www.msri.org/web/msri/scientific/request-for-proposals/propose-a-program`.

—From MSRI announcements

Inside the AMS

New Journals from AMS

January 2014 will see the launch of two new gold open access research journals from the AMS.

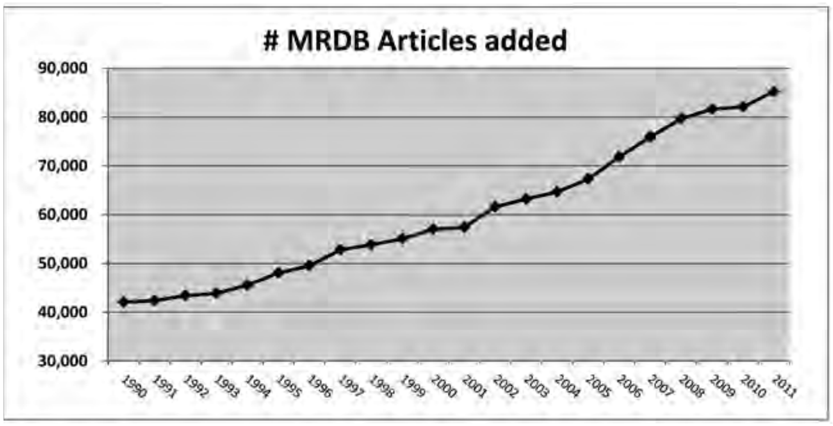
A proposal for the two new journals was considered in some depth by a special committee, appointed by the president of the AMS. The committee was asked to look at the concept, business model, and implementation issues. The proposal was then subsequently approved by the AMS Council.

The two new journals, *Proceedings of the American Mathematical Society, Series B* and *Transactions of the American Mathematical Society, Series B* will serve as companions to the subscription journals *Proceedings* and *Transactions of the AMS*. Each of the new journals will be electronic-only and freely available online, supported by article processing charges (APC) designed to cover the Society's publication costs (these charges are typically paid by a funding agency or by the author's institution and are not expected to be paid by the author personally).

Editorial decisions will be completely independent of whether a paper is intended for the open access journal or its subscription counterpart. *Proceedings B* and *Transactions B* will share common editorial boards and thus submission procedures with their companion journals.

Why Launch Gold Open Access Journals?

The world is changing under our feet. There are shifting profiles of all stakeholders in academic research: authors, readers, institutions, societies, libraries, and publishers. It is quite remarkable to watch the rate of increase of articles published in mathematics and related disciplines. The accompanying graph shows the number of research journal articles added to the Mathematical Reviews (MR) database (MRDB) by journal publication year.



In addition to the stress on publishers and libraries of needing to publish more, there are cultural, market, and consequent business model factors that have led to the need for society publishers to experiment with open access models.

The open access movement really began through the energetic advocacy of the academic community in response to the perceived throttling effect of overly aggressive pricing policies practiced by commercial publishers. As advances in technology shifted the balance of power towards individual authors and users, it was clear to some that it was time to face copyright issues and the ability to devise new ways of providing access. Such is the nature of this advocacy, of course, that the movement created a polarizing effect on the academic and publishing communities, creating open access advocates pitted against those urging caution in throwing out established business models. These business models remain the lifeblood for many academic societies as their main income stream—so the stage was set for battle—and it roars on amidst politics, rhetoric, pragmatism, and words of caution.

Even some of the world's major funding agencies have become involved. The Research Councils of the UK (RCUK)[1] has issued a mandate that will force RCUK funded researchers to publish in green open access, or gold open access journals. In the U.S., the Office of Science and Technology Policy (OSTP)[2] has issued a memorandum to U.S. funding agencies requesting that they formulate a suitable open access policy for their funded researchers. Others are following suit.

In many ways, the debate over whether gold or green open access is to be favored is at this stage to drill down too far into the detail. The message is loud and clear to society publishers like the AMS. For the AMS to be able to cater to authors as political funders require their researchers to publish in green or gold open access journals, we must provide a path for these authors so as not to

[1] http://www.rcuk.ac.uk/documents/documents/RCUKOpenAccessPolicy.pdf.

[2] http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf.

disenfranchise mathematicians from wherever they may be in the world.

For the AMS this is an experiment with a new business model that not only allows us to test our innovative variation of gold open access but also allows us to publish more, relieving the stress in the research community caused by the sharp increase of high quality research papers.

It is worth noting that mathematicians are in many respects ahead of the curve in terms of open access, given that much of a mathematician's works appears in one form or another on arXiv[3] (an open e-print archive with 8,555,382 e-prints in physics, mathematics, computer science, quantitative biology, quantitative finance, and statistics). The AMS is of course already a green open access publisher with liberal policies for deposit of an author's manuscript in repositories, or on an author's own website.

What Is the AMS Model for Gold Open Access?

The key to the AMS approach to gold open access publishing is to separate the editorial decision to publish from the business model applied to the journal.

Consider the case of *Proceedings*, for example. An author will submit his or her article to a common editorial board for both *Proceedings* and *Proceedings B*. Once the article has been through full peer review and is accepted, the author is given the option of routing the article to the regular journal or to the open access companion journal. If an author chooses the open access journal, then on payment of an article processing charge (APC) that paper will move into the relevant queue. There is no jumping a queue, so only those papers with paid APC will enter the open access journal queue in strict order of their acceptance date. An author's article will be published in either the regular journal or the open access journal and thus peer review is entirely separated from the business model.

The open access publication option will be available starting September 1, 2013, for all articles accepted by the *Proceedings* and *Transactions of the AMS* editorial boards. New articles should be submitted via `www.ams.org/procsubmit` or `www.ams.org/transubmit`, and the open access publication decision may be determined by the author upon notification of acceptance.

The article processing charges are:

- *Proceedings of the AMS, Series B*: list price US$1,500 (2014 discount price US$750),
- *Transactions of the AMS, Series B*: list price US$2,750 (2014 discount price US$1,400).

Further information will become available on `www.ams.org` as the journals approach their January 2014 release date.

Robert M. Harington, D. Phil.
Associate Executive Director, Publishing
American Mathematical Society
`rmh@ams.org`

[3]`http://arxiv.org/`

From the AMS Public Awareness Office

New Albums on Mathematical Imagery. See *Daina Taimina's Hyperbolic Crochet*, works inspired by William Thurston (see photo, left); *Frank Farris: Seeing Mathematics*, digital works based on photographs of everyday scenes and objects; and *Robert J. Lang: Origami*, additional images of animals, insects, and other folded paper works, at `www.ams.org/mathimagery`.

AMS—Publishing Mathematics Research for 125 Years. This poster features some of the many notable articles in AMS journals and highlights of MathSciNet and is free upon request. Email `paoffice@ams.org` with subject line: AMS publishing poster.

AMS exhibits at non-AMS meetings, fall 2013. Please visit the AMS exhibits at the National SACNAS Conference in San Antonio, Texas, October 3–5, and the AMATYC Annual Conference in Anaheim, California, October 31–November 2, and see more upcoming exhibit information at `www.ams.org/ams-at-mtgs`.

AMS Blogs. There are a lot of thought-provoking blog posts on the *Blog on Math Blogs*, *e-Mentoring Network in the Mathematical Sciences*, *AMS Grad Student Blog*, and on *Ph.D. + epsilon*. AMS members are invited to follow the blogs via an RSS feed, share them via social media or email, and comment at `blogs.ams.org`.

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

Deaths of AMS Members

Gerard G. Emch, of Gainesville, Florida, died on March 5, 2013. Born on July 21, 1936, he was a member of the Society for 41 years.

Alan M. Kriegsman, of Chevy Chase, Maryland, died on August 31, 2012. Born on February 28, 1928, he was a member of the Society for 5 years.

Robert R. Phelps, of Shoreline, Washington, died on January 4, 2013. Born on March 22, 1926, he was a member of the Society for 57 years.

Albert W. Sanez, of Alexandria, Virginia, died on December 5, 2012. Born on August 27, 1923, he was a member of the Society for 13 years.

Charles J. Standish, of Greene, New York, died on January 3, 2013. Born on November 10, 1926, he was a member of the Society for 61 years.

Nick H. Vaughan, of Sugar Land, Texas, died on May 18, 2013. Born on February 11, 1923, he was a member of the Society for 45 years.

Reference and Book List

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

Contacting the *Notices*

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

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

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

Upcoming Deadlines

August 28, 2013: Full proposals for NSF REU sites. See `http://www.nsf.gov/pubs/2009/nsf09598/nsf09598.htm`.

September 1–November 15, 2013: Applications for AMS travel grants for ICM 2014. See `http://www.ams.org/programs/travel-grants/icm`.

September 15, 2013: Nominations for 2013 Ostrowski Prize. See "Mathematics Opportunities" in this issue.

September 15, 2013: Applications for spring 2014 semester of Math in Moscow. See `http://www.mccme.ru/mathinmoscow`, or contact: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7095-291-65-01; e-mail: `mim@mccme.ru`. Information and application forms for the AMS scholarships are available on the AMS website at `http://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`.

September 16, 2013: Nominations for Sloan Fellowships. Contact Sloan Research Fellowships, Alfred P. Sloan Foundation, 630 Fifth Avenue, Suite 2550, New York, New York 10111-0242, or consult the foundation's website: `http://www.sloan.org/fellowships`.

September 20, 2013: Full proposals for NSF Focused Research Groups. See `http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5671`.

September 30, 2013: Nominations for W. K. Clifford Prize. See `http://www.wkcliffordprize.org`.

October 1, 2013: Applications for MSRI research professorships. See "Mathematics Opportunities" in this issue.

October 1, 2013: Applications for AWM Travel Grants, Mathematics Education Research Travel Grants, Mathematics Mentoring Travel Grants, and Mathematics Education Research Mentoring Travel Grants. See "Mathematics Opportunities" in this issue.

October 1, 2013: Nominations for Parzen Prize. Submit to Thomas

Where to Find It

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

Wehrly, Department of Statistics, 3143 TAMU, Texas A&M University, College Station, Texas 77843-3143. For more information see the website http://www.stat.tamu.edu/awards-and-prize-details.php?prizeid=7.

October 4, 2013: Letters of intent for NSF Program ADVANCE Institutional Transformation and Institutional Transformation Catalyst awards. See http://www.nsf.gov/pubs/2012/nsf12584/nsf12584.htm?WT.mc_id=USNSF_36&WT.mc_ev=click.

October 15, 2013: Proposals for NSA Grants for Research in Mathematics. See http://www.nsa.gov/research/math_research/index.shtml or contact the program office at 301-688-0400; email: mspgrants@nsa.gov.

October 16, 2013: Proposals for National Science Foundation (NSF) Postdoctoral Research Fellowships. See http://www.nsf.gov/pubs/2012/nsf12496/nsf12496.htm.

November 1, 2013: Applications for November review for National Academies Research Associateship Programs. See the website http://sites.nationalacademies.org/PGA/RAP/PGA_050491 or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email rap@nas.edu.

November 12, 2013: Full proposals for NSF Program ADVANCE Institutional Transformation and Institutional Transformation Catalyst awards. See http://www.nsf.gov/pubs/2012/nsf12584/nsf12584.htm?WT.mc_id=USNSF_36&WT.mc_ev=click.

December 1, 2013: Applications for AMS Centennial Fellowship. See "Mathematics Opportunities" in this issue.

December 1, 2013: Applications for MSRI research memberships and postdoctoral fellowships. See "Mathematics Opportunities" in this issue.

December 1, 2013: Applications for PIMS postdoctoral fellowships. See the website http://www.pims.math.ca/scientific/postdoctoral, or contact assistant.director@pims.math.ca.

December 2, 2013: Nominations for Ferran Sunyer i Balaguer Prize. See http://ffsb.iec.cat.

December 31, 2013: Nominations for Otto Neugebauer Prize. See the website http://www.euro-math-soc.eu/otto_neugebauer_prize.html.

February 1, 2014: Applications for AWM Travel Grants, Mathematics Education Research Travel Grants, Mathematics Mentoring Travel Grants, and Mathematics Education Research Mentoring Travel Grants. See "Mathematics Opportunities" in this issue.

February 15, 2014: Nominations for AWM-Joan & Joseph Birman Prize in Topology and Geometry. See the website http://www.awm-math.org.

April 15, 2014: Applications for fall 2014 semester of Math in Moscow. See http://www.mccme.ru/mathinmoscow, or contact: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7095-291-65-01; email: mim@mccme.ru. Information and application forms for the AMS scholarships are available on the AMS website at http://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, 2014: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See "Mathematics Opportunities" in this issue.

October 1, 2014: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See "Mathematics Opportunities" in this issue.

Conference Board of the Mathematical Sciences

1529 Eighteenth Street, NW
Washington, DC 20036
202-293-1170
http://www.cbmsweb.org/

Ronald C. Rosier
Director
202-293-1170
410-730-1426 (home—try this first)
rosier@georgetown.edu
Lisa R. Kolbe
Administrative Coordinator
202-293-1170
301-601-9449 (home)
kolbe.lisa@gmail.com

Member Societies:
American Mathematical Association of Two-Year Colleges (AMATYC)
American Mathematical Society (AMS)
Association of Mathematics Teacher Educators (AMTE)
American Statistical Association (ASA)
Association for Symbolic Logic (ASL)
Association for Women in Mathematics (AWM)
Association of State Supervisors of Mathematics (ASSM)
Benjamin Banneker Association (BBA)
Institute of Mathematical Statistics (IMS)
Mathematical Association of America (MAA)
National Association of Mathematicians (NAM)
National Council of Supervisors of Mathematics (NCSM)
National Council of Teachers of Mathematics (NCTM)
Society for Industrial and Applied Mathematics (SIAM)
Society of Actuaries (SOA)
TODOS: Mathematics for ALL (TODOS)

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.

An Accidental Statistician: The Life and Memories of George E. P. Box, by George E. P. Box. Wiley, April 2013. ISBN-13: 978-1-118-40088-3.

Algorithmic Puzzles, by Anany Levitin and Maria Levitin. Oxford University Press, October 2011. ISBN-13: 978-01997-404-44.

American Mathematicians as Educators, 1893–1923: Historical Roots of the "Math Wars", by David Lindsay

Roberts. Docent Press, July 2012, ISBN-13: 978-09837-004-49.

Assessing the Reliability of Complex Models: Mathematical and Statistical Foundations of Verification, Validation, and Uncertainty Quantification, by the National Research Council. National Academies Press, 2012. ISBN-13: 978-0-309-25634-6.

The Best Writing on Mathematics 2012, edited by Mircea Pitici. Princeton University Press, November 2012. ISBN-13: 978-06911-565-52.

The Big Questions: Mathematics, by Tony Crilly. Quercus, April 2011. ISBN-13:978-18491-624-01. (Reviewed October 2012.)

Charles S. Peirce on the Logic of Number, by Paul Shields. Docent Press, October 2012. ISBN-13: 978-0-9837004-7-0.

The Continuity Debate: Dedekind, Cantor, du Bois-Reymond, and Peirce on Continuity and Infinitesimals, by Benjamin Lee Buckley. Docent Press, December 2012. ISBN-13: 978-0-9837004-8-7.

Decoding the Heavens: A 2,000-Year-Old Computer—and the Century-Long Search to Discover Its Secrets, by Jo Marchant. Da Capo Press, February 2009. ISBN-13: 978-03068-174-27. (Reviewed June/July 2013).

**Do I Count?: Stories from Mathematics, by Günter Ziegler* (translation of *Darf ich Zahlen?: Geschichte aus der Mathematik,* Piper Verlag, 2010). CRC Press/AK Peters, July 2013.

The Foundations of Geometry and Religion from an Abstract Standpoint, by Salilesh Mukhopadhyay. Outskirts Press, July 2012. ISBN-13: 978-1-4327-9424-8.

The Fractalist: Memoir of a Scientific Maverick, by Benoît Mandelbrot. Pantheon, October 2012. ISBN-13: 978-03073-773-57.

Fueling Innovation and Discovery: The Mathematical Sciences in the 21st Century, by the National Research Council. National Academies Press, 2012. ISBN-13: 978-0-309-25473-1.

Galileo's Muse: Renaissance Mathematics and the Arts, by Mark Austin-Peterson. Harvard University Press, October 2011. ISBN-13: 978-06740-597-26. (Reviewed November 2012.)

Game Theory and the Humanities: Bridging Two Worlds, by Steven J. Brams. MIT Press, September 2012. ISBN-13: 978-02625-182-53.

Games and Mathematics: Subtle Connections, by David Wells. Cambridge University Press, November 2012. ISBN-13: 978-11076-909-12.

Girls Get Curves: Geometry Takes Shape, by Danica McKellar. Plume, July 2013. ISBN-13: 978-04522-987-43.

The Golden Ticket: P, NP, and the Search for the Impossible, by Lance Fortnow. Princeton University Press, March 2013. ISBN-13: 978-06911-564-91.

Google's PageRank and Beyond: The Science of Search Engine Rankings, by Amy Langville and Carl Meyer. Princeton University Press, February 2012. ISBN-13: 978-06911-526-60.

Guesstimation 2.0: Solving Today's Problems on the Back of a Napkin, by Lawrence Weinstein. Princeton University Press, September 2012. ISBN-13: 978-06911-508-02.

Gösta Mittag-Leffler: A Man of Conviction, by Arild Stubhaug (translated by Tiina Nunnally). Springer, November 2010. ISBN: 978-36421-167-11. (Reviewed in this issue.)

Heavenly Mathematics: The Forgotten Art of Spherical Trigonometry, by Glen Van Brummelen. Princeton University Press, December 2012. ISBN-13: 978-06911-489-22.

Henri Poincaré: Impatient Genius, by Ferdinand Verhulst. Springer, August 2012. ISBN-13: 978-14614-240-62.

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

How to Study as a Mathematics Major, by Lara Alcock. Oxford University Press, March 2013. ISBN-13: 978-0199661312.

I Died for Beauty: Dorothy Wrinch and the Cultures of Science, by Marjorie Senechal. Oxford University Press, December 2012. ISBN-13:978-01997-325-93.

Ibn al-Haytham's Theory of Conics, Geometrical Constructions and Practical Geometry, by Roshdi Rashed. Routledge, February 2013. ISBN-13: 978-0-415-58215-5.

In Pursuit of the Unknown: 17 Equations That Changed the World, by Ian Stewart. Basic Books, March 2012. ISBN-13: 978-04650-297-30. (Reviewed December 2012.)

Infinity: New Research Frontiers, edited by Michael Heller and W. Hugh Woodin. Cambridge University Press, February 2011. ISBN-13: 978-11070-038-73.

Introduction to Mathematical Thinking, by Keith Devlin. Keith Devlin, July 2012. ISBN-13: 978-06156-536-31.

Invisible in the Storm: The Role of Mathematics in Understanding Weather, by Ian Roulstone and John Norbury. Princeton University Press, February 2013. ISBN-13: 978-06911-527-21. (Reviewed in this issue.)

The Joy of x: A Guided Tour of Math, from One to Infinity, by Steven Strogatz. Eamon Dolan/Houghton Mifflin Harcourt, October 2012. ISBN-13: 978-05475-176-50.

Late Style: Yuri I. Manin Looking Back on a Life in Mathematics. A DVD documentary by Agnes Handwerk and Harrie Willems. Springer, March 2012. ISBN NTSC: 978-3-642-24482-7; ISBN PAL: 978-3-642-24522-0. (Reviewed January 2013.)

Levels of Infinity: Selected Writings on Mathematics and Philosophy, by Hermann Weyl. Edited by Peter Pesic. Dover Publications, February 2013. ISBN-13: 978-0486489032.

The Logician and the Engineer: How George Boole and Claude Shannon Created the Information Age, by Paul J. Nahin, Princeton University Press, October 2012. ISBN-13: 978-06911-510-07.

Manifold Mirrors: The Crossing Paths of the Arts and Mathematics, by Felipe Cucker. Cambridge University Press, April 2013. ISBN-13: 978-0521728768.

Math Goes to the Movies, by Burkard Polster and Marty Ross. Johns Hopkins University Press, July 2012. ISBN-13: 978-14214-048-44.

Math on Trial: How Numbers Get Used and Abused in the Courtroom, by Leila Schneps and Coralie Colmez. Basic Books, March 2013. ISBN-13: 978-04650-329-21. (Reviewed August 2013.)

Mathematical Excursions to the World's Great Buildings, by Alexander J. Hahn. Princeton University Press, July 2012. ISBN-13: 978-06911-452-04.

The Mathematical Writings of Évariste Galois, edited by Peter M. Neumann. European Mathematical Society, October 2011. ISBN-13: 978-3-03719-104-0. (Reviewed December 2012.)

A Mathematician Comes of Age, by Steven G. Krantz. Mathematical Association of America, December 2011. ISBN-13: 978-08838-557-82.

A Mathematician's Lament: How School Cheats Us Out of Our Most Fascinating and Imaginative Art Form, by Paul Lockhart. Bellvue Literary Press, April 2009. ISBN-13: 978-1-934137-17-8. (Reviewed April 2013.)

Mathematicians in Bologna 1861-1960, edited by Salvatore Coen. ISBN-13: 978-30348-022-60.

Mathematics in Victorian Britain, by Raymond Flood, Adrian Rice, and Robin Wilson. Oxford University Press, October 2011. ISBN-13: 978-019-960139-4.

Mathematics under the Microscope: Notes on Cognitive Aspects of Mathematical Practice, by Alexandre V. Borovik. AMS, January 2010. ISBN-13: 978-0-8218-4761-9.

Maverick Genius: The Pioneering Odyssey of Freeman Dyson, by Phillip F. Schewe. Thomas Dunne Books, February 2013. ISBN-13:978-03126-423-58.

Meaning in Mathematics, edited by John Polkinghorne. Oxford University Press, July 2011. ISBN-13: 978-01996-050-57. (Reviewed May 2013.)

Measurement, by Paul Lockhart. Belknap Press of Harvard University Press, September 2012. ISBN-13: 978-06740-575-55.

**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.

Nine Algorithms That Changed the Future: The Ingenious Ideas That Drive Today's Computers, by John MacCormick.Princeton University Press, December 2011. ISBN-13: 978-06911-471-47.

The Noether Theorems: Invariance and Conservation Laws in the Twentieth Century, by Yvette Kosmann-Schwarzbach. Springer, December 2010. ISBN-13: 978-03878-786-76. (Reviewed August 2013.)

Paradoxes in Probability Theory, by William Eckhardt. Springer, September 2012. ISBN-13: 978-94007-513-92. (Reviewed March 2013.)

Peirce's Logic of Continuity: A Conceptual and Mathematical Approach, by Fernando Zalamea. Docent Press, December 2012. ISBN-13: 978-0-9837004-9-4.

Relations between Logic and Mathematics in the Work of Benjamin and Charles S. Peirce, by Allison Walsh. Docent Press, October 2012. ISBN-13: 978-0-9837004-6-3.

The Search for Certainty: A Journey through the History of Mathematics, 1800-2000, edited by Frank J. Swetz. Dover Publications, September 2012. ISBN-13: 978-04864-744-27.

Secrets of Triangles: A Mathematical Journey, by Alfred S. Posamentier and Ingmar Lehman. Prometheus Books, August 2012. ISBN-13: 978-16161-458-73.

Seduced by Logic: Emilie Du Châtelet, Mary Somerville and the Newtonian Revolution, by Robyn Arianrhod. Oxford University Press, September 2012. ISBN-13: 978-01999-316-13. (Reviewed June/July 2013).

Selected Papers: Volume II: On Algebraic Geometry, including correspondence with Grothendieck, by David Mumford. Edited by Amnon Neeman, Ching-Li Chai, and Takahiro Shiota. Springer, July 2010. ISBN-13: 978-03877-249-11. (Reviewed February 2013.)

The Signal and the Noise: Why So Many Predictions Fail—But Some Don't, by Nate Silver. Penguin Press, September 2012. ISBN-13:978-15942-041-11.

Simon: The Genius in My Basement, by Alexander Masters. Delacorte Press, February 2012. ISBN-13: 978-03853-410-80.

Thinking in Numbers: On Life, Love, Meaning, and Math, by Daniel Tammet. Little, Brown and Company, July 2013. ISBN-13: 978-03161-873-74.

Thinking Statistically, by Uri Bram. CreateSpace Independent Publishing Platform, January 2012. ISBN-13: 978-14699-123-32.

Transcending Tradition: Jewish Mathematicians in German Speaking Academic Culture, edited by Birgit Bergmann, Moritz Epple, and Ruti Ungar. Springer, January 2012. ISBN-13: 978-36422-246-38. (Reviewed February 2013.)

Turbulent Times in Mathematics: The Life of J. C. Fields and the History of the Fields Medal, by Elaine McKinnon Riehm and Frances Hoffman. AMS, November 2011. ISBN-13: 978-0-8218-6914-7.

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

Uneducated Guesses: Using Evidence to Uncover Misguided Education Policies, by Howard Wainer. Princeton University Press, August 2011. ISBN-13: 978-06911-492-88. (Reviewed June/July 2012.)

The Universe in Zero Words: The Story of Mathematics as Told through Equations, by Dana Mackenzie. Princeton University Press, April 2012. ISBN-13: 978-06911-528-20. (Reviewed in this issue.)

Visions of Infinity: The Great Mathematical Problems, by Ian Stewart. Basic Books, March 2013. ISBN-13: 978-04650-224-03.

A Wealth of Numbers: An Anthology of 500 Years of Popular Mathematics Writing, edited by Benjamin Wardhaugh. Princeton University Press, April 2012. ISBN-13: 978-06911-477-58. (Reviewed March 2013.)

Who's #1?: The Science of Rating and Ranking, by Amy N. Langville and Carl D. Meyer. Princeton University Press, February 2012. ISBN-13: 978-06911-542-20. (Reviewed January 2013.)

New *From the*

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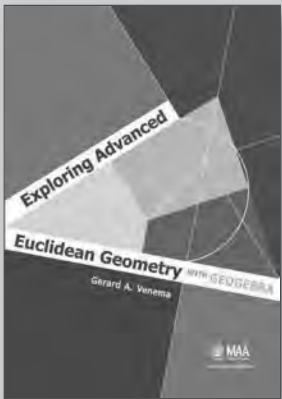


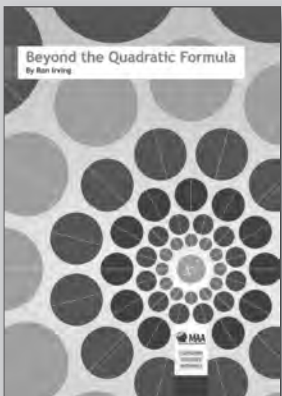
Catalog Code:
EAEG

129 pp., 2013
978-0-88385-784-7
List: $50.00
MAA Member: $40.00

Exploring Advanced Euclidean Geometry with GeoGebra

By Gerard A. Venema

This book provides an inquiry-based introduction to advanced Euclidean geometry. It utilizes dynamic geometry software, specifically GeoGebra, to explore the statements and proofs of many of the most interesting theorems in the subject. Topics covered include triangle centers, inscribed, circumscribed, and escribed circles, medial and orthic triangles, the nine-point circle, duality, and the theorems of Ceva and Menelaus, as well as numerous applications of those theorems. The final chapter explores constructions in the Poincaré disk model for hyperbolic geometry. The book can be used either as a computer laboratory manual to supplement an undergraduate course in geometry such as *Foundations in Geometry, 2/E* by the author, or as a stand-alone introduction to advanced topics in Euclidean geometry.



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244 pp., 2013
ISBN 978-0-88385-783-0
List: $55.00
MAA Member: $44.00

Beyond the Quadratic Formula

By Ron Irving

The quadratic formula for the solution of quadratic equations was discovered independently by scholars in many ancient cultures and is familiar to everyone. Less well known are formulas for solutions of cubic and quartic equations whose discovery was the high point of 16th century mathematics. Their study forms the heart of this book, as part of the broader theme that a polynomial's coefficients can be used to obtain detailed information on its roots. A closing chapter offers glimpses into the theory of higher-degree polynomials, concluding with a proof of the fundamental theorem of algebra. The book also includes historical sections designed to reveal key discoveries in the study of polynomial equations as milestones in intellectual history across cultures.

To order call **1-800-331-1622**
or online at: http://maa-store.hostedbywebstore.com/

SPECIAL SECTION

2013 American Mathematical Society Elections

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2013 AMS Elections

Special Section

List of Candidates–2013 Election

President
(one to be elected)
Robert L. Bryant
Benedict H. Gross

Vice President
(one to be elected)
Helmut Hofer
Susan Montgomery

Board of Trustees
(one to be elected)
Robert Lazarsfeld
Michael F. Singer

Member at Large of the Council
(five to be elected)
Edward Bierstone
Richard Durrett
Lisa Fauci
Srikanth B. Iyengar
Michael Larsen
Kristin E. Lauter
Kannan Soundararajan
Jennifer Taback
Rodolfo H. Torres
C. Eugene Wayne

Nominating Committee
(three to be elected)
Sami Hayes Assaf
Carlos Castillo-Chavez
Peter Constantin
Robert L. Griess Jr.
Kailash C. Misra
David J. Wright

Editorial Boards Committee
(two to be elected)
Rafe Mazzeo
Anne Schilling
Daniel W. Stroock
Michelle Wachs

Ballots

AMS members will receive email with instructions for voting online by August 26, or a paper ballot by September 15. If you do not receive this information by that date, please contact the AMS (preferably before October 1) to request a ballot. Send email to `ballot@ams.org` or call the AMS at 800-321-4267 (within the U.S. or Canada) or 401-455-4000 (worldwide) and ask to speak with Member Services. The deadline for receipt of ballots is November 8, 2013.

Write-in Votes

It is suggested that names for write-in votes be given in exactly the form that the name occurs in the *Combined Membership List* (`www.ams.org/cml`). Otherwise the identity of the individual for whom the vote is cast may be in doubt and the vote may not be properly credited.

Replacement Ballots

For a paper ballot, the following replacement procedure has been devised: A member who has not received a ballot by September 15, 2013, or who has received a ballot but has accidentally spoiled it, may write to `ballot@ams.org` or Secretary of the AMS, 201 Charles Street, Providence, RI 02904-2294, USA, asking for a second ballot. The request should include the individual's member code and the address to which the replacement ballot should be sent. Immediately upon receipt of the request in the Providence office, a second ballot, which will be indistinguishable from the original, will be sent by first class or airmail. Although a second ballot will be supplied on request and will be sent by first class or airmail, the deadline for receipt of ballots cannot be extended to accommodate these special cases.

Biographies of Candidates

The next several pages contain biographical information about all candidates. All candidates were given the opportunity to provide a statement of not more than 200 words to appear at the end of their biographical information.

Description of Offices

The **president** of the Society serves one year as president elect, two years as president, and one year as immediate past president. The president strongly influences, either directly or indirectly, most of the scientific policies of the Society. A direct effect comes through the president's personal interactions with both members of the Society and with outside organizations. In addition, the president sits as member of all five policy committees (Education, Meetings and Conferences, Profession, Publications, and Science Policy), is the chair of the Council's Executive Committee, and serves ex officio as a trustee. Indirect influence occurs as the president appoints chairs and members of almost all committees of the Society, including the policy committees. The president works closely with all officers and administrators of the Society, especially the executive director and the secretary. Finally, the president nominates candidates for the Nominating Committee and the Editorial Boards Committee. Consequently, the president also has a long-term effect on Society affairs.

The **vice president** and the **members at large of the AMS Council** serve for three years on the Council. That body determines all scientific policy of the Society, creates and oversees numerous committees, appoints the treasurers and members of the Secretariat, makes nominations of candidates for future elections, and determines the chief editors of several key editorial boards. Typically, each of these new members of the Council also will serve on one of the Society's five policy committees. Current members of the Council may be found here: `www.ams.org/council`.

The **Board of Trustees**, of whom you will be electing one member for a five-year term, has complete fiduciary responsibility for the Society. Among other activities, the trustees determine the annual budget of the Society, prices of journals, salaries of employees, dues (in cooperation with the Council), registration fees for meetings, and investment policy for the Society's reserves. The person you select will serve as chair of the Board of Trustees during the fourth year of the term. Current members of the Board may be found here: `www.ams.org/bt`.

The candidates for **president** were suggested to the Council by the Nominating Committee. The candidates for **vice president**, **members at large**, and **trustee** were suggested to the Council either by the Nominating Committee or by petition from members. While the Council has the final nominating responsibility, the groundwork is laid by the **Nominating Committee**. The candidates for election to the Nominating Committee were nominated by the current president, David A. Vogan Jr. The three elected will serve three-year terms. The main work of the Nominating Committee takes place during the annual meeting of the Society, during which it has four sessions of face-to-face meetings, each lasting about three hours. The Committee then reports its suggestions to the spring Council, which makes the final nominations. Current members of the Nominating Committee may be found here: `www.ams.org/nomcom`.

The **Editorial Boards Committee** is responsible for the staffing of the editorial boards of the Society. Members are elected for three-year terms from a list of candidates named by the president. The Editorial Boards Committee makes recommendations for almost all editorial boards of the Society. Managing editors of *Journal of the AMS*, *Mathematics of Computation*, *Proceedings of the AMS*, and *Transactions of the AMS*; and Chairs of the *Collquium*, *Mathematical Surveys and Monographs*, and *Mathematical Reviews* editorial committees are officially appointed by the Council upon recommendation by the Editorial Boards Committee. In virtually all other cases, the editors are appointed by the president, again upon recommendation by the Editorial Boards Committee. Current members of the Editorial Boards Committee may be found here: `www.ams.org/ebc`.

Elections to the **Nominating Committee** and the **Editorial Boards Committee** are conducted by the method of approval voting. In the approval voting method, you can vote for as many or as few of the candidates as you wish. The candidates with the greatest number of the votes win the election.

A Note from AMS Secretary Carla D. Savage

The choices you make in these elections directly affect the direction the Society takes. If the past election serves as a reliable measure, about 13 percent of you will vote in the coming election, which is comparable with voter participation in other professional organizations which allow an online voting option. This is not mentioned as encouragement for you to throw the ballot in the trash; instead, the other officers and Council members join me in urging you to take a few minutes to review the election material, fill out your ballot, and submit it. The Society belongs to its members. You can influence the policy and direction it takes by voting.

Also, let me urge you to consider other ways of participating in Society activities. The Nominating Committee, the Editorial Boards Committee, and the Committee on Committees are always interested in learning of members who are willing to serve the Society in various capacities. Names are always welcome, particularly when accompanied by a few words detailing the person's background and interests. Self-nominations are probably the most useful. Recommendations can be transmitted through an online form (`www.ams.org/committee-nominate`) or sent directly to the secretary (`secretary@ams.org`) or Office of the Secretary, American Mathematical Society, Department of Computer Science, Box 8206, North Carolina State University, Raleigh, NC 27695-8206 USA.

PLEASE VOTE.

Nominations for President

Nomination of Robert L. Bryant

David Eisenbud

Robert Bryant is an intensely engaged mathematician with broad interests both in and beyond core mathematics. He was my successor as Director of MSRI, where he has served from 2007 until now—his term will end in August 2013, so, if elected, he would be able to concentrate his attention on the AMS Presidency. Robert is justly recognized for his major research achievements: He is a Fellow of the American Academy of Arts and Sciences and a member of the National Academy of Sciences. Phillip Griffiths and Mike Eastwood describe Robert's research below, so I will focus on other aspects of his activity.

Robert has been very much oriented toward serving the mathematics community. Before becoming Director of MSRI, he had been Chair of MSRI's board, and had served as Director of the Park City Mathematics Institute. In 2002, he was appointed by then-President Bush to serve on the Board of Directors of the Vietnam Education Foundation, and he currently serves on the International Committee for the National Mathematics Center of Nigeria. In all these roles he has thought carefully and deeply about programs to support a broad range of mathematicians and prospective mathematicians: at Park City, for example, he was responsible for programs ranging from the teaching of high school teachers and undergraduates to the frontiers of research.

Again during his service at MSRI, Robert has demonstrated his powerful commitment to the fostering of underrepresented groups in mathematics. He has worked with MSRI's Deputy Director to support and enhance the activities of the Human Resources Advisory Committee, first set up by Bill Thurston and Lenore Blum in the 90's. Under his leadership, MSRI has greatly extended the National Math Circles movement, both on local and national levels. (Math Circles, borrowing and adapting an East European tradition, bring research mathematicians, scientists, and others with mathematical sophistication into contact with kids with a view to engaging them in mathematics well beyond that of the conventional classroom.)

Robert has also continued to foster the engagement of the mathematical community with other sciences, and with societal needs. For example his team at MSRI has collaborated with a large group of other Mathematics Institutes to engage the support of the Simons Foundation and sponsor an international series of high-profile lectures on the Mathematics of Planet Earth, which is now ongoing. The first of these, held in Australia, was aired on two national Australian television channels, and others will follow. (Video of all the lectures, and much else of similar relevance, is posted at `http://www.mpe2013.org/`.)

Robert has a very wide experience of life and of the mathematical community. A North Carolina native, Robert grew up on a farm. Remaining in North Carolina, he received his Ph.D. in Mathematics in 1979 at the University of North Carolina at Chapel Hill, working under Robert B. Gardner. He served on the faculty at Rice University for seven years, and then moved to Duke University in 1987, where he held the Juanita M. Kreps Chair in Mathematics until moving to the University of California at Berkeley in July 2007. He has held numerous visiting positions at universities and research institutes around the world.

From experience I know that one of the most important activities of the AMS President is to reach out to invite mathematicians to serve on the many AMS committees that knit the mathematical community together. Robert's experience with the enormous number of mathematicians who come to MSRI, from graduate students to senior leaders, and especially with members from underrepresented groups, will give him an excellent basis for doing this.

He has my strongest endorsement for the important role of President of the AMS.

David Eisenbud is professor of mathematics at the University of California at Berkeley. His email address is `de@math.berkeley.edu`.

Phillip Griffiths

Robert Bryant would make an excellent President of the AMS and I strongly support his candidacy. The following are some personal observations on his scientific work.

Robert Bryant is the leading geometer of our time in the grand tradition of Elie Cartan and S.-S. Chern. His research shows an unexcelled combination of geometric insight and taste, together with computational power. Bryant's work exhibits both remarkable depth and breadth: he has solved a wide range of deep and frequently longstanding geometric questions, and he has developed fundamental general theory and techniques. Bryant's work has been pioneering in multiple areas, a sample of which I shall mention here. One is his analysis of the Willmore conjecture, proving the amazing result that it is an integrable system and opening the door to significant progress on the problem. Another is the work of Bryant and collaborators on the local smooth isometric embedding of Riemannian manifolds of dimension n in Euclidean space in the best

Phillip Griffiths is professor of mathematics at the Institute for Advanced Study. His email address is `pg@math.ias.edu`.

possible embedding dimension $n(n+1)/2$, combining both differential and algebraic geometry and hard analysis. Algebraic geometry enters through the subtle analysis of the characteristic variety. This work solved a large part of the problem when $n = 3$ and clarified the general situation. For example, for n at least 3, it can never be an elliptic or hyperbolic system. On another front, Bryant's determination of the surfaces of constant Finsler curvature spawned major progress and was instrumental in the revitalization of the subject. He has made significant contributions in dynamical systems in which the global analysis of the solution dynamics to the classical problem of elastica was obtained. Bryant has also made a contribution to algebraic geometry in the analysis of the variations of the Hodge structure of Calabi-Yau varieties.

A theme that runs throughout much of Bryant's work is the "geometry of differential equations". This is a rich and deep subject, beginning with Lie and his contemporaries in the late nineteenth century and continuing into the twentieth century through the works of Cartan and others. In this area, Bryant is a leading current practitioner. The emphasis in the subject is more on the understanding of special equations, usually of geometric origin, than on developing a vast general theory. There is a general approach for addressing problems in the subject, namely Cartan's so-called method of equivalence. Its application is more of an art than a science; one must use considerable geometric insight to guide the calculations, which are frequently of great subtlety and intricacy. The differential equations of interest are frequently overdetermined, and the relevant calculations have a cohomological as well as a geometric aspect. Bryant is the undisputed master in the use of the equivalence method, as demonstrated in his work on exceptional holonomy that Mike Eastwood will describe. Another illustration of the range of problems into which Bryant has brought the equivalence method is his work on the geometry of Euler-Lagrange equations, in which a complete set of invariants is obtained and using which one may characterize those equations that have special properties, such as additional conservation laws and exceptional symmetries.

The above comments have been about Robert Bryant's contributions, which are at the highest level, to our field. As chair of the Board of Trustees of MSRI for the past four years, I have been able to observe at first hand Bryant's leadership, both scientific and administrative, of that institution which is so central to the mathematical community. His commitment to service to our community is exceptional and complete. Robert Bryant would be an outstanding President of the AMS.

Mike Eastwood

I am delighted to contribute to the nomination of Robert Bryant for President of the American Mathematical Society. I have been fortunate enough to have known Robert for more than 30 years and he is undoubtedly one of the most impressive and exceptional individuals that I have ever met. Although I shall mostly confine my remarks to his mathematics, I would also like to attest to his outstanding leadership abilities. His vision and depth of knowledge are surely evident to all who meet him, most recently in his capacity as Director of MSRI. In short, I cannot imagine a more suitable President.

Robert works in differential geometry, especially from the point of view of "exterior differential systems". Indeed, he is one of the authors of the classic text of the same title (but known affectionately as BCG^3 after Bryant, Chern, Gardner, Goldschmidt, and Griffiths). Exterior differential systems provide the modern framework for understanding the notoriously difficult but pioneering works of Élie Cartan from the early twentieth century. Bryant is one of the very few mathematicians to have absorbed and effectively utilized the methods of Cartan, starting with his 1979 Ph.D. thesis where he analyzed generic 3-plane distributions on 6-manifolds in the spirit of Cartan's famous 1910 "five variables" article (which analyses generic 2-plane distributions on 5-manifolds). These numbers are very special. The maximally symmetric instance of a 2-plane distribution in 5 dimensions has symmetries lying in the split form of the exceptional Lie algebra. For 3-planes in 6 dimensions, the corresponding local symmetries also constitute a simple Lie algebra, this time the split form Spin(4, 3).

It is no coincidence that the compact Lie groups G_2 and Spin(7) star in Bryant's seminal 1987 *Annals* article on exceptional holonomy. He shows the existence of Riemannian manifolds with holonomy G_2 in 7 dimensions and Spin(7) in 8 dimensions, thereby, after having been open for more than 30 years, settling Berger's list of potential holonomies. For me, this article also secures Robert's reputation as a superb expositor. The original comments sprinkled throughout ensure that it is highly readable. It is a style that he has maintained in all his work. Several other articles from this time are concerned with holonomy. Complete metrics with exceptional holonomy are constructed in joint work with Salamon. Bryant also constructs torsion-free connections with "exotic holonomies" (remarkable non-metric connections lying outside Berger's list), which have been the inspiration for many other authors.

Much of Robert's work is driven by his intimate knowledge of the simple Lie groups and their genesis in the geometry of ordinary differential equations. In recent years, my own interest has been in the development of "parabolic geometry". These are differential geometries modelled, in the sense of Cartan, on homogeneous spaces of the form G/P for G semisimple and P parabolic. There is now a well-developed theory of such geometries due to Čap, Slovák, Souček, et al. with origins in the classical works of Cartan, Tanaka, et al. Bryant's work provides significant impetus in this theory, going right back to his Ph.D. thesis. This impact continues and not only through his published work, as two of my current postdocs can confirm: both recently posted what I thought to be hard questions on "MathOverflow", a place for mathematicians to ask and answer questions. Both questions were answered within a day by Robert Bryant (current "reputation" 20,189)!

Mike Eastwood is professor of mathematics at the Institute for Advanced Study. His email address is `pg@math.ias.edu`.

Finally, I should mention Robert's extraordinary skill as a lecturer and public speaker. In particular, I recall a colloquium he gave in Auckland in 2008 entitled "The idea of holonomy". In addition to rolling cubes around, the main visual aid for this talk was a porter's trolley (which undergoes holonomy when manipulated)! It was a very fine demonstration and, of course, much more appropriate for a colloquium than a bunch of equations.

In conclusion, I wholeheartedly support Robert Bryant's nomination for President of the AMS both as an extraordinary mathematician and leader.

Nomination of Benedict Gross

Joe Buhler and Ken Ribet

It is a pleasure to write in support of the nomination of Benedict (Dick) Gross for the Presidency of the American Mathematical Society. Professor Gross is a superb mathematician who has risen to the top of our profession. In addition, he has the rare quality of being equally at ease with people as he is with mathematical ideas. His warm personality and empathy for others go hand in hand with his inspired teaching and clear exposition. These same qualities have made him a valued colleague and administrator.

It is natural to begin with Gross's mathematics. Gross wrote his Ph.D. dissertation on the arithmetic of complex multiplication on elliptic curves, working with John Tate at Harvard University. His thesis was published in the Lecture Notes in Mathematics series, and has been influential in many ways. In particular, Gross's thesis inaugurated the study of "**Q**-curves", which continue to be studied actively.

Gross's Ph.D. thesis represented only a fraction of the work that he carried out as a graduate student. Before writing his thesis, he gave the first conceptual proof via arithmetic geometry of a famous formula that Chowla and Selberg first proved in 1947, thereby answering a question of André Weil and sparking Deligne's theorem to the effect that Hodge cycles on abelian varieties are "absolutely Hodge". At roughly the same time, Gross studied the arithmetic of Jacobians of Fermat curves with David Rohrlich, and he proved an identity relating Gauss sums and special values of Morita's p-adic Γ-function in joint work with Neal Koblitz.

Gross's rather startling output as a graduate student launched a sustained and rich research career that has produced more than 100 mathematical articles touching on number theory, arithmetic geometry, representation theory and many other subjects. In this short article, we will focus on some highlights of his work.

In the early 1980s, Gross and Don Zagier proved a celebrated formula that relates the heights of special points on modular curves to the derivatives of suitable L-series attached to modular forms. The Gross–Zagier formula is an extremely deep result whose proof interweaves analytic and algebraic techniques. The formula, in addition to its intrinsic beauty, has several important applications. When combined with work from the same period by Kolyvagin and others, it implies a statement toward the conjecture of Birch and Swinnerton-Dyer for elliptic curves that has not been improved significantly in subsequent decades. Recall that the BSD Conjecture postulates an equality between the algebraic and analytic ranks of an elliptic curve. The results of Gross–Zagier and others establish this equality whenever the analytic rank is at most 1.

In addition, the Gross–Zagier formula implies the existence of an elliptic curve with analytic rank 3. A few years earlier, Dorian Goldfeld had shown that the existence of such a curve would imply an effective lower bound on the class number of imaginary quadratic fields—given any $a < 1$ there would be a c such that $h > c\,(\log(|D|))a$, where h is the class number and D is the discriminant of the quadratic field. Gauss had implicitly raised the question of effectively enumerating all imaginary quadratic fields with a given class number, and the Goldfeld–Gross–Zagier result gives an explicit solution. In 1987, the Frank Nelson Cole Prize in Number Theory was awarded to Goldfeld, Gross, and Zagier for their resolution of Gauss's problem.

The Gross–Zagier theorem has been the basis of much further work; the formula and its proof continue to be at the center of current research on the arithmetic of abelian varieties and automorphic representations.

Roughly during the same period, Gross formulated an analogue of conjectures of H. Stark that relate values of L-series and their derivatives to objects of interest in algebraic number theory. Gross's conjecture was for the p-adic analogue of L-functions that were constructed by Iwasawa. Gross's elegant formulation connects the values of certain p-adic L-functions over totally real number fields with what have become known as "Gross–Stark" units. Over the last thirty years, a number of mathematicians have proposed refinements and extensions of the Gross–Stark conjecture.

In the early 1990s, Gross and Dipendra Prasad studied the automorphic representations that arise in the Langlands program. They began with the idea that the restriction of automorphic representations of $\mathbf{SO}_n$ to $\mathbf{SO}_n$-1 should be describable in terms of arithmetic data, both over local and global fields. Their study uncovered an incredibly rich mathematical lode, with surprising applications and the potential for numerous generalizations.

Over the last several years, Gross and Manjul Bhargava have obtained new results in a subject that might be termed Arithmetic Invariant Theory. In particular, they have extended Bhargava's results on Selmer groups and average ranks of elliptic curves to the family of hyperelliptic curves of a fixed genus. Their extension has applications to counting points on hyperelliptic curves; for example, they prove that among hyperelliptic curves $y_2 = f(x)$, of fixed odd degree > 5, at least half have no more than twenty rational points. The Bhargava–Gross work on Selmer groups has recently been used by Poonen and Stoll to prove that a positive proportion of such curves have

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Ken Ribet is professor of mathematics at the University of California at Berkeley. His email address is `ribet@math.berkeley.edu`.

exactly one rational point, and that the fraction of curves with this property approaches 1 exponentially fast as the genus goes to infinity. These striking results have sparked considerable interest, and are likely to be improved and extended in the near future.

We stress again that the above summary touches on only a small fraction of Gross's mathematical output. His research achievements have been recognized in a number of ways. In addition to the AMS Cole Prize, Gross received a Sloan fellowship and a MacArthur fellowship, and was elected a fellow of the American Academy of Arts and Sciences and a member of the U.S. National Academy of Sciences.

Gross has not only an extraordinarily penetrating intellect, but also a remarkable capacity for collaborating with others in a way that elevates both his work and theirs. Gross's collaborators since 2000 include Bryan Birch, Pierre Deligne, Noam Elkies, Edward Frenkel, Wee Teck Gan, Joe Harris, Eriko Hironaka, Mark Lucianovic, Curt McMullen, Gabriele Nebe, Ariel Pacetti, James Parson, David Pollack, Mark Reeder, Fernando Rodriguez Villegas, Gordan Savin and Nolan Wallach.

In both his oral and written exposition, Gross is deeply committed to clarity, elegance, and depth. It is hard to separate his mathematics from his pedagogical sensibilities and teaching, since exactly these qualities permeate his approach to exposition at all levels.

For instance, Gross enjoys teaching introductory mathematics courses to non-majors. His course with Joe Harris on number theory led to the charming book *The Magic of Numbers*. More recently, he developed Fat Chance, a course with Joe Harris and Nathan Kaplan on probabilistic and statistical reasoning. Two years ago Gross was named a Harvard College Professor for a five-year term; this title is bestowed on selected faculty to recognize them for exceptional undergraduate teaching.

On the other end of the spectrum, he has taught a wide array of graduate courses, and has advised thirty-four graduate students, many of whom are now well known mathematicians in their own right. The Mathematics Genealogy Project shows that quite a few of Gross's students have had doctoral students of their own; it lists seventy-two descendants for Benedict Gross.

We now turn to Professor Gross's service to the mathematics profession and to the academic community more broadly. His common sense, charm, good taste, and outgoing personality have made Gross a compelling choice as committee member and administrator. He has served Harvard University, the AMS, numerous editorial boards, the Sloan Foundation and the Mathematical Sciences Research Institute; he is now a trustee of the Institute for Advanced Study at Princeton. Fans of films with mathematical connections know that Gross coached Jill Clayburgh on her proof of the Snake Lemma in the 1980 film "It's My Turn".

Gross served as the Chair of the Mathematics Department at Harvard from 1999 to 2002. His skill in this position, and perhaps especially his rapport with members of the university community outside the department, led to his appointment as Dean of Harvard College. This appointment came at an especially critical time for Harvard because the college was going through the process of revising its undergraduate curriculum. Gross became the overall chair of this endeavor, and coordinated efforts that led to the most thoroughgoing curricular changes in the last thirty years. As Dean of Harvard College, Gross had to manage a large staff, cope with innumerable crises, represent the College to external audiences, and mediate among a diverse group of constituencies. His success as Dean stemmed no doubt from his knack for giving a fair hearing to all sides of an issue before setting a course of action.

On the personal side, we note that Dick is an all-around great guy who is never too busy to pitch in to help solve a problem. His broad experience, talent at social interaction, and wide range of interests are unusual among top-notch mathematicians. Gross's intelligence, wisdom, and interpersonal skills make him extraordinarily well qualified to be the next President of the AMS.

Biographies of Candidates 2013

Biographical information about the candidates has been supplied and verified by the candidates.

Candidates have had the opportunity to make a statement of not more than 200 words (400 words for presidential candidates) on any subject matter without restriction and to list up to five of their research papers.

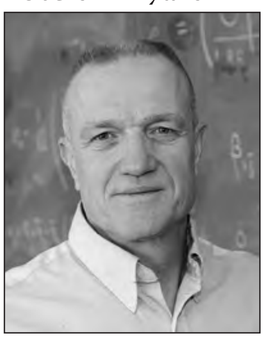
Candidates have had the opportunity to supply a photograph to accompany their biographical information.

Candidates with an asterisk (*) beside their names were nominated in response to a petition.

Abbreviations: American Association for the Advancement of Science (AAAS); American Mathematical Society (AMS); American Statistical Association (ASA); Association for Computing Machinery (ACM); Association for Symbolic Logic (ASL); Association for Women in Mathematics (AWM); Canadian Mathematical Society, Société Mathématique du Canada (CMS); Conference Board of the Mathematical Sciences (CBMS); Institute for Advanced Study (IAS), Institute of Mathematical Statistics (IMS); International Mathematical Union (IMU); London Mathematical Society (LMS); Mathematical Association of America (MAA); Mathematical Sciences Research Institute (MSRI); National Academy of Sciences (NAS); National Academy of Sciences/National Research Council (NAS/NRC); National Aeronautics and Space Administration (NASA); National Council of Teachers of Mathematics (NCTM); National Science Foundation (NSF); Society for Industrial and Applied Mathematics (SIAM).

President

Robert L. Bryant



Professor of Mathematics, Duke University, Durham, NC.

Born: August 30, 1953, Harnett County, NC.

Ph.D.: University of North Carolina, Chapel Hill, 1979.

AMS Offices: Council, 1999–2004; Associate Editor, *Journal of the American Mathematical Society*, 2005–2008; Vice President, 2007–2010.

AMS Committees: AMS–SIAM Committee on Chinese Graduate Students, 1984–1989; Centennial Fellowships Committee, 1990–1992; U.S. National Committee for Mathematics, 1992–1995; Editorial Committee, *Transactions and Memoirs of the AMS*, 1992–1996; Task Force on Membership, 1998–2000; Committee on Publications, 1998–2004 (chair, 2002–2004); Executive Committee, 2000–2004; Editorial Boards Committee, 2006–2009.

Selected Addresses: AMS Invited Address, "Surfaces in Conformal Geometry", Laramie, 1985; International Congress of Mathematicians, "A survey of Riemannian metrics with special holonomy groups", Berkeley, 1986; AMS Invited Address, "The idea of curvature for differential equations", Baltimore, MD, 1998; Ruth and Irving Adler Expository Lecture, "Calibrations in Geometry and Topology", Institute for Advanced Study, Princeton, NJ, 2004; Simons Science Series, "The concept of holonomy", New York, 2013.

Additional Information: Editorial Board Member: *Transactions of the AMS*, 1992–1997; *Duke Mathematical Journal*, 1997–; *Differential Geometry and its Applications*, 1999–2009; *Communications in Analysis and Geometry*, 2002–. Associate Editor: *Journal of the AMS*, 2005–2009. Alfred P. Sloan Fellowship, 1982–1984; NSF Presidential Young Investigator, 1984–1989; Trinity College Distinguished Teaching Award, 1992; MAA Southeastern Region Distinguished Teaching Award, 1993; Chair, Mathematical Sciences Research Institute Board of Trustees, 1999–2004; MAA Southeastern Section Lecturer, 2001–2003; Fellow of the American Academy of Arts and Sciences, elected 2002; National Academy of Sciences, elected 2007; Director of the Mathematical Sciences Research Institute, 2007–2013; Fellow of the AMS, appointed 2013; Member: MAA, AWM, NAM.

Selected Publications: 1. Classical, exceptional, and exotic holonomies: a status report, *Actes de la Table Ronde de Géométrie Différentielle* (Luminy, 1992), Sémin. Congr., **1** (1996), Soc. Math. France, Paris, 93–165. **MR1427757 (98c:53037)**; 2. Bochner–Kähler metrics, *J. Amer. Math. Soc.*, **14** (2001), no. 3, 623–715. **MR1824987 (2002i:53096)**; 3. with P. Griffiths and D. Grossman, *Exterior Differential Systems and Euler–Lagrange Partial Differential Equations*, Chicago Lectures in Mathematics, University of Chicago Press, 2003. **MR1985469 (2004g:58001)**; 4. Some remarks on G_2–structures, *Proceedings of Gökova Geometry–Topology Conference 2005*, 75–109, Gökova Geometry/

Topology Conference (GGT), Gökova, (2006). **MR2282011 (2007k:53019)**; 5. Non–embedding and nonextension results in special holonomy, *The Many Facets of Geometry*, (J.–P. Bourguignon, S. Salamon, and O. Garcia–Prada eds.), 2010, Oxford University Press, Oxford, pp. 346–367. **MR2681703 (2011m:53078)**.

Statement by Candidate: It is a tremendous honor for me to be nominated for the Presidency of the American Mathematical Society. I have been involved with the AMS since the beginning of my mathematical career, while still a graduate student, and, over the years, I have had ample opportunity to observe the innumerable benefits that the AMS brings to our society and the incredible dedication and creativity that its members at all levels have brought to the enterprise of sustaining it for the common good. In my various roles in the governing structures of the AMS, I have had the privilege to work with many talented individuals, and the opportunity to continue that work at this level is an exciting one for me.

For the past six years, I have served as the Director of the Mathematical Sciences Research Institute, whose mission statement is very similar to that of the AMS. Both institutions exist to promote mathematics research and mathematics knowledge, to aid in the development of our society's capacity to use mathematical knowledge to meet its challenges, and to promote the understanding and appreciation of mathematical modes of thought.

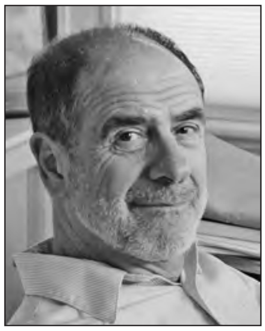
Promoting research in mathematics and supporting research and teaching is a fundamental concern for the AMS. I believe that we can and should continue our growth in traditional areas of mathematics but at the same time take advantage of new interdisciplinary opportunities, which will enliven our own research programs and simultaneously increase employment opportunities for our students.

This does not mean, though, that the AMS should only focus on what immediately benefits professional research mathematicians. We must also be concerned with educating the general public about the fundamental nature of mathematics and its importance in our increasingly technological lives, and in helping shape the level and contents of mathematics education, not only at the college and university level, but earlier as well.

While at MSRI, I have seen how effective outreach to underserved groups can be in encouraging their participation in mathematics research and creating opportunities to fully develop the store of mathematical talent we have in our society. The AMS has a responsibility to nurture the diversity that reflects the fact that mathematical ways of thinking are not limited by cultural, social, or gender barriers.

The next several years will present major challenges to any business–as–usual approach to the AMS. Changing demographics, funding structures, and employment opportunities will affect the professional lives of all mathematicians. I look forward to an opportunity to work with the members of the AMS to study these challenges and contribute to finding effective responses.

Benedict H. Gross



Leverett Professor of Mathematics, Harvard University.

Born: June 22, 1950, South Orange, NJ.

Ph.D.: Harvard, 1978.

AMS Committees: Postdoctoral research fellowships, 1978; Summer research conferences, 1981; Editor, JAMS, 1994–2000.

Selected Addresses: International Congress of Mathematicians, 1986.

Additional Information: Sloan Fellowship, 1980; MacArthur Fellowship, 1986; Cole Prize in Number Theory, 1987; National Academy of Sciences, 2004.

Selected Publications: 1. with N. Koblitz, Gauss sums and the p–adic Γ–function, *Ann. of Math.*, **109** (1979), 569–581. **MR0534763 (80g:12015)**; 2. with D. Zagier, Heegner points and derivatives of L–series, *Invent. Math.*, **84** (1986), 225–320. **MR0833192 (87j:11057)**; 3. with M. Hopkins, Equivariant vector bundles on the Lubin–Tate moduli space, *Contemp. Math.*, **158** (1994), 23–88. **MR1263712 (95b:14033)**; 4. with W.–T. Gan and D. Prasad, Sur les conjectures de Gross et Prasad, *Asterisque*, **346** (2012). 5. with M. Bhargava, The average size of the 2–Selmer group of Jacobians of hyperelliptic curves with a rational Weierstrass point, *ArXiv* 1208.1007 (2012).

Statement by Candidate: It is an honor to be nominated to run for the Presidency of the AMS. I had the opportunity to see the Society at close hand when I taught at Brown and my wife served as associate executive director. The meetings and publications that we members take for granted involve a great deal of preparation and hard work by the staff. I would enjoy working closely with them.

I have spent most of my mathematical career involved in research, and the training of undergraduates and graduate students. I also served as the Dean of Harvard College at a time when we were conducting a curricular review. This nomination gives me the opportunity to represent the profession at a national level.

The President also has the responsibility to set priorities with the Council, and to ensure that the Society remains responsive to its members. My first priority would be to create the best conditions to further the discovery of new mathematics.

I would also try to help our new graduates enter a difficult and changing job market, and to communicate the amazing discoveries of mathematics to the general public. In a time when funding for science (and everything else) will be short, we need to make our case to the leadership in Washington. This is a case that I have no problem making—mathematics is an essential part of our culture!

Vice President

Helmut Hofer

Professor of Mathematics, Institute for Advanced Study.
Born: February 18, 1956, Sinzig am Rhein, Germany.
Ph.D.: University of Zürich, 1981.
Selected Addresses: Invited Speaker, ICM Kyoto, 1990; Plenary Speaker, ICM Berlin, 1998; Colloquium Lecture, San Antonio, 1999; Plenary Speaker, 5th International Joint Meeting AMS and SMM, Morelia, 2001; Landau Lectures, Hebrew University, 2011; Aisenstadt Lectures, University of Montreal, 2013.
Additional Information: Alfred P. Sloan Fellowship, 1987; Ostrowski Prize, 1999; Heinz Hopf Prize, 2013; Chairman of the Scientific Advisory Board of the Max Planck Institute for Mathematics in the Sciences, Leipzig, 1999–2011; MSRI Scientific Advisory Board, Berkeley, 2005–2009 (co–chair, 2006–2009); Member, National Academy of Sciences, 2008–; Foreign Associate, Academia Europaea, 2008–; Steering Committee, Park City/IAS Mathematical Institute, 2009–; German National Academy of Sciences Leopoldina, 2010–; Fellow of the AMS, 2013; Member of the Scientific and Strategic International Committee of the Colleges de France, 2013–.
Selected Publications: 1. On the topological properties of symplectic maps, *Proc. Roy. Soc. Edinburgh Sect. A*, **115** (1990), 25–38. **MR1059642 (91h:58042)**; 2. Pseudoholomorphic curves in symplectizations with applications to the Weinstein conjecture in dimension three, *Inv. Math.*, **114** (1993), 515–563. **MR1244912 (94j:58064)**; 3. with Y. Eliashberg and A. Givental, Introduction to symplectic field theory, GAFA 2000, Special Volume, Part II, *Geom. Funct. Anal.* (2000), 560–673. **MR1826267 (2002e:53136)**; 4. with K. Wysocki and E. Zehnder, Finite energy foliations of tight three–spheres and Hamiltonian dynamics, *Ann. of Math.*, **157** (2003), 125–255. **MR1954266 (2004a:53108)**; 5. with K. Wysocki and E. Zehnder, A general Fredholm theory. III: Fredholm functors and polyfolds, *Geom. Topol.*, **13** (2009), no. 4, 2279–2387. **MR2515707 (2010h:53138)**.
Statement by Candidate: I feel honored having been asked to run for the position of Vice President. The society has done an excellent job of promoting mathematical research and education. Though I would find mathematics without applications still a worthwhile pursuit, I am thrilled by interesting applications. The field's impact on modern society is persuasive. Many of its basic ideas, however, which have substantial applied impact, were initially not introduced for these purposes, but were derived in a different, (quite often mathematical) context. Moreover, these applications are often perceived as direct contributions of technology and engineering. Their impact is consequently mostly secondary and not attributed to mathematics. Precisely this fact makes mathematics vulnerable for funding cuts in times of financial distress. Mathematics is a rather cheap science and consistently shows a significant return on investment for society. I think that mathematicians individually can play an important part in educating the public about the field's importance, and on the political level the AMS holds a privileged position. The time is ripe to develop some innovative strategies to convey its compelling story. As Vice President I hope to contribute to all aspects of the core mission, particularly to public awareness and funding issues.

Susan Montgomery

Professor of Mathematics, University of Southern California.
Born: April 2, 1943, Lansing, Michigan.
Ph.D.: University of Chicago, 1969.
AMS Offices: Member at Large of the Council, 1981–1984; Board of Trustees, 1986–1996 (chair, 1989 and 1994).
AMS Committees: Research Fellowship Committee, 1982–1984 (chair, 1983–1984); Math Surveys and Monographs Editorial Committee, 1983–1990 (chair, 1989–1990); Proceedings Editorial Committee, editor for Algebra, 1992–1996; Committee on Publications, 1996–1999 (chair, 1996–1998); Nominating Committee, 2006 –2009.
Selected Addresses: AMS Invited Address, Louisville, 1984; CBMS Principal Lecturer, Chicago, 1992; Invited Address, joint meeting of the AMS and the Israel Math Union, Jerusalem, 1995; Canadian Math Society Plenary Lecture, St. Johns, Newfoundland, 2009; AWM Noether Lecturer, New Orleans, 2011.
Additional Information: Guggenheim Fellow, 1984–1985; NSF Mathematical Sciences Advisory Committee, 1986–1989; Editorial Board, *Journal of Algebra*, 1988–2007; Conference Board of the Mathematical Sciences, 1995–1998; Fellow: AMS, AAAS; Member: AWM, LMS.
Selected Publications:
1. with M. Cohen, Group graded rings, smash products, and group actions, *Trans. Amer. Math. Soc.*, **282** (1984), 237–258. **MR0728711 (85i:16002)**; 2. with R. Blattner and M. Cohen, Crossed products and inner actions of Hopf algebras, *Trans. Amer. Math. Soc.*, **298** (1986), 671–711. **MR0860387 (87k:16012)**; 3. *Hopf Algebras and Their Actions on Rings*, CBMS Regional Conference Series in Mathematics, American Math. Society, Providence, **82** (1993). **MR1243637 (94i:16019)**; 4. with R. Guralnick, Frobenius–Schur indicators for subgroups and the Drinfel'd double of Weyl groups, *Trans. Amer. Math. Soc.*, **361** (2009), 3611–3632. **MR2491893 (2009m:16075)**; 5. with Y. Kashina and S.–H. Ng, On the trace of the antipode and higher indicators, *Israel J. Math.*, **188** (2012), 57–90. **MR2897723**.
Statement by Candidate: The AMS and its programs are crucially important for the mathematical life of research mathematicians, through its meetings, publications, and many outreach activities. However the mathematical community faces multiple challenges, many brought on by the economic crisis. Universities are hiring more lecturers and

fewer assistant professors, so it is harder for our young people to get good jobs. The federal government is cutting back on grant support. It is harder for mathematicians in other countries to access our resources.

The AMS is already helping. For example, MathSciNet is too expensive for small colleges in the U.S., and for poorer countries overseas. The AMS has consortia pricing here and the National Math Reviews Program giving a deep discount to developing countries. Just recently this has been expanded to provide MathSciNet free for some poor countries. Both programs should be expanded. There are also many other things we can do.

If elected, I would work for these programs and others to help our profession, while maintaining our support for research and education.

Trustee

Robert Lazarsfeld

Professor of Mathematics, Stony Brook University.
Born: April 15, 1953.
Ph.D.: Brown University, 1980.
AMS Offices: Member at Large of the Council, 1994–1997; JAMS Representative on the Council, 2007–2009.
AMS Committees: JAMS: Editorial Committee, 2002–2009, Managing Editor 2007–2009; Committee to select recipients of AMS Centennial Fellowship, 2004, 2005.
Selected Addresses: Invited Address, International Congress of Mathematicians, Kyoto, 1990; Rademacher Lectures, University of Pennsylvania, 1998; Myhill Lectures, SUNY Buffalo, 2002; AMS Colloquium Lectures, Atlanta, 2005; Summer school in complex geometry, Grenoble, France, 2007.
Additional Information: AMS Postdoctoral Fellow, 1981–1982; Sloan Fellow, 1984–1987; Presidential Young Investigator, 1985–1990; Guggenheim Fellow, 1998–1999; BIRS Scientific Advisory Board, 2005–2008; Elected to American Academy of Arts and Sciences, 2006; Clay Senior Scholar, 2008; Managing editor, *Michigan Mathematical Journal*, 2012–2013; Fellow of the AMS, 2012.
Selected Publications: 1. with W. Fulton, Positive polynomials for ample vector bundles, *Ann. of Math.*, **118** (1983), 35–60. **MR0707160 (85e:14021)**; 2. with M. Green, Deformation theory, generic vanishing theorems, and some conjectures of Enriques, Catanese and Beauville, *Invent. Math.*, **90** (1987), 389–407. **MR0910207 (89b:32025)**; 3. with L. Ein, Singularities of theta divisors and the birational geometry of irregular varieties, *J. Amer. Math. Soc.*, **10** (1997), 243–258. **MR1396893 (97d:14063)**; 4. *Positivity in Algebraic Geometry*, vols. I & II, Ergebnisse der Mathematik, vols. 48 and 49, Springer–Verlag, Berlin, 2004. **MR2095471 (2005k:14001a)**, **MR2095472 (2005k:14001b)**; 5. with M. Mustata, Convex bodies associated to linear series, Ann. Sci. ENS 42 (2009), 783–835. **MR2571958 (2011e:14012)**.

Statement by Candidate: The AMS serves the mathematical community in myriad ways, ranging from its scientific and educational undertakings to its role in encouraging the entry of young mathematicians into the profession. The Society has also taken the lead in partnering with other scientific societies to stress the societal importance of mathematics to Congress and the broader public. Naturally the ability to carry out all these activities ultimately depends upon the continued financial health of the Society, and I would be honored to contribute to its mission by serving on the Board of Trustees. The approaching years are likely to present some new challenges to the AMS, notably in the business model of its publication programs. Indeed, the rise of open access journals and related developments promise to reshape the whole landscape of scientific publishing. As a consumer, an author, an editor, and (through the *Michigan Mathematical Journal*) a publisher of mathematics, I have given quite a bit of thought to these questions. I believe that I would be able to help the AMS navigate through some of the changes to come.

Michael F. Singer

Professor of Mathematics, North Carolina State University.
Born: February 25, 1950, New York City, New York.
Ph.D.: University of California, Berkeley, 1974.
AMS Offices: Member at Large of the Council, 2005–2008.
AMS Committees: Committee on Science Policy, 2005–2008; Committee on Committees, 2005–2008; Editorial Boards Committee, 2009–2012.
Selected Addresses: Kolchin Lecture, New York, 1995; Invited Address, AMS Regional Meeting, New York, 1996; Invited Lectures of the London Math Society, Heriot–Watt University, Edinburgh, 2006; Plenary Speaker, Bicentenaire de la naissance d'Evariste Galois, IHP, Paris, 2011; Evelyn Nelson Lecture, McMaster U., Hamilton, Canada, 2012.
Additional Information: Member, Institute for Advanced Study, 1978–1979, 1985; MSRI: Chair, Organizing Committee, Symbolic Computation in Geometry and Analysis Program, 1998, Deputy Director, 2002–2003, Acting Director 2003–2004; Member, Scientific Advisory Board, Banff International Research Station, 2003–2004; Fellow of the AMS.
Selected Publications: 1. Liouvillian solutions of nth order homogeneous linear differential equations, *Amer. J. Math.*, **103** (1981), no. 4, 661–682. **MR0623132 (82i:12028)**; 2. Moduli of linear differential equations on the Riemann sphere with fixed Galois groups, *Pacific J. Math.*, **160** (1993), 343–395. **MR1233356 (94k:12009)**; 3. with M. van der Put, *Galois Theory of Linear Differential Equations*, Grundlehren der Mathematischen Wissenschaften, volume 328 (2003), Springer–Verlag, Berlin. **MR1960772 (2004c:12010)**; 4. with C. Hardouin, Differential Galois theory of linear difference equations, *Math. Ann.*, **342** (2008), 333–377. **MR2785770 (2012d:39003)**; 5. with

P. Cassidy, A Jordan–Hölder theorem for differential algebraic groups, *J. Algebra*, **328** (2011), 190–217. **MR2745562 (2012b:12007)**.

Statement by Candidate: The mission of the AMS is to promote mathematical research, support mathematical education, advance the status of the profession, encourage full participation of all people, and promote appreciation of mathematics by the general public. These are goals I fully support. I have served on the Council and on several AMS committees. These opportunities have given me an understanding of the workings of the Society and I feel the organization is in general having success in achieving these goals. As a trustee I would work to ensure that the AMS maintains its financial health and has the ability to continue activities supporting these goals. I would also work with the Society's leadership to anticipate new needs and challenges and make sure that the Society has the ability to anticipate and respond. I would take this responsibility seriously and I would be honored to serve as a trustee.

Member at Large

Edward Bierstone

Professor of Mathematics, University of Toronto.

Born: December 21, 1946, Toronto, Ontario, Canada.

Ph.D.: Brandeis University, 1973.

Selected Addresses: AMS Invited Address, Joint Mathematics Meetings, San Diego, CA, 1997; Invited Lecture, 70th Birthday Conference for R. C. Gunning and J. J. Kohn, Princeton, NJ, 2002; Jeffery-Williams Prize Lecture, CMS Summer Meeting, Waterloo, ON, 2005; CMS Excellence in Teaching Award Prize Lecture, Canada-France Congress, Montreal, QC, 2008; Invited Lecture, Conference in Honor of the 80th Birthday of Heisuke Hironaka, Tordesillas, Spain, 2011.

Additional Information: Fellow of the Royal Society of Canada, 1992; Outstanding Teaching Award, Faculty of Arts and Science, University of Toronto, 1996; Director of the Fields Institute, 2009–2012; Fellow of the American Mathematical Society, 2012; Member of the Canadian Mathematical Society.

Selected Publications: 1. with P. D. Milman, Semianalytic and subanalytic sets, *Publ. Math. IHES*, **67** (1988), 5–42. **MR0972342 (89k:32011)**; 2. with P. D. Milman, Canonical desingularization in characteristic zero by blowing up the maximum strata of a local invariant, I*nvent. Math.*, **128** (1997), 207–302. **MR1440306 (98e:14010)**; 3. with P. D. Milman, Geometric and differential properties of subanalytic sets, *Ann.of Math.*, **147** (1998), 731–785. **MR1637671 (2000c:32027)**; 4. with P. D. Milman and W. Pawlucki, Differentiable functions defined in closed sets. A problem of Whitney, *Invent. Math.*, **151** (2003), 329–352. **MR1953261 (2004h:58009)**; 5. with P. Lairez and P. D. Milman, Resolution except for minimal singularities II. The case of four variables, *Adv. Math.*, **231** (2012), 3003–3021. **MR2970471**.

Statement by Candidate: During the past four years, I have been honored to serve the mathematics community as Director of the Fields Institute, and have been deeply involved in the organization of scientific, educational and outreach activities, bringing together people of all backgrounds who love mathematics, and advocating for the support of the mathematical sciences with universities, granting agencies and governments. It would be a privilege to serve the community as a member of the Council of the AMS. If elected, I will do my best to help advance the goals of the AMS in scientific communication, education and outreach, diversity and fairness.

Richard Durrett

James B. Duke Professor of Mathematics, Duke University.

Born: August 17, 1951, Anniston, Alabama.

Ph.D.: Stanford University (Operations Research), 1976.

AMS Committees: *Transactions and Memoirs* Board, 1991–1996; *Proceedings* Editorial Board, 1993–1996; Centennial Fellowship Committee, 1998–2000, 2007–2009; *Notices* Editorial Board Committee, 2001–2006; AMS-IMS-SIAM Committee on Summer Research Conferences in the Mathematical Sciences, 2003–2005; Nominating Committee, 2010–2012.

Selected Addresses: One hour talk, Joint Mathematics Meeting, San Antonio, 1986; 45-minute talk, International Congress, Kyoto, 1990; Wald Lectures (IMS), 2008.

Additional Information: Sloan Fellow, 1984–1986; Guggenheim Fellowship, 1988–1989; Elected to American Academy of Arts and Sciences, 2002; National Academy of Science, 2007.

Selected Publications: 1. B*rownian Motion and Martingales in Analysis*, Wadsworth Mathematics Series, Wadsworth International Group, Belmont, CA, 1984. **MR0750829 (87a:60054)**; 2. *Random Graph Dynamics*, Cambridge Series in Statistical and Probabilistic Mathematics, Cambridge University Press, Cambridge, 2007. **MR2271734 (2008c:05167)**; 3. *Probability Models for DNA Sequence Evolution*, second edition, Probability and its Applications, Springer, New York, 2008. **MR2439767 (2009k:60001)**; 4. *Probability: Theory and Examples*, fourth edition, Cambridge Series in Statistical and Probabilistic Mathematics, Cambridge University Press, Cambridge, 2010. **MR2722836 (2011e:60001)**.

Statement by Candidate: The membership of the AMS is very diverse, so it is important to have a wide variety of members on the Council. For the last 25 years I have worked on probability problems at the interface between math and biology: first in ecology, then in population genetics, and recently in cancer modeling. I think my perspective would complement that of pure mathematicians and applied mathematicians who work on problems from the physical sciences. I have the good (and bad) property of not being afraid to say what I think, but I have always taken my responsibilities seriously and do my best to play well with others.

Throughout my career I have done outreach to high schools, first in Ithaca and now in Durham. At Cornell, I helped start their summer math program for minority undergraduate students, which aims to improve their success in graduate school by increasing their skills in algebra or analysis. I am the founder of the Workshop for Women in Probability, which now meets every four years. I have supervised more than 40 graduate students and mentored two dozen postdocs, so I am well acquainted with the needs of young researchers.

Lisa Fauci

Professor of Mathematics and Associate Director, Center for Computational Science, Tulane University.

Born: September 21, 1960, Brooklyn, NY.

Ph.D.: Courant Institute, New York University, 1986.

AMS Committees: Editorial Committee, *Mathematical Reviews*, 2003–2008.

Selected Addresses: Distinguished Lecture, Institute for Applied Mathematics, University of British Columbia, Vancouver, 2009; Keynote Speaker, Joint Conference of the Society for Mathematical Biology and the Chinese Society for Mathematical Biology, Hangzhou, China, 2009; Invited Speaker, Modelling at Different Scales in Biology, University of Oxford, England, 2010; Dr. Karen Ames Memorial Lecture on Applied Mathematics, University of Alabama, Huntsville, 2010; Keynote Speaker, Vortex Dynamics, Biofluids and Related Fields, NIMS, Daejon, South Korea, 2011.

Additional information: Alfred P. Sloan Research Fellow, 1992–1994; Member, SIAM Board of Trustees, 2010 –; Fellow, Society for Industrial and Applied Mathematics (SIAM), 2012–; Outstanding Researcher Award, School of Science and Engineering, Tulane University, 2013.

Selected publications: 1. with R. Cortez and A. Medovikov, The method of regularized Stokeslets in three dimensions: analysis, validation, and application to helical swimming, *Physics Fluids*, **17** (2005), no. 3. **MR2136417 (2005k:76031)**; 2. with R. Dillon, Biofluidmechanics of reproduction, *Annu. Rev. Fluid Mech.*, **38** (2006), 371–394. **MR2206979 (2006j:92004)**; 3. with J. Teran and M. Shelley, Viscoelastic response can increase the speed and efficiency of a free swimmer, *Phys. Rev. Letters*, **104** (2010); 4. with S. Olson and S. Suarez, A model of CatSper channel mediated calcium dynamics in mammalian spermatozoa, *Bull. Math. Biol.*, **72** (2010), no. 8, 1925–1946. **MR2734051**; 5. with E. Tytell, C. Hsu, T. Williams and A. Cohen, Interactions between internal forces, body stiffness and fluid environment in a neuromechanical model of lamprey swimming, *Proc. Natl. Acad. Sci.*, **107** (2010).

Statement by Candidate: If elected to the AMS Council, I would be committed to fostering the AMS mission to encourage and promote mathematical research and scholarship, and to continue to embrace the connection of mathematics with other disciplines.

Srikanth B. Iyengar

Willa Cather Professor, University of Nebraska-Lincoln.

Born: August 19, 1970, Hyderabad, A.P., India.

Ph.D.: Purdue University, West-Lafayette, 1998.

AMS Committees: AMS-Simons Travel Grants Committee, 2011–2012.

Selected Addresses: Lecture series, Research Institute for Mathematical Sciences, Kyoto University, Japan, 2009; Invited Address, International Congress in the Representation Theory of Algebras, Tokyo, Japan, 2010; Lecture Series, Morningside Center of Mathematics, Chinese Academy of Science, Beijing, China, 2011; Plenary Address, INdAM Day, Genoa, Italy, 2012; Invited Address, Workshop, Mathematical Sciences Research Institute, 2013.

Additional Information: Friedrich Wilhelm Bessel Research Prize (Humboldt Foundation), 2007; Editorial Board, *Journal of Pure and Applied Algebra*, 2008–; Arts and Sciences College Distinguished Teaching Award, University of Nebraska, 2009; Simons Fellow in Mathematics, 2012–2013; Organizer (with D. Eisenbud, E. Miller, A. Singh, K. Smith), Special Year in Commutative Algebra, MSRI, 2012–2013, Berkeley, California.

Selected Publications: 1. with W. Dwyer and J. P. C. Greenlees, Duality in algebra and topology, *Adv. Math.*, **200** (2006), 357–402. **MR2200850 (2006k:55017)**; 2. with L. L. Avramov and R.-O. Buchweitz, Class and rank of differential modules, *Invent. Math.*, **169** (2007), 1–35. **MR2308849 (2008h:13032)**; 3. with G. Leuschke, A. Leykin, C. Miller, E. Miller, A. Singh, and U. Walther, *Twenty-Four Hours of Local Cohomology*, Graduate Stud. Math., volume **87** (2007), American Mathematical Society, Providence, RI. **MR2355715 (2009a:13025)**; 4. with L. L. Avramov, R.-O. Buchweitz, and C. Miller, Homology of perfect complexes, *Adv. Math.*, **223** (2010), 1731–1781. **MR2592508 (2011k:13014)**; 5. with D. Benson and H. Krause, Stratifying modular representations of finite groups, *Ann. of Math.*, **174** (2011), 1643–1684. **MR2846489**.

Statement by Candidate: I am honored to be considered for election as a Member at Large on the Council of the American Mathematical Society. I first encountered the AMS through the *Notices*, as a graduate student at Purdue University. It has since been a constant presence in my mathematical life, thanks to the services it provides, like Math.Sci.Net and Math Jobs; the various meetings and conferences it runs; and its publications. The AMS incorporates various facets of (my idea of) an ideal mathematician, contributing towards research, teaching, and outreach. If elected, I would be delighted to have an opportunity to serve the AMS.

Michael Larsen

Distinguished Professor of Mathematics, Indiana University.
Born: 1962, Boston, MA.
Ph.D.: Princeton University, 1988.
AMS Committees: Editor, *Transactions of the American Mathematical Society* and *Memoirs of the American Mathematical Society*, 2000–2002.
Selected Addresses: Algebraic Geometry, Seattle, 2005; Invited Address, AMS Spring Central Sectional Meeting, 2006; Frontier Lecture Series, Texas A&M University, 2008; Invited Address, AMS Spring Central Sectional Meeting, 2008; Binghamton University Dean's Speaker Series in Geometry/Topology, 2011.
Additional Information: Putnam Prize Scholarship, 1983; Sloan Fellowship, 1994; E. H. Moore Prize, 2013; Simons Fellow, 2013.
Selected Publications: 1. Maximality of Galois actions for compatible systems, *Duke Math. J.*, **80** (1995), 601–631. **MR1370110 (97a:11090)**; 2. with M. Freedman, A. Kitaev, and Z. Wang, Topological quantum computation. Mathematical challenges of the 21st century, (Los Angeles, CA, 2000). *Bull. Amer. Math. Soc.*, **40** (2003), 31–38. **MR1943131 (2003m:57065)**; 3. with V. Lunts, Motivic measures and stable birational geometry, *Mosc. Math. J.*, **3** (2003), 85–95. **MR1996804 (2005a:14026)**; 4. with A. Shalev and P. Tiep, The Waring problem for finite simple groups, *Ann. of Math.*, **174** (2011), 1885–1950. **MR2846493 (2012j:20040)**; 5. with R. Pink, Finite subgroups of algebraic groups, *J. Amer. Math. Soc.*, **24** (2011), 1105–1158. **MR2813339 (2012f:20148)**.
Statement by Candidate: This is a wonderful time to be a mathematician, especially if you are fortunate enough to be a tenured professor in a research university. Access to the ideas of other mathematicians has never been easier. The AMS must strive to remain relevant in the face of changes to the online landscape, including the growth of the arXiv, the rise of Google Scholar as a viable competitor to MathSciNet, and the emergence of MOOCs. As it works on behalf of the whole mathematical community, I think it is especially important for the Society to keep in mind those who are not (or not yet) in positions of seniority.

Kristin E. Lauter

Principal Researcher, Microsoft Research.
Born: December 8, 1969, Appleton, Wisconsin.
Ph.D.: University of Chicago, 1996.
Selected Addresses: Invited Address, AMS Western Section Regional Meeting, 2000; Invited Plenary Lecture, Canadian Number Theory Association (CNTA XI), 2010; MAA Invited Address, SoCal-Nev Section Meeting, CSU Fullerton, 2012; SIAM Invited Address, SIAM Annual Meeting, Minneapolis, 2012; Arnold Family Public Lecture, IMA, 2012.
Additional Information: Affiliate Professor, Department of Mathematics, University of Washington; T. H. Hildebrandt Assistant Professor of Mathematics, University of Michigan, 1996–1999; Visiting Scholar, Max Planck Institut für Mathematik, 1997; Selfridge Prize in Computational Number Theory, 2008; Co-founder of the Women In Numbers Network, 2008, a research collaboration community for women in number theory; Research Manager, Cryptography Research group, 2008–2013; Senior Leadership Team, MSR-XCG Lab, 2010–2013; Executive Committee, Association for Women in Mathematics, 2012–2014; Program Co-Chair: SAC2013 Selected Areas of Cryptography, 2013; Advisory Board for SHARPS, the Strategic Healthcare IT Advanced Research Projects on Security; Steering Committee, ACM Cloud Computing Security Workshop; Editorial Boards: *Journal of Algebra and Its Applications*, *International Journal of Information and Coding Theory*; U.S. Patents held: 25; Member: AWM, SIAM.
Selected Publications: 1. The maximum or minimum number of rational points on genus three curves over finite fields, with an appendix by Jean-Pierre Serre, *Compositio Math.*, **134** (2002), 87–111. **MR1931964 (2003i:14025)**; 2. with E. Howe, Improved upper bounds for the number of points on curves over finite fields, *Ann. Inst. Fourier (Grenoble)*, **53** (2003), 1677–1737. **MR2038778 (2005c:11079)**; 3. with R. Bröker and D. Gruenewald, Explicit CM-theory for level 2-structures on abelian surfaces, *Algebra Number Theory*, **5** (2011), 495–528. **MR2870099**; 4. with A. Cojocaru, R. Pries, R. Scheidler, co-editors, *WIN-Women in Numbers: Research Directions in Number Theory*, Fields Institute Communications Series, volume **60** (2011); 5. with E. Goren, Genus 2 curves with complex multiplication, *Int. Math. Res. Not.* (2012), 1068–1142. **MR2899960**.
Statement by Candidate: I am honored to be nominated. Mathematics is a core engine of innovation and economic growth, and enriches and contributes to scientific endeavors in many ways; therefore strengthening interactions with other disciplines such as computer science, physics, chemistry, biology and engineering is likely to improve the public perception of the fundamental value of mathematics. If elected to the AMS Council as a Member at Large, I will work to:
1. Promote inclusivity for under-represented groups in the profession,
2. Expand career options for research mathematicians in industry,
3. Promote the image of mathematics in the general public,
4. Increase support for the profession from industry,
5. Promote excellence in mathematical collaborations across disciplines.

We have an opportunity to build better relationships with industrial partners across disciplines who may hire mathematicians into rewarding research careers. Outreach to expand career options for mathematicians may also have a positive impact by attracting a broader swath of talent into mathematics.

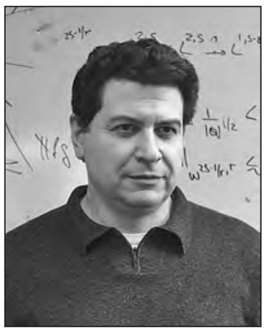
Kannan Soundararajan

Professor of Mathematics, Stanford University.
Born: December 27, 1973, Chennai, India.
Ph.D.: Princeton University, 1998.
AMS Committees: Morgan Prize Committee, AMS Joint meetings speaker committee.
Selected Addresses: Clay Research Conference, 2009; Texas A&M Frontiers Lecture series, 2009; Number Theory Section Speaker, ICM, 2010; Joint AMS-MAA Invited Address, New Orleans, 2011; Heilbronn lecture series, Bristol University, 2012.
Additional Information: Morgan Prize, 1995; Salem Prize, 2003; SASTRA Ramanujan Prize, 2005; Ostrowski Prize, 2011; Infosys Prize, 2011.
Selected Publications: 1. with A. Granville, Large character sums: pretentious characters and the Polya-Vinogradov theorem, *J. Amer. Math. Soc.*, **20** (2007), 357–384. **MR2276774 (2007k:11128)**; 2. Moments of the Riemann zeta function, *Ann. of Math.*, **170** (2009), 981–993. **MR2552116 (2010i:11132)**; 3. with R. Holowinsky, Mass equidistribution for Hecke eigenforms, *Ann. of Math.* **172** (2010), 1517–1528. **MR2680499 (2011i:11061)**; 4. Quantum unique ergodicity for $SL_2(Z)\backslash H$, *Ann. of Math.*, **172** (2010), 1529–1538. **MR2680500 (2011j:11098)**; 5. with J. B. Conrey and H. Iwaniec, The sixth power moment of Dirichlet *L*-functions, *Geom. Funct. Anal.*, **22** (2012), 1257–1288. **MR2989433**.

Jennifer Taback

Professor of Mathematics, Bowdoin College.
Born: October 3, 1971, New York, NY.
Ph.D.: University of Chicago, 1998.
AMS Committees: Eastern Sectional Program Committee, 2012–.
Selected addresses: Introduction to Geometric Group Theory Workshop, MSRI, 2006; Geometric and asymptotic group theory with applications, Stevens Institute of Technology, 2009; International Conference on Geometric and Combinatorial Methods in Group Theory and Semigroup Theory, University of Nebraska-Lincoln, 2009; Park City Mathematics Institute, Park City, UT, 2012; New York Group Theory Seminar, CUNY Graduate Center, 2013.
Additional Information: National Science Foundation Research Grants, 2003–2006, 2006–2009, 2011–2014; Co-organizer, AIM Conference, "Thompson's group at 40 years", 2004; Bowdoin College Faculty Research Award, 2006–2007, 2009–2010; Colby-Bates-Bowdoin Mellon Foundation Award, 2007, 2010; Director, Clare Boothe Luce Research Fellowships Program at Bowdoin College.
Selected Publications: 1. with P. Wong, Twisted conjugacy and quasi-isometry invariance for generalized solvable Baumslag-Solitar groups, *J. Lond. Math. Soc.*, **75** (2007), no. 3, 705–717. **MR2352731 (2008h:20043)**; 2. with S. Cleary, M. Elder and A. Reichnitzer, Random subgroups of Thompson's group *F, Groups Geom. Dyn.*, **4** (2010), 91–126. **MR2566302 (2011e:20062)**; 3. with P. Wong, The geometry of twisted conjugacy classes in wreath products, B. Farb and D. Fisher, editors, *Geometry, Rigidity and Group Actions*, Chicago Lectures in Math., Univ. Chicago Press, Chicago, IL, 2011, 561–587. **MR2807843 (2012f:20096)**; 4. with S. Cleary, S. Hermiller and M. Stein, Tame combing and almost convexity conditions, *Math. Z.*, **269** (2011), 879–915. **MR2860269 (2012k:20076)**; 5. with A. Akhmedov and M. Stein, Free limits of Thompson's group *F, Geom. Dedicata*, **155** (2012), 163–176. **MR2863899**.
Candidate Statement: It is an honor to have been nominated as a Member-at-Large of the Council of the AMS. If elected, I will be a strong voice for excellence in mathematics at both the graduate and undergraduate levels. The AMS must play an active role in attracting and retaining undergraduate as well as graduate students; at my institution, mathematics has risen to one of the largest majors on campus. I hope to assist the AMS in developing programs which generate the enthusiasm for mathematics that I see among my students. Of equal importance to me is supporting female students of all backgrounds interested in the physical sciences, and I have administered a successful program awarding grants to such students.

Rodolfo H. Torres



Professor of Mathematics and Associate Vice Chancellor for Research and Graduate Studies, University of Kansas.
Born: November 20, 1960, Rosario, Argentina.
Ph.D.: Washington University, St. Louis, 1989.
AMS Committees: Central Section Program Committee, 2004 and 2005.
Selected Addresses: Invited Address, AMS Sectional Meeting, Kent State University, 1995; Invited Hour Lecture, Annual Meeting of the Argentine Mathematical Society, Neuquen, Argentina, 2004; Public Lecture, Spring Lecture Series, University of Arkansas, Fayetteville, 2004; Brent Smith Memorial Lecture, Kansas State University, Manhattan, Kansas, 2010; Invited Lecture to the Royal Academy of Science of Seville, Spain, 2011.
Additional Information: G. Bailey Price Teaching of Graduate Mathematics Award, University of Kansas, 2000 and 2009; Kemper Excellence in Teaching Award, University of Kansas, 2003; President of the Faculty Senate, University of Kansas, 2011–2012; Fellow of the American Mathematical Society, 2013. Editorial Boards: *Journal of Mathematical Analysis and Applications*, 2000–; *Journal of*

Function Spaces and Applications, 2011–; *Journal of Fourier Analysis and Applications*, 2013–.

Selected Publications: 1. Boundedness results for operators with singular kernels on distribution spaces, Mem. Amer. Math. Soc., **90** (1991), no. 442. **MR1048075 (91g:47044)**; 2. with R. Prum, S. Williamson and J. Dick, Coherent light scattering by blue feather barbs, *Nature*, **396** (1998), 28–29. 3. with L. Grafakos, Multilinear Calderón-Zygmund theory, *Adv. Math.*, **165** (2002), no. 1, 124–164. **MR1880324 (2002j:42029)**; 4. with A. Lerner, S. Ombrosi, C. Pérez, and R. Trujillo-González, New maximal functions and multiple weights for the multilinear Calderón-Zygmund theory, *Adv. in Math.*, **220** (2009), no. 4, 1222–1264. **MR2483720 (2010f:42024)**; 5. with Á. Bényi, C. Demeter, A. R. Nahmod, C. M. Thiele, and P. Villarroya, Modulation invariant bilinear T(1) theorem, *J. Anal. Math.*, **109** (2009), 279–352. **MR2585397 (2011b:42032)**.

Statement by Candidate: The American Mathematical Society plays an essential role in promoting our discipline, not only within our academic and research environments but also to the public at large and governmental agencies. This role becomes especially relevant in difficult economic times when federal support for research and development is unfortunately shrinking. While mathematics and mathematicians continue to produce tremendous progress within our own scientific landscape and provide invaluable support to other disciplines, they do not always receive the credit they deserve in the public eye. A lack of public support is problematic given the increasing demand for accountability and the use of outcome metrics to assess the return of public investment in research and education. If elected, I will work with the Council to address scientific policies and issues affecting our organization and I will continue to be an advocate for the mathematical community. We should find innovative ways to showcase the contributions of mathematics to our intellectual enlightenment and scientific knowledge, which are sometimes perceived as intangible. At the same time, we should make a bigger effort to communicate the many economic benefits that the hard work of mathematicians also provides to our everyday life.

C. Eugene Wayne

Professor of Mathematics, Boston University.

Born: June 5, 1956, Moundsville, West Virginia.

Ph.D.: Harvard University, 1982.

AMS Committees: Committee to Select the Gibbs Lecturer, 1999; Summer Institute and Symposia, 1999.

Selected Addresses: Plenary Lecture, SIAM Meeting on Applied Dynamical Systems, Snowbird, Utah, 2003; Plenary Lecture, Dynamics Days, Europe, Loughborough University, 2007; Plenary Lecture, Symposium on Dynamical Systems, Chinese Academy of Sciences, Beijing, 2007; Plenary Lecture, international conference on Emerging Topics in Dynamical Systems and Partial Differential Equations, Barcelona, Spain, 2010; Distinguished Lecture in Applied Mathematics, University of Massachusetts, Amherst, 2010.

Additional Information: Member of the Editorial Boards of the SIAM *Journal of Mathematical Analysis*, the SIAM *Journal of Applied Dynamical Systems*, the *Journal of Differential Equations* and the *Journal of Mathematical Analysis and Applications*.

Selected Publications: 1. with W. Craig, Newton's method and periodic solutions of nonlinear wave equations, *Comm. Pure Appl. Math.*, **46** (1993), 1409–1498. **MR1239318 (94m:35023)**; 2. with G. Schneider, The long-wave limit for the water wave problem. I. The case of zero surface tension, *Comm. Pure Appl. Math.*, **53** (2000), 1475–1535. **MR1780702 (2002c:76025a)**; 3. with T. Schäfer, Propagation of ultra-short optical pulses in cubic nonlinear media, *Phys. D*, **196** (2004), 90–105. **MR2089976**; 4. with T. Gallay, Global stability of vortex solutions of the two-dimensional Navier-Stokes equations, *Comm. Math. Phys.*, **255** (2005), 97–129. **MR2123378 (2005m:35224)**; 5. with M. Beck, Using global invariant manifolds to understand metastability in the Burgers equation with small viscosity, *SIAM Rev.*, **53** (2011), 129–153. **MR2785882**.

Statement by Candidate: The AMS has a proud history of supporting research and teaching in mathematics since its founding. I hope that it will continue to play this role in coming years. I feel that an especially important consideration for the Society at this point in time is to try and support younger members of the profession as they search for permanent jobs. The AMS already does a great deal in this direction, both through traditional channels like the EIMS, MathJobs.org and the JMM Employment Center, and through more modern outlets like the "On the Market" and "Ph.D._epsilon" blogs. If I have the privilege to serve on the AMS Council my principal goal will be to support and extend these services to the next generation of mathematicians so that they have the same opportunities that my own generation has had.

Nominating Committee

Sami Hayes Assaf

Assistant Professor, University of Southern California.

Born: Fort Lauderdale, FL.

Ph.D.: University of California at Berkeley, 2007.

Selected Addresses: Localization techniques in equivariant cohomology, American Institute of Mathematics, Palo Alto, CA, 2010; Combinatorial Representation Theory, Mathematisches Forschungsinstitut Oberwolfach, Oberwolfach, Germany, 2010; Affine Schubert Calculus Workshop, Fields Institute, Toronto, Canada, 2010; Quasisymmetric Functions, Banff International Research Station, Banff, Canada, 2010; International conference on Schubert calculus, Mathematical Society of Japan Seasonal Institute, Osaka, Japan, 2012.

Additional Information: Herb Alexander Prize for outstanding dissertation, 2007; NSF Postdoctoral Fellow, 2007–2011; Co-Organizer: Bay Area Discrete Math Day, 2007–2008, AWM Schafer Mini symposium, 2011; Member: AMS, AWM, MAA.

Selected Publications: 1. A generalized major index statistic, *Sém. Lothar. Combin.*, **60** (2008/09). **MR2465404 (2010a:05010)**; 2. Cyclic derangements, *Electron. J. Combin.*, **17** (2010). **MR2745716 (2012b:05017)**; 3. with P. Diaconis and K. Soundararajan, A rule of thumb for riffle shuffling, *Ann. Appl. Probab.*, **21** (2011), 843–875. **MR2830606 (2012f:60012)**; 4. with P. McNamara, A Pieri rule for skew shapes, *J. Combin. Theory Ser. A*, **118** (2011), 277–290. **MR2737201 (2011k:05262)**; 5. with S. Billey, Affine dual equivalence and *k*-Schur functions, *J. Comb.*, **3** (2012).

Statement by Candidate: I am honored that President Vogan chose to nominate me as a candidate for the AMS Nominating Committee. This committee plays a vital role in shaping the future of the AMS. I hope to contribute to the mission of the AMS by promoting nominees who will, as a group, maintain a broad and balanced representation across mathematical disciplines, geographic areas, ethnicity, and gender.

Carlos Castillo-Chavez

Regents Professor and Joaquin Bustoz Jr. Professor of Mathematical Biology, Mathematical, Computational and Modeling Sciences Center, Arizona State University.

Born: March 29, 1952, Mexico City, Mexico.

Ph.D.: University of Wisconsin, Madison, 1984.

AMS Committees: Liaison Committee with AAAS, 2002–2003; Committee on Committees, 2005–2006; Committee on Committees, 2011–2012; Committee to Select the Winner of the Prize for Exemplary Program or Achievement by a Mathematics Department, 2011–2013.

Selected Addresses: Keynote Speaker, The 2nd International Conference on Mathematical Modeling and Computation and The 5th East Asia SIAM Conference, University of Brunei, Darussalam, 2009; Major Issues in Modern Biology, UC Davis, 2009; Speaker, Leading Voices in Public Health, East Tennessee University, 2010; Mathematical Models and Public Security, Marschak Colloquium, UCLA, 2013; Spatial patterns of infection: from foot and mouth disease to influenza, Spatial Management of Biodiversity, Henri Poincaré Institute, 2013.

Additional Information: Presidential Faculty Fellowship Award, 1992; Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring, 1997; American Association for the Advancement of Science Mentor Award, 2007; American Mathematical Society Distinguished Public Service Award, 2010; Fellow: Society for Industrial and Applied Mathematics, 2007, American Association for the Advancement of Science, 2007, American Mathematical Society, 2013; Committee on the National Medal of Science, 2010–2015. Past Member of advisory boards of the Statistical and Applied Mathematics Sciences Institute (SAMSI), Banff's International Research Station (BIRS), and the National Institute for Mathematical and Biological Synthesis (NIMBioS); Member, National Research Council's Board of Higher Education and Workforce (BHEW), 2009–2015.

Selected Publications: 1. *Mathematical and Statistical Approaches to AIDS Epidemiology*, Lecture Notes in Biomathematics, volume 83 (1989). **MR1040581 (91k:92022)**; 2. with H. Hethcote, V. Andreasen, S. Levin, and W. Liu, Epidemiological models with age structure, proportionate mixing, and cross-immunity, *J. Math. Biol.*, **27** (1989), 233–258. **MR1000090 (90g:92056)**; 3. with B. Song, Dynamical models of tuberculosis and their applications, *Math. Biosci. Eng.*, **1** (2004), 361–404. **MR2130673 (2005k:92027)**; 4. with E. Fenichel, M. Ceddia, G. Chowell, P. Gonzalez Parra, G. Hickling, G. Holloway, R. Horan, B. Morin, C. Perrings, M. Springborn, L. Velazquez, and C. Villalobos, Adaptive human behavior in epidemiological models, *Proceedings of the National Academy of Sciences*, 2011; 5. with F. Brauer, *Mathematical Models in Population Biology and Epidemiology*, Texts in Applied Mathematics, volume 40, Springer, New York (2012). **MR3024808**.

Statement by Candidate: The Nominating Committee plays a critical role in maintaining a model of excellence and inclusiveness that it is characteristic of great organizations. If elected, I will work hard to be sure that those nominated are representative of the communities that make the American Mathematical Society a great organization.

Peter Constantin

William R. Kenan Jr. Professor of Mathematics, Princeton University.

Born: August 29, 1951, Cluj, Romania.

Ph.D.: The Hebrew University, Jerusalem, 1981.

AMS Committees: Proceedings of Symposia in Applied Mathematics, 1993–2004.

Selected Addresses: Invited Plenary Address, AMS, Denton, 1990; International Congress of Mathematical Physics, Paris, 1994; International Congress of Mathematicians, Zurich, 1994; International Congress of Industrial and Applied Mathematics, Edinburgh, 1999; Collège de France, Paris, 2008.

Additional Information: Alfred P. Sloan Research Fellow, 1986–1990; Fellow of the Institute of Physics (London); ISI Highly Cited Researcher; SIAM Fellow; Fellow of the American Academy of Arts and Sciences; Inaugural Fellow of AMS.

Selected Publications: 1. with C. Foias, Global Lyapunov exponents, Kaplan-Yorke formulas and the dimension of the attractors for 2-D Navier-Stokes equations, *Comm. Pure Appl. Math.*, **38** (1985), 1–27. **MR0768102 (87g:35186)**; 2. with J.-C. Saut, Local smoothing properties of dispersive equations, *J. Amer. Math. Soc.*, **1** (1988), 413–439. **MR0928265 (89d:35150)**; 3. with A. Majda and E. Tabak, Formation of strong fronts in the 2-D quasi-geostrophic thermal active scalar, *Nonlinearity*, **7** (1994), 1495–1533. **MR1304437 (95i:76107)**; 4. On the Euler equations of incompressible fluids, *Bull. Amer. Math. Soc. (N.S.)*, **44** (2007), 603–621. **MR2338368 (2008i:76010)**; 5. with V. Vicol, Nonlinear maximum principles for dissipative linear nonlocal operators and applications, *Geom. Funct. Anal.*, **22** (2012), 1289–1321. **MR2989434**.

Statement by Candidate: I am honored to have been asked to be considered for election to the Nominating Committee. The committee's function is to identify suitable candidates for election to AMS offices and committees.

If elected, I will try to help find people who best represent and can serve the broad interests of AMS.

Robert L. Griess Jr.

Richard D. Brauer Collegiate Professor of Mathematics, University of Michigan.

Born: October 10, 1945, Savannah, Georgia.

Ph.D.: University of Chicago, 1971.

AMS Committees: Central Section Program Committee, 1990–1992 (chair, 1991); Electronic Research Announcements Editorial Board, 2006–2007; Cole Prize Committee (chair, 2011–2012).

Selected Addresses: Invited Address, AMS summer meeting, Pittsburgh, 1982; Invited Lecture in Algebra section, International Congress of Mathematicians, 1983.

Additional Information: Guggenheim Fellowship, 1981–1982; Maitre de Recherche, CNRS, Ecole Normale Supérieure, Paris, academic year 1986–1987; Dozor Visiting Fellow, Ben-Gurion University of the Negev, Israel, 1999; Harold R. Johnson Diversity Service Award, University of Michigan, 2003; Electronic Research Announcements in the Mathematical Sciences, 2008–; Steele Prize for Seminal Contribution to Research, 2010; Member, American Academy of Arts and Sciences; Fellow, American Mathematical Society; Visiting positions: Rutgers University, the Institute for Advanced Study, Yale University, the University of California, Santa Cruz, National Cheng Kung University, Taiwan and Zhejiang University, China.

Selected Publications: 1. The friendly giant, *Invent. Math.*, **69** (1982), 1–102. **MR0671653 (84m:20024)**; 2. with Robert H. Gilman, Finite groups with standard components of Lie type over fields of characteristic two, *J. Algebra*, **80** (1983), 383–516. **MR0691810 (84g:20024)**; 3. with A. Ryba, Classification of finite quasisimple groups which embed in exceptional algebraic groups, *J. Group Theory*, **5** (2002), 1–39. **MR1879514 (2002j:20091)**; 4. with C. Dong and C. Lam, Uniqueness results for the moonshine vertex operator algebra, *Amer. J. Math.*, **129** (2007), 583–609. **MR2306046 (2008a:17031)**; 5. with C. Lam, A new existence proof of the monster by VOA theory, *Michigan Math. J.*, **61** (2012), 555–573. **MR2975262**.

Statement by Candidate: As a Nominating Council member, I would try to represent the interests of the American Mathematical Society community thoughtfully and fairly.

Kailash C. Misra

Professor of Mathematics, North Carolina State University.

Born: April 11, 1954, Dhenkanal, India.

Ph.D.: Rutgers University, 1982.

AMS Committees: AMS Southeastern Section Program Committee, 2006–2008; Editorial Boards: *Proceedings of the American Mathematical Society*, 2011–, *Contemporary Mathematics*, 2012–; AMS Committee on Meetings and Conferences, 2013–.

Selected Addresses: Invited Address, International Conference, "Kac-Moody Lie algebras and applications", Ramanujan Institute for Advanced Study, India, 2002; Invited Address, AMS Summer Research Conference, "Representations of Algebraic groups, quantum groups and Lie algebras", Snowbird, Utah, 2004; Invited Address, International Conference, "Geometric Representation Theory", University of Ottawa, Canada, 2009; Invited Address, International Conference, "Quantized Algebra and Physics", Chern Institute of Mathematics, Nankai University, Tianjin, China, 2009; Invited Address, International Conference, "Infinite Analysis 11: Frontier of Integrability", University of Tokyo, Japan, 2011.

Additional Information: Editorial Board, *Communications in Algebra*, 1995–; NCSU Outstanding Teacher Award, 2004.

Selected Publications: 1. with S. Kang, M. Kashiwara, T. Miwa, T. Nakashima, and A. Nakayashiki, Affine crystals and vertex models, *Adv. Ser. Math. Phys.*, **16** (1992), 449–484. **MR1187560 (94a:17008)**; 2. with G. Benkart and S. Kang, Graded Lie algebras of Kac-Moody type, *Adv. Math.*, **97** (1993), 154–190. **MR1201842 (94b:17039)**; 3. with A. Kuniba, M. Okado and J. Uchiyama, Demazure modules and perfect crystals, *Comm. Math. Phys.*, **192** (1998), 555–567. **MR1620507 (2000c:17025)**; 4. with N. Jing, Vertex operators for twisted quantum affine algebras, *Trans. Amer. Math. Soc.*, **351** (1999), 1663–1690. **MR1458306 (99i:17027)**; 5. with M. Kashiwara, M. Okado and D. Yamada, Perfect crystals for $U_q(D_4^{(3)})$, *J. Algebra*, **317** (2007), 392–423. **MR2360156 (2009b:17035)**.

Statement by Candidate: It would be an honor and a privilege for me to serve on the Nomination Committee. American Mathematical Society plays a critical role in promoting the importance of mathematics nationally and internationally. If elected, I will do my best to help strengthen the AMS by nominating qualified diverse slate of candidates for critical elected positions at AMS. I look forward to the opportunity to play a role in the future emphasis and focus of the American Mathematical Society.

David J. Wright

Professor of Mathematics, Oklahoma State University.
Born: September 15, 1955, Brooklyn, NY.
Ph.D.: Harvard University, 1982.
Selected Addresses: Invited Address, "Counting number fields as orbits of representations", AMS meeting, Stillwater, 1994; "Speculations on the finer aspects of the asymptotics of discriminant counting functions", Conference, Rings of Low Rank, Lorentz Center, Leiden, NL, 2006; Exploring Kleinian Groups, Nathan A. Court Lecture, MAA Meeting, University of Arkansas, Fort Smith, 2008; On *L*-functions with poles at s=1 and 5/6, Patterson 60++ Conference, Göttingen, 2009; Exploring Kleinian Groups: activities for students, Circle on the Road: the Julia Robinson Math Festival, Arizona State University, 2010.
Additional Information: Honors: Putnam Fellow, 1976; NSF Postdoctoral Fellow, 1982–1985; Alfred P. Sloan Fellow, 1989–1990; MAA Oklahoma-Arkansas Distinguished Teaching Award, 2009; AMS Fellow, 2012; Member: MAA.
Selected Publications: 1. Distribution of discriminants of abelian extensions, *Proc. London Math. Soc.*, **58** (1989), 17–50. **MR0969545 (90b:11115)**; 2. with A. Yukie, Prehomogeneous vector spaces and field extensions, *Invent. Math.*, **110** (1992), 283–314. **MR1185585 (93j:12004)**; 3. with D. Mumford and C. Series, *Indra's Pearls: The Vision of Felix Klein*, Cambridge University Press, New York, 2002. **MR1913879 (2003f:00005)**; 4. with A. Kable, Uniform distribution of the Steinitz invariants of quadratic and cubic extensions, *Compos. Math.*, **142** (2006), 84–100. **MR2196763 (2006k:11225)**; 5. Searching for the cusp, in *Spaces of Kleinian Groups*, Minsky, Sakuma and Series, eds., London Math. Soc. Lect. Notes, volume **329** (2006), 301–336. **MR2258756 (2008c:30049)**.
Statement by Candidate: It would be a privilege and grave responsibility to serve on the nominating committee, and to contribute to the effort to find dedicated leaders to cultivate the many activities of the AMS in mathematical research, education, and outreach. I believe simultaneously in the joy of pure mathematics and at the same time in the great power of mathematics when applied to problems in all fields of human endeavor. I have also enjoyed and benefited from a life in the greater mathematical community that has brought me into contact with many outstanding individuals, and I hope these experiences will prove of service to the AMS.

Editorial Boards Committee

Rafe Mazzeo

Professor of Mathematics, Stanford University.
Born: March 21, 1961, Boston, MA.
Ph.D.: Massachusetts Institute of Technology, 1986.
AMS Committees: Math in Moscow Committee, chair, 2001–2004; Graduate Studies in Mathematics, 2008–2016, Epsilon Award Committee, 2009–2012; *Notices* Editorial Board Committee, 2010–2014; Committee on Committees, 2013–2015.
Selected Addresses: Yamabe Lectures, Northwestern University, 2012; Spring Lecture Series, Main Lecturer, University of Arkansas, 2012.
Additional Information: NSF Postdoctoral Fellowship, 1987–1990; Sloan Fellowship, 1991–1995; NSF Young Investigator, 1992–1997; Director of Stanford University Math Camp, 1995–2008; Faculty Director, Stanford Pre-Collegiate Studies, 2010–; Scientific Advisory Committee, Banff International Research Station, 2008–2010 and American Institute of Mathematics, 2010–; Organizing Committee, MSRI Semester on Spectral Invariants, Spring 2001 and Park City Mathematical Institute, Summer 2013.
Selected Publications: 1. Elliptic theory of differential edge operators I, *Comm. Partial Differential Equations*, **16** (1991), 1616–1664. **MR1133743 (93d:58152)**; 2. with C. Epstein, *Degenerate Diffusion Operators Arising in Population Biology*, Annals of Mathematics Studies, Princeton University Press (2013); 3. with T. Jeffres and Y. Rubinstein, Kähler–Einstein metrics with edge singularities, *Annals of Mathematics*, to appear.
Statement by Candidate: The publishing activities of the AMS play a key place in the current discussion about the future of academic publishing. The AMS must be proactive in its policies toward this important issue. Members of the editorial boards of AMS journals and book series should not only be aware of what is at stake, but must also play a role in this dialogue. I would certainly be very honored to undertake this more active role.

Anne Schilling

Professor of Mathematics, University of California, Davis.
Born: Geneva, Switzerland.
Ph.D.: SUNY Stony Brook, 1997.
Selected Addresses: Plenary Speaker, annual international combinatorics conference FPSAC'04, Vancouver, Canada, 2004; Plenary Speaker, AMS Sectional Meeting, Claremont, McKenna, 2008; Plenary Lecturer, Seminaire Lotharingien Combinatoire, Ellwangen, Germany, 2011; Distiguished Lecturer,

University of New Brunswick, 2011; Invited Speaker, Joint Mathematics Meeting, San Diego, 2013.

Additional Information: Fulbright Scholarship, 1992–1993; President's Award to Distinguished Doctoral Student, 1997; Humboldt Research Fellowship, 2002; UC Davis Faculty Research Development Award, 2006; UC Davis Chancellor's Fellowship, 2006–2007; Simons Fellowship, 2013.

Selected Publications: 1. with G. Fourier and M. Okado, Kirillov-Reshetikhin crystals for nonexceptional types, *Adv. Math.*, **222** (2009), no. 3, 1080–1116. **MR2553378 (2010j:17028)**; 2. with T. Lam and M. Shimozono, Schubert polynomials for the affine Grassmannian of the symplectic group, *Math. Z.*, **264** (2010), 765–811. **MR2593294 (2011f:14088)**; 3. with T. Lam and M. Shimozono, *K*-theory Schubert calculus of the affine Grassmannian, *Compos. Math.*, **146** (2010), 811–852. **MR2660675 (2011h:14078)**; 4. with F. Hivert and N. Thiéry, The biHecke monoid of a finite Coxeter group, *Algebra and Number Theory Journal*, to appear (arXiv:1012:1361[math.CO]). *Discrete Math. Theor. Comput. Sci. Proc., AN* (2010). **MR2673845 (2012k:05452)**; 5. with C. Lenart, S. Naito, D. Sagaki and M. Shimozono, A uniform model for Kirillov-Reshetikhin crystals I: Lifting the parabolic quantum Bruhat graph, submitted (arXiv.1211.2042 [math.QA]).

Statement by Candidate: Publishing has undergone a huge change in the past years due to the advent of electronic resources such as electronic journals or the ArXiv. As a professional society, the AMS can take a leading role in setting new trends for publishing practices. Whilst I believe that peer review is critical to maintain high quality research, I think it is worth investigating open access models. I am personally an advocate of open-source material (for example by contributing to the free open-source mathematics software system Sage licensed under the GPL license). As a member of the AMS Editorial Board Committee, I would work on maintaining high quality editorial boards for all AMS journals and setting the trends for the future.

Daniel W. Stroock

Emeritus Professor of Mathematics, Massachusetts Institute of Technology.

Born: March 20, 1940, New York, New York.

Ph.D.: Rockefeller Institute, 1966.

AMS Committees: *Transactions* and *Memoirs* Editorial Committee, 1975–1978; Committee to Select Hour Speakers for Far Western Sectional Meetings, 1979–1980; *Proceedings* Editorial Committee, 1983–1987; Committee on Committees, 1997–1998; Science Policy Committee, 1998–2005.

Selected Addresses: Invited Address, Claremont, 1978; Invited Address, International Congress of Mathematicians, Warsaw, 1983; Hour Lecture, Canadian Mathematical Society, 1992; Invited Address, International Joint Mathematics Meetings of the AMS and the Sociedad Matemática Mexicana (SMM), Merida, Mexico, 1993; AMS Colloquium Lectures, San Diego, 1997.

Additional Information: Steele Prize for Seminal Research Contributions (with S. R. S. Varadhan), 1997; Member: American Academy of Arts and Sciences, National Academy of Sciences, and the Polish Academy of Arts and Sciences; Other Organizations: has served NRC Board of Mathematical Sciences and on the editorial boards of several journals, including *Journal of Functional Analysis, Advances in Mathematics, Annals of Probability*, the *Illinois Journal of Mathematics*, and *Mathematical Research Letters*.

Selected Publications: 1. with R. Holley, In one and two dimensions, every stationary measure for a stochastic Ising model is a Gibbs state, *Comm. Math. Phys.*, **55** (1977), 37–45. **MR0451455 (56 #9741)**; 2. The Malliavin calculus and its application to second order parabolic differential equations. I. *Math. Systems Theory*, **14** (1981), 25–65. **MR0603973 (84d:60092a)**; 3. with S. Kusuoka, Application of the Malliavin calculus, parts II & III, *J. Fac. Sci. Univ. Tokyo Sec. IA*, **32** & **34** (1985 & 1987), 1–76 & 391–442. **MR0783181 (86k:60100b)**, **MR0914028 (89c:60093)**; 4. with E. Fabes, The DiGiorgi–Moser Harnack principle via the old ideas of Nash, *Arch. Rational Mech.* (1987). 5. with P. Malliavin, Short time behavior of the heat kernel and its logarithmic derivatives, *J. Differential Geom.*, **44** (1996), 550–570. **MR1431005 (98c:58164)**.

Statement by Candidate: Academic publications are in a transition period. Ten years from now traditional journals may be a thing of the past. In the meantime, it is extremely important that there be a mechanism for maintaining rigorous standards, and I believe that traditional journals play that role. If elected, I will do my best to select candidates who share my concern that the AMS journals continue to apply high standards.

Michelle Wachs

Professor of Mathematics, University of Miami.

Born: November 30, 1952, New York, NY.

Ph.D.: University of California, San Diego, 1977.

AMS Offices: Member at Large of the Council, 2009–2012.

AMS Committees: Southeastern Section Program Committee, 1994–1996 (chair, 1995–1996); Committee on the Profession, 2009–2012.

Selected Addresses: AMS Invited Hour Address, Knoxville, 1993; Plenary Address, International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC), Minnesota, 1996 and San Diego, 2006; Graduate School Lecturer, IAS/Park City Mathematics Institute, Geometric Combinatorics Program, 5 lectures, 2004; Plenary Address, Ulam Centennial Conference, University of Florida, 2009; Hayden-Howard Lecture, University of Kentucky, 2013.

Additional Information: Editorial Boards: *Advances in Applied Mathematics*, 1994–, *SIAM Journal on Discrete*

Mathematics, 1996–2010, *Order*, 1998–2005, *Journal of Combinatorics*, 2012–; Visiting Positions: UCSD, Visiting Associate Professor of Electrical Engineering and Computer Science, 1983–1984; Université Louis Pasteur, Strasbourg, France, Visiting Professor, June 1989; Mittag-Leffler Institute, May 1992 and May–June 2005; MSRI, General Member, October 1996 and May 1997; KTH Stockholm, Guest Researcher, January–June 1999 and October 2008; Isaac Newton Institute, Member, May–July 2001; Cambridge University, Visiting Scholar, September–December, 2005; De Giorgi Center, Pisa, June 2010. Conference Co-organization: AMS Special Session on Algebraic Combinatorics, Knoxville, 1993 and Louisville, 1998; MSRI Workshop on Enumeration and Posets, 1996; AMS Special Session on Combinatorial Representation Theory, Topological Combinatorics and Interactions Between Them, Bloomington, 2008; Cochair of program committee for FPSAC, 2011. Honors: University of Miami Cooper Fellow, 2006–, Simons Fellow, 2013, Fellow of the AMS.

Selected Publications: 1. with A. Björner, Bruhat order of Coxeter groups and shellability, *Adv. Math.*, **43** (1982), No. 1, 87–100. **MR0644668 (83i:20043)**; 2. with A. Björner, Shellable nonpure complexes and posets. I., *Trans. Amer. Math. Soc.*, **348** (1996), No. 4, 1299–1327. **MR1333388 (96i:06008)**; 3. with J. Shareshian, Torsion in the matching complex and chessboard complex, *Adv. Math.*, **212** (2007), No. 2, 525–570. **MR2329312 (2008d:55012)**; 4. Poset topology: tools and applications, *Geometric Combinatorics*, *IAS/Park City Math. Ser.*, **13**, Amer. Math. Soc., Providence, RI, 2007, pp. 497–615. **MR2383132**; 5. with J. Shareshian, Eulerian quasisymmetric functions, *Adv. in Math.*, **225** (2010), No. 6, 2921–2966. **MR2728998 (2012a:05336)**.

Statement by Candidate: One of the most significant ways in which the AMS contributes to the advancement of mathematics is by publishing first rate mathematics journals. Indeed, the AMS publishes some of the most prestigious journals in the world. If elected to the Editorial Boards Committee, I would strive to maintain the high standards and stature of the AMS publications by identifying highly qualified individuals to serve on the editorial boards.

CALL FOR Suggestions

Your suggestions are wanted by:

The Nominating Committee, for the following contested seats in the 2014 AMS elections:
vice president, trustee,
and five members at large of the Council

Deadline for suggestions: November 1, 2013

The President, for the following contested seats in the 2014 AMS elections:
three members of the Nominating Committee
two members of the Editorial Boards Committee

Deadline for suggestions: January 31, 2014

The Editorial Boards Committee, for appointments to various editorial boards of AMS publications

Deadline for suggestions: Can be submitted any time
Send your suggestions for any of the above to:

Carla D. Savage, Secretary
American Mathematical Society
Department of Computer Science
Box 8206
North Carolina State University
Raleigh, NC 27695-8206 USA
email: secretary@ams.org

2014 AMS Election

Nominations by Petition

Vice President or Member at Large

One position of vice president and member of the Council *ex officio* for a term of three years is to be filled in the election of 2014. The Council intends to nominate at least two candidates, among whom may be candidates nominated by petition as described in the rules and procedures.

Five positions of member at large of the Council for a term of three years are to be filled in the same election. The Council intends to nominate at least ten candidates, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

Petitions are presented to the Council, which, according to Section 2 of Article VII of the bylaws, makes the nominations. The Council of 23 January 1979 stated the intent of the Council of nominating all persons on whose behalf there were valid petitions.

Prior to presentation to the Council, petitions in support of a candidate for the position of vice president or of member at large of the Council must have at least fifty valid signatures and must conform to several rules and procedures, which are described below.

Editorial Boards Committee

Two places on the Editorial Boards Committee will be filled by election. There will be four continuing members of the Editorial Boards Committee.

The President will name at least four candidates for these two places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and procedures, described below, should be followed.

Nominating Committee

Three places on the Nominating Committee will be filled by election. There will be six continuing members of the Nominating Committee.

The President will name at least six candidates for these three places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and procedures, described below, should be followed.

Rules and Procedures

Use separate copies of the form for each candidate for vice president, member at large, member of the Nominating or Editorial Boards Committees.

1. To be considered, petitions must be addressed to Carla D. Savage, Secretary, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA, and must arrive by 24 February 2014.
2. The name of the candidate must be given as it appears in the *Combined Membership List* (`www.ams.org/cml`). If the name does not appear in the list, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the *Notices.* If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate's mailing label or by the candidate contacting the AMS headquarters in Providence (`amsmem@ams.org`).
3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.
4. On the next page is a sample form for petitions. Petitioners may make and use photocopies or reasonable facsimiles.
5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.
6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the *Combined Membership List* and the mailing lists. No attempt will be made to match variants of names with the form of name in the *CML*. A name neither in the *CML* nor on the mailing lists is not that of a member. (Example: The name Carla D. Savage is that of a member. The name C. Savage appears not to be.)
7. When a petition meeting these various requirements appears, the secretary will ask the candidate to indicate willingness to be included on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving consent.

Nomination Petition
for 2014 Election

The undersigned members of the American Mathematical Society propose the name of

____

as a candidate for the position of (check one):

- ☐ **Vice President**
- ☐ **Member at Large of the Council**
- ☐ **Member of the Nominating Committee**
- ☐ **Member of the Editorial Boards Committee**

of the American Mathematical Society for a term beginning 1 February, 2015

Return petitions by 24 February 2014 to:
Secretary, AMS, 201 Charles Street, Providence, RI 02904-2294 USA

Name and address (printed or typed)	
	Signature
	Signature
	Signature
	Signature
	Signature
	Signature

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/.

September 2013

1–5 **Motivic Galois Groups**, Alfréd Rényi Institute of Mathematics, Budapest, Hungary. (Mar. 2013, p. 362)
Description: Mini-courses by: Yves André (Institut de Mathématiques de Jussieu, Paris), Joseph Ayoub (Universität Zürich), Marc Levine (Universität Duisburg–Essen).
Invited Lecturers: Michael Dettweiler (Universität Bayreuth), Hélène Esnault (Freie Universität Berlin), Jochen Heinloth (Universität Duisburg–Essen), Annette Huber-Klawitter (Albert-Ludwigs-Universität Freiburg), Peter Jossen (Université de Paris-Sud, Orsay), Bruno Kahn (Institut de Mathématiques de Jussieu, Paris).
Organizers: Stefan Müller-Stach (Universität Mainz), Tamás Szamuely (Rényi Institute, Budapest).
Information: http://renyi.mta.hu/~szamuely/mgg.html.

1–6 **Kangro-100, Methods of Analysis and Algebra, International Conference dedicated to the Centennial of Professor Gunnar Kangro**, University of Tartu, Tartu, Estonia. (Feb. 2013, p. 264)
Description: Professor Gunnar Kangro (1913-1975), member of the Estonian Academy of Sciences, was the most famous Estonian mathematician of his time. He was a world-class professional in his main research area — summability theory. His excellent courses and textbooks in algebra and analysis advocated the use of new theories developed in the first half of the twentieth century, and led the transition of Estonian mathematics to modern basis. Having also supervised 23 Cand. Sci. Theses, he is fully considered the founder of contemporary Estonian mathematical school.
Topics: Modern methods of analysis and algebra. The working program of the conference consists of plenary lectures in the mornings and parallel sessions in afternoons.
Proceedings: Peer-reviewed contributions will be published in a special issue of the open access journal "Acta et Commentationes Universitatis Tartuensis de Mathematica"; http://math.ut.ee/acta.
Social events: Include excursions introducing Estonia http://www.visitestonia.com and an accompanying persons' program.
Information: http://kangro100.ut.ee.

* 1–7 **51st Summer School on Algebra and Ordered Sets**, Hotel Troyer, Trojanovice, Czech Republic.
Description: A traditional conference focused on general algebra and ordered sets. The scientific program consists of 20- or 30-minute talks by the participants, plus plenary lectures by invited speakers.
Information: http://ameql.math.muni.cz/ssaos.

1–August 31, 2014 **Call for Research Programmes 2013-2014**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Sept. 2012, p. 1175)
Description: The Centre de Recerca Matemàtica (CRM) invites proposals for Research Programmes for the academic year 2013–2014. CRM Research Programmes consist of periods ranging between two to five months of intensive research in a given area of mathematics and its applications. Researchers from different institutions are brought together to work on open problems and to analyse the state and perspectives of their area.
Deadline: The deadline for submission of proposals is November 18, 2011.
Information: Guidelines and application instructions can be found at http://www.crm.cat/CALLS/CALLS RESEARCH PROGRAMS/Call Research Program 1314.htm.

* 1–November 30 **Research Programme on Geometry and Dynamics of Integrable Systems**, Centre de Recerca Matemàtica, Bellaterra, Barcelona.

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: This research Programme wants to focus on the geometrical and the dynamical aspects in the study of integrable systems. We want to specially stress the following topics in the study of integrable systems: Connections of several aspects showing up in the geometry, topology and dynamics of integrable systems in symplectic manifolds such as singular aspects of integrable systems, symplectic topology of integrable systems, integrability criteria and obstructions to integrability, connection with geometric quantization and integrable systems in contact and Poisson manifolds; study of geodesic flows, their integrability and non-integrability: methods and examples; applications to mathematical physics and classical differential geometry.
Scientific Committee: Vladimir Matveev, Eva Miranda, Francisco Presas and Iskander Taimanov.
Information: `http://www.crm.cat/2013/RPIntegrable-Systems`.

1–December 20 **Research Program on Automorphisms of Free Groups: Algorithms, Geometry and Dynamics**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Dec. 2012, p. 1596)
Description: The study of automorphisms of free groups is a classical subject, with more than 100 years of history. The last 25 years have witnessed the development of many interesting new tools, resulting in the subject's diversification into algorithmic, geometric and dynamical aspects. While these aspects continue to be heavily intertwined, they have meanwhile taken root in several other areas of mathematics. The purpose of the proposed program is to assemble experts from these three aspects, with the object of finding innovative approaches to the main open questions from each.
Information: `http://www.crm.cat/2012/RPAutomorphisms`.

2–5 **XXII International Fall Workshop on Geometry and Physics**, University of Évora, Évora, Portugal. (Mar. 2013, p. 362)
Description: The Fall Workshops on Geometry and Physics have been held yearly since 1992, and bring together Spanish and Portuguese geometers and physicists, along with an ever increasing number of participants from outside the Iberian peninsula. The meetings aim to provide a forum for the exchange of ideas between researchers of different fields in Differential Geometry, Applied Mathematics and Physics, and always include a substantial number of enthusiastic young researchers amongst the participants.
Information: `http://www.ifwgp2013.uevora.pt/`.

* 2–6 **School and Workshop on Conformal Blocks, Vector Bundles on Curves and Moduli of Curves**, Mathematics Department, G. Castelnuovo Sapienza, Universita di Roma, Rome, Italy.
Aim: Of this school/workshop is to give an introduction to conformal blocks, their construction and use as research tools and objects in different branches of algebraic geometry and topology, in particular moduli spaces of algebraic curves and of vector bundles on curves. Four mini-courses of 5 hours each will be held.
Speakers: Prakash Belkale (Univ. North Carolina at Chapel Hill), Angela Gibney (Univ. of Georgia at Athens), Christian Pauly (Univ. de Nice Sophia-Antipolis), Aaron Pixton (Princeton University).
Funding: It is possible for Ph.D. students and young post-docs to apply for funding for lodging guaranteed by our sponsors. Subscribe to the conference on the registration page to apply.
Deadline: For applying for funding is May 31st, 2013.
Information: `http://conformalmoduli.sciencesconf.org/`.

3–4 **Connections for Women: Mathematical General Relativity**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)
Description: Ever since the epic work of Yvonne Choquet-Bruhat on the well-posedness of Einstein's equations initiated the mathematical study of general relativity, women have played an important role in many areas of mathematical relativity. In this workshop, some of the leading women researchers in mathematical relativity present their work.
Information: `http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9551`.

3–6 **CAI 2013: 5th Conference on Algebraic Informatics**, ERISCS and IML, Aix-Marseille University, IGESA, Porquerolles Island, France. (Dec. 2012, p. 1596)
Description: CAI 2011 continues the tradition established by the previous sessions: to bring together researchers from theoretical computer science and algebra. This should enhance the understanding of syntactic and semantic problems by algebraic models; and it should also propagate the application of modern techniques from informatics in algebraic computation. Authors are invited to submit papers (in PDF format) presenting original research work, electronically to `cai2013@acrypta.fr`. All submissions should be formatted according to the usual LNCS article style and should not exceed 12 pages. The Proceedings of CAI 2013 will be published in the Lecture Notes in Computer Science Series (LNCS) by Springer.
Important dates: Submission Due: March 1, 2013. Notification: April 25, 2013. Proceedings Version Due: May 14, 2013.
Information: `http://iml.univ-mrs.fr/ati/conferences/CAI2013/`.

4–6 **Loday Memorial Conference**, Institut de Recherche Mathématique Avancée (IRMA), Strasbourg, France. (May 2013, p. 654)
Description: Jean-Louis Loday, directeur de recherche CNRS in Strasbourg, suddenly passed away on June 6, 2012. This conference, in his memory, aims to give a general picture of the research that he passed down to the mathematical community, notably the study of the interplays between algebraic K-theory and cyclic homology, and the applications of the theory of algebraic operads.
Speakers: Pierre Cartier (IHES), Alain Connes (Collège de France), Pierre-Louis Curien (Université Paris 7), Vladimir Dotsenko (Trinity College Dublin), Alice Fialowski (Eötvös Loránd University), Hebert Gangl (Durham University), Grégory Ginot (Université Paris 6), Lars Hesselholt (Nagoya University), Mikhail Kapranov (Yale University), Teimuraz Pirashvili (Leicester University), Maria Ronco (Talca University), Christophe Soulé (IHES), Jean-Yves Thibon (Université Paris Est), Boris Tsygan (Northwestern University), Bruno Vallette (Université de Nice).
Information: `http://www-irma.u-strasbg.fr/article1351.html`.

* 4–6 **Semiclassical Origins of Density Functional Approximations**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: Density functional theory (DFT) has become an enormously successful tool for electronic structure calculations. Recent work has sought to re-examine the link between DFT, semiclassical approximations, and functional analysis. Numerical and heuristic results suggest a close (but subtle) underlying link. Understanding of these links, and using them to build new and more powerful approximations, could have tremendous impact in modern electronic structure calculations. The aim of this workshop is to reunite these disparate strands and begin a conversation among the different communities, including researchers from mathematics, physics, and theoretical chemistry. An application and registration form are available online.
Information: `http://www.ipam.ucla.edu/programs/dft2013/`.

* 6–12 **Conference on Integrability, Topological Obstructions to Integrability and Interplay with Geometry**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.
Description: The main goal of this workshop is to gather specialists in different aspects, dynamical aspects and connection with other areas like mathematical physics.
List of speakers: Alain Albouy (CNRS), Sergey Bolotin (UW-Madison), Alexey V. Borisov (Udmurt State Univ.), Vincent Colin (Univ.

de Nantes), Lucia Di Vizio (Univ. de Versailles-St. Quentin), Christian Duval (Centre National de la Recherche Scientifique Marseille, France), Rui Loja Fernandes (Univ of Illinois at Urbana-Champaign), Valerij Vasilievich Kozlov (Russian Academy of Sciences), Boris Kruglikov (Univ. of Tromso), Ivan Sergeevich Mamaev (Institute of Computer Science), Valentin Ovsienko (Univ. Claude Bernard-Lyon), Daniel Peralta (ICMAT), Jean-Pierre Ramis (Univ. Paul Sabatier), Tudor Ratiu (EPFL), Dmitry Treschev (Steklov Mathematical Institute) and Jacques-Arthur Weil (Univ. de Limoges).
Information: `http://www.crm.cat/2013/CIntegrability`.

8–14 **Combinatorial Methods in Topology and Algebra**, Il Palazzone, Cortona, Italy. (Feb. 2013, p. 264)
Description: CoMeTA is an opportunity of meeting and sharing ideas among emerging researchers, enhanced by the interaction with a small group of experts. We plan to organize talks, poster sessions, and thematic discussions. The proceedings of the conference will be published in the “Springer INdAM series”. We particularly welcome young researchers and female researchers.
Venue: “Il Palazzone” is a beautiful Renaissance palace, whose frescoed halls have hosted several important scientifical events. It is located in Cortona, one of the most well-preserved medieval cities in Tuscany, on a hilltop with free-ranging views of the surrounding contryside.
Organizers: Bruno Benedetti (KTH), Emanuele Delucchi (Bremen), Luca Moci (INdAM Fellow). Funding: INdAM (Istituto Nazionale di Alta Matematica).
Information: `http://www.cometa2013.org/`.

9–11 **Aachen Conference on Computational Engineering Science (AC.CES)**, AC.CES takes place at RWTH Aachen University (SuperC building), Germany. (May 2013, p. 654)
Description: AC.CES will bring together leading experts in theory, method development, and applications in computational engineering. The main objectives of the conference are to present cutting-edge research and to foster the growth of a stronger CES community, as well as to facilitate collaborations and cross-fertilization of ideas across the different CES disciplines. The conference consists of a series of plenary sessions featuring invited talks by leading experts; these will be accompanied by poster sessions. During the three days topics such as uncertainty quantification, inverse problems in materials science, computational biology, model order reduction, optimization and control, as well as imaging/tomographic inversion will be presented and discussed. The following invited speakers have confirmed their attendance at AC.CES: `http://www.ac-ces.rwth-aachen.de/MainContents/KeynoteLect.php`. If you have specific questions contact the organizers at `acces@aices.rwth-aachen.de`.
Information: `http://www.ac-ces.rwth-aachen.de/`.

9–11 **S.Co. 2013 - Complex Data Modeling and Computationally Intensive Statistical Methods for Estimation and Prediction**, Politecnico di Milano, Milano, Italy. (Apr. 2013, p. 515)
Description: The conference provides a forum for the discussion of new developments and applications of statistical models and computational methods for the analysis of complex and high dimensional data.
Information: `http://mox.polimi.it/sco2013/`.

* 9–11 **Seventh International Workshop Meshfree Methods for Partial Differential Equations**, Universität Bonn, Germany.
Organizers: Ivo Babuska (University of Texas, Austin, USA), Ted Belytschko (Northwestern University, USA), Jiun-Shyan Chen (University of California, USA), Michael Griebel (Universität Bonn, Germany), Wing Kam Liu (Northwestern University, USA), Marc Alexander Schweitzer (Universität Bonn, Germany), Harry Yserentant (Technische Universitaet Berlin, Germany).
Contact: `http://wissrech.ins.uni-bonn.de/meshfree`; email: `meshfree@ins.uni-bonn.de`.
Deadlines and Important Dates: Online Regisration Open: May 1, 2013. 2013 Abstract Submission: June 15, 2013. Notification of Acceptance: July 15, 2013.
Information: `http://wissrech.ins.uni-bonn.de/meshfree`.

* 9–13 **AIM Workshop: Definability and decidability problems in number theory**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to studying definability and decidability questions in number theory, more specifically over rational numbers and their algebraic extensions, as well as over rings of functions of natural interest.
Information: `http://aimath.org/ARCC/workshops/definabilityinnt.html`.

9–13 **European Conference on Combinatorics, Graph Theory and Applications - Eurocomb 2013**, National Research Council of Italy (CNR), Pisa, Italy. (Mar. 2013, p. 362)
Description: In the tradition of EuroComb’01 (Barcelona), Eurocomb’03 (Prague), EuroComb’05 (Berlin), Eurocomb’07 (Seville), Eurocomb’09 (Bordeaux), and Eurocomb’11 (Budapest), this conference will cover the full range of combinatorics and graph theory including applications in other areas of mathematics, computer science and engineering.
Topics: Include, but are not limited to: Algebraic combinatorics, combinatorial geometry, combinatorial number theory, combinatorial optimization, designs and configurations, enumerative combinatorics, extremal combinatorics, graph theory, ordered sets, random methods, topological combinatorics.
Information: `http://www.eurocomb2013.it/`.

9–13 **Introductory Workshop: Mathematical General Relativity**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)
Description: Mathematical relativity is a very widely ranging area of mathematical study, spanning differential geometry, elliptic and hyperbolic PDE, and dynamical systems. We introduce in this workshop some of the leading areas of current interest, with a special focus on those areas which are related to the geometry and physics of the initial data of general relativity, and those which primarily involve Riemannian geometry and elliptic PDE.
Information: `http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9552`.

* 9–14 **Advanced Course on Geometry and Dynamics of Integrable Systems**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.
Objectives: This advanced course aims at describing different aspects in the study of integrable systems from a geometrical, algebraic and dynamical point of view.
Organizing and scientific committee: Vladimir Matveev (Jena), Eva Miranda (UPC), Francisco Presas (ICMAT) and Iskander Taimanov (Novosibirsk).
Speakers at Minicourses: There are 4 sessions in each group. Alexey Bolsinov (Louborough), “singularities of bi-Hamiltonian systems and stability analysis”; Juan Jose Morales-Ruiz (UPM), “integrable systems and differential galois theory”; Nguyen Tien Zung (Toulouse), “geometry of integrable non-Hamiltonian systems”
Information: `http://www.crm.cat/2013/ACIntegrable-Systems`.

9–December 6 **ICERM Semester Program on “Low-Dimensional Topology, Geometry, and Dynamics”**, Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, Rhode Island. (Sept. 2012, p. 1176)
Description: The program focuses on the recent impact of computation and experiment on the study of the pure mathematics sides of topology, geometry, and dynamics. Specific areas include 3-dimensional topology, the study of locally symmetric spaces, low-dimensional dynamics, and geometric group theory. Included are

areas where computation has not yet had an impact, but might do so in the near future.
Information: http://icerm.brown.edu/sp-f13.

* 11–13 **BioDynamics 2013**, Bristol, United Kingdom.
Description: Rhythms in biological systems – the theme for our first in a series of annual international workshops designed to bring together biologists, mathematicians, clinicians, physicists, and computer scientists who are interested in dynamical systems in the biological and medical sciences. These workshops will provide a unique forum for multidisciplinary interactions, which we hope will lead to rewarding collaborations between theoretical, experimental, and clinical scientists.
Confirmed keynote speakers: Professor Russell Foster, University of Oxford, UK; Dr. Michael Hastings, MRC Laboratory of Molecular Biology, Cambridge, UK; Professor David Hazlerigg, University of Aberdeen, UK; Professor Allan Herbison, University of Otago Centre for Neuroendocrinology, New Zealand; Professor Kevin O'Byrne, King's College, London, UK; Professor David Rand, University of Warwick, UK; Professor James Sneyd, University of Auckland, New Zealand.
Information: http://www.bio-dynamics2013.org.

11–13 **14th IMA Conference on Mathematics of Surfaces**, University of Birmingham, United Kingdom. (Sept. 2012, p. 1176)
Description: Computer-based methods for the capture, construction, representation, fitting, interrogation and manipulation of complicated surfaces have led to a wide interest in, and need for, the mathematics of surfaces and related curves. Many applications require the use of surface descriptions, especially in such fields as computer aided design and manufacturing, computer graphics and computer vision. The description of surfaces is also of interest in geographic information systems, multimedia, and many other areas of science and medicine. This diversity and the wide range of applicability of the subject have already enabled the IMA to hold thirteen very successful international conferences in the Mathematics of Surfaces series. Several international authorities are being invited to present papers. The Institute of Mathematics and its Applications is a not-for-profit organisation registered as a charity in the UK.
Information: http://www.ima.org.uk/conferences/conferences_calendar/14th_mathematics_of_surfaces.cfm

11–14 **The Sixth International Workshop on Differential Equations and Applications**, Izmir University of Economics, Izmir, Turkey. (Apr. 2013, p. 515)
Description: The scope of the conference is to bring together members of the mathematical community whose interest lies in applied mathematics to assess new developments, ideas and methods. The conference will cover a wide range of topics of differential equations, difference equations, dynamic equations and stochastic differential equations.
Information: http://dm.ieu.edu.tr/wdea2013.

12–14 **The Algerian-Turkish International Days on Mathematics 2013**, Fatih University, Istanbul, Turkey. (May 2013, p. 654)
Description: The aim of this conference is to provide a platform for scientific expertise in mathematics to present their recent works, exchange ideas and to bring together mathematicians to improve collaboration between local and international participants.
Information: http://atim.fatih.edu.tr/.

15–20 **ICERM Workshop: Exotic Geometric Structures**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 116)
Description: This workshop will focus on recent advances in the study of geometric structures and their associated group representations. As well as featuring hyperbolic structures, the workshop will also consider more exotic structures, such as projective structures, complex hyperbolic and spherical CR-structures and locally homogeneous space-times. A related focus includes aspects of coarse or non-positively curved geometry such as Gromov hyperbolic spaces and CAT(0) complexes. We will explore the interaction between experimental evidence and rigorous proof.
Information: http://icerm.brown.edu/sp-f13-w1.

16–20 **Mathematics for an Evolving Biodiversity**, Centre de Recherches Mathématiques, Montréal, Canada. (Dec. 2012, p. 1596)
Description: This workshop will provide an overview of recent theoretical and methodological developments for modeling the complex evolutionary dynamics that have shaped the structure of contemporary biodiversity. Theoretical work at the interface between ecology and evolutionary studies will be presented, as well as its applications to empirical data.
Support: Financial support is available.
Information: http://www.crm.math.ca/Biodiversity2013/.

16–20 **MatTriad'2013 - Conference on Matrix Aanalysis and its Applications**, Herceg-Novi, Montenegro. (Dec. 2012, p. 1596)
Description: The aim is to bring together researchers sharing an interest in a variety of aspects of matrix analysis and its applications in other fields of mathematics and offer them a possibility to discuss current developments in these subjects.
Information: http://mattriad2013.pmf.uns.ac.rs.

16–October 11 **Mathematics and Physics of the Holographic Principle**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Dec. 2012, p. 1596)
Description: Holographic duality relates a string theory to a quantum field theory without gravity. Currently it is an area of research located at the confluence of previously seemingly distant fields in physics and mathematics including superconductivity and other exotic phases of strongly coupled quantum matter, string theory, numerical general relativity and the theory of non-linear partial differential equations. The main aim of the programme is to tackle questions which the traditional methods within each discipline have proved inadequate to address, with special emphasis on strongly correlated condensed matter systems and non-equilibrium dynamics. Preliminary progress includes the application of the duality to concrete experimental questions about the quark-gluon plasma and the emergence of various fascinating condensed matter phenomena from the physics of AdS black holes. A number of workshops will take place during the programme. For full details see: http://www.newton.ac.uk/programmes/HOL/ws.html.
Information: http://www.newton.ac.uk/programmes/HOL/.

* 19–22 **Conference on Applied and Industrial Mathematics - CAIM 2013**, Faculty of Mathematics and Computer Science, University of Bucharest, Romania.
Description: Caim 2013 provides a forum for the review of the recent trends in applied mathematics: mathematical modeling, studies of models coming from industry, biology, economy, etc., either from a qualitative or from a numerical point of view. Since theoretical studies find sooner or later their applicability, the conference has also sections for more theoretical branches of mathematics like algebra or geometry. Computer science communications are welcome.
Information: http://www.romai.ro/conferintele_romai/caim2013_en.html.

21–23 **The First International Conference on New Horizons in Basic and Applied Science Session "Aspects of Mathematics and its Applications"**, Hurghada, Egypt. (May 2013, p. 654)
Description: The first international conference "New horizons in basic and applied science" (ICNHBAS) provides a unique opportunity for scientists, scholars, engineers and students from the universities, technologists, entrepreneurs and policy makers all around the world to present current researches being carried out in basic and applied science area. The conference promotes for the delegates

to exchange new ideas and application experiences face to face, to establish business or research relations and to find global partners for future collaboration. The conference will also have numerous invited talks from distinguished scientists from all over the world, to interact with the experts in their fields and to foster interdisciplinary collaborations required to meet the challenges of modern science, technology and society. All the papers that are submitted to the conference will undergo a review process for either oral or poster presentation.
Information: http://www.nhbas2013.com.

21–27 **"Wavelets and Related Multiscale Methods" within ICNAAM2013: 11th International Conference of Numerical Analysis & Applied Mathematics**, Rodos Palace Hotel, Rhodes, Greece. (Apr. 2013, p. 515)
Aim: To bring together specialists in both theory and application of multiscale harmonic analysis.
Topics: The topics include but are not restricted to: Wavelet bases and frames (construction, properties, etc.), applications of wavelet and other multiscale decompositions to computational problems, modeling multiscale (fractal) structures and anomalous (multiscale self-similar) kinetics, mathematical modeling and analysis biophysical (e.g., in acoustics, oscillating chemical reactions, neuroscience, etc.) signals with non-stationary multifrequent periodicity. Thus, presentations of researchers developing mathematical basics of multiscale analysis as well as those who apply these methods for practical computational applications are welcomed.
Information: http://www.icnaam.org/sessions_minisymposia.htm.

* 22–26 **18th Annual cum 3rd International Conference of Gwalior Academy of Mathematical Sciences (GAMS)**, Department of Mathematics Maulana Azad National Institute of Technology, Bhopal, India 462051.
Description: The academic program of the conference will consist of keynote, plenary and invited talks, and paper presentations in mathematical biology, statistics, air pollution, differential equations, special functions and other allied topics.
Theme: Mathematical, Computational and Integrative Sciences.
Call for Papers: Original research papers on recent developments in Mathematical and Computational Sciences are invited for presentation in the conference. Intended participants are invited to send the abstracts (not exceeding 250 words) on or before May 31, 2013. After receiving the acceptance the authors will have to submit full-length papers no later than June 30, 2013. The author will have to follow "Instructions to Authors" as given in the website http://www.gamsinfo.com for the GAMS Journal. All abstracts should be submitted online to the Organizing Secretary.
Important dates: Deadline for Submission of Abstract: May 31, 2013. Notification of Acceptance: June 15, 2013. Early bird Registration: June 15, 2013. Full length Paper Submission: June 30, 2013.
Information: http://www.gamsinfo.com and http://www.manit.ac.in.

23–27 **Mathematics of Sequence Evolution: Biological Models and Applications**, Centre de Recherches Mathématiques, Montréal, Canada. (Dec. 2012, p. 1596)
Description: Models of evolution of biological sequences have gone a long way since Jukes and Cantor. First, it is no longer acceptable to consider that mutations of a given type occur independently and uniformly across time and space. A large number of factors affect the rate at which mutations occur. Second, selective pressure makes that the probability of fixation of a mutation depends on the fitness of the mutated individual, which sometimes places unexpected constraints on the mutational process and induces strong dependencies between positions along the sequences.
Support: Financial support is available.
Information: http://www.crm.math.ca/Biodiversity2013/.

* 23–27 **Solar Cells**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: This is the first workshop in the long program "Materials for a Sustainable Energy Future." The workshop will include a poster session; a request for posters will be sent to registered participants in advance of the workshop.
Organizing committee: Claudia Draxl (Humboldt-Universitt), Jeff Neaton (Lawrence Berkeley Laboratory), and Keith Promislow (Michigan State University, Mathematics).
Registration: An application and a registration form is available online.
Application deadline: July 29, 2013.
Information: http://www.ipam.ucla.edu/programs/msews1/.

* 23–28 **International conference "Complex Analysis and Related Topics"**, Lviv Ivan Franko National University, Lviv, Ukraine.
Description: The following topics will be presented on the conference: - complex analysis of one variable; - complex analysis of several variables; - complex approximation.
Information: http://analysis13.mathlviv.org.ua.

* 27–28 **The twelfth annual Prairie Analysis Seminar**, Kansas State University, Manhattan, Kansas.
Description: The conference features Gui-Qiang Chen, University of Oxford, who will give two one-hour talks, and Mikhail Feldman, University of Wisconsin, Augusto Ponce, Université Catholique de Louvain, and Mónica Torres, Purdue University, who will each give a one-hour talk. There is time scheduled for contributed talks; all participants, especially mathematicians early in their careers, are encouraged to contribute a 20-minute talk. The conference is supported by the NSF and funding is available with priority given to students, postdocs and those early in their careers.
Organizers: Marianne Korten, Charles Moore, Kansas State University; Estela Gavosto, Rodolfo Torres, University of Kansas
Information: http://www.math.ksu.edu/pas/2013/PrairieAnalysisSeminar/2013.html.

28–29 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Mathematical Modeling of Indigenous Population Health**, BIRS, Banff, Canada. (Sept. 2012, p. 1176)
Description: In Canada, the 2009 influenza H1N1 pandemic disproportionately affected Indigenous populations with severe disease outcomes often necessitating hospitalization and intensive care unit admission. The maintenance of surge capacity for the healthcare was seriously challenged in many several geographic areas, including northern remote communities and First Nation reserves. The reasons for this disproportionate impact are not well understood, but important factors may include the prevalence of pre-disposing health conditions, limited access to healthcare, and environmental and demographic characteristics including the transportation network. Same factors apply to other diseases and hence the inequity issues arise from many other diseases and settings.
Information: http://www.crm.umontreal.ca/act/theme/theme_2013_1_en/indigenous_population13_e.php.

* 30–October 3 **57th Annual Meeting of the Australian Mathematical Society**, The University of Sydney, Sydney, Australia.
Description: This is the largest annual event in Australian mathematics. The meeting features plenary talks and special sessions on a wide range of topics. Special events include public lectures and an education afternoon.
Information: http://www.maths.usyd.edu.au/u/austms2013/.

October 2013

5–6 **2013 Fall Southeastern Section Meeting**, University of Louisville, Louisville, Kentucky. (Sept. 2012, p. 1176)

Information: `http://www.ams.org/meetings/sectional/sectional.html`.

7–11 **Coalescent Theory: New Developments and Applications**, Centre de Recherches Mathématiques, Montréal, Canada. (Dec. 2012, p. 1596)
Description: Coalescent theory is one of the most elegant and powerful probabilistic approaches in mathematical population genetics. It formalizes the backward perspective on evolution in large finite populations by considering a population evolving forward in time under the effects of various factors, conditional on genetic data observed in the current generation, providing a link between evolutionary models and empirical data.
Support: Financial support is available.
Information: `http://www.crm.math.ca/Biodiversity2013/`.

* 7–11 **Differential Geometry and Global Analysis**, Leipzig University, Department of Mathematics, Leipzig, Germany.
Description: International conference, topics include (Pseudo-) Riemannian and conformal geometry, geometry of metric spaces, geometry of differential operators, geometric variational problems, Hamiltonian systems, symplectic geometry and topology.
Information: `http://www.math.uni-leipzig.de/~rademacher/dgga13.html`.

10–12 **International Conference on Statistical Distributions and Applications**, Mt. Pleasant, Michigan. (Mar. 2013, p. 362)
Description: This international conference is being organized to provide a platform for researchers and practitioners to share and discuss recent advancements on distribution theory and applications, and to provide opportunities for collaborative work. The scope includes, but not limited to (1) new methodology for generating discrete and continuous (univariate and multivariate) distributions, (2) properties, estimation techniques, and goodness of fit tests on generalized distributions from both frequentist and Bayesian perspectives, (3) Bayesian priors using generalized distributions, (4) statistical modeling using generalized distributions, and (5) applications of generalized distributions in disciplines including biosciences, medical sciences, finance, insurance, and engineering.
Information: `http://people.cst.cmich.edu/lee1c/icosda/`.

* 11–13 **International Symposium on Biomathematics and Ecology: Education and Research**, Marymount University, Arlington, Virginia.
Description: This is the sixth annual meeting which traditionally covers a wide spectrum of topics in biomathematics, biology, exology, biostatistics focused on both education and research.
Information: `http://www.biomath.ilstu.edu/beer`.

12–13 **2013 Eastern Sectional Meeting**, Temple University, Philadelphia, Pennsylvania. (Sept. 2012, p. 1176)
Information: `http://www.ams.org/meetings/sectional/sectional.html`.

* 12–13 **Fifth Dr. George Bachman Memorial Conference**, Manhattan Campus of St. John's University, New York, New York.
Description: The conference invites articles from all disciplines, and welcomes the participation of graduate students.
Deadline: Abstracts should be submitted by September 5, 2013 to the organizers: Dr. Edward Beckenstein (`drbeckense@aol.com`), and Dr. Charles Traina (`trainac@stjohns.edu`).

14–18 **Fluid Mechanics, Hamiltonian Dynamics, and Numerical Aspects of Optimal Transportation**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1176)
Description: The workshop will be devoted to emerging approaches to fluid mechanical, geophysical and kinetic theoretical flows based on optimal transportation. It will also explore numerical approaches to optimal transportation problems.
Information: `http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9227`.

* 14–18 **Fuels from Sunlight**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: This workshop seeks to enhance the quality of research on chemical energy conversion and open new directions. We invite colleagues from materials science, physics, chemistry, chemical engineering, applied mathematics and statistics, and computer science.
Organizing Committee: Rupert Klein (Freie Universitt Berlin), Jens Norskov (Stanford University), and Matthias Scheffler (Fritz-Haber-Institut der Max-Planck-Gesellschaft).
Registration: An application and a registration form are available online.
Application deadline: August 19, 2013.
Information: `http://www.ipam.ucla.edu/programs/msews2/`.

* 14–18 **Topological and Combinatorial Problems in One-dimensional Complex Dynamics**, Centro di Ricerca Matematica "Ennio De Giorgi", Piazza dei Cavalieri 3, Pisa, Italy.
Description: One dimensional complex dynamics involves the usage of many different tools taken from other areas of mathematics. We would like to focus on the interaction of holomorphic dynamics with topology on one side, and with combinatorics on the other side. The goal of this workshop is to investigate these two themes from the threefold view-point of local dynamics, dynamics of transcendental maps, and dynamics of rational maps, emphasizing the similarities between these problems in the three settings. This will outline a fairly complete summary of the current topological and combinatorial methods available in the three areas, with the hope of suggesting new applications. Emphasis will be on open problems and interrelations between the two major themes of the workshop. A side goal is to encourage the participation of graduate students and recent Ph.D.'s in the field.
Registration: On-line registration required. No attendance fee. Support for selected young participants available.
Deadline: Application: June 23, 2013.
Information: `http://www.crm.sns.it/event/271/`.

15–19 **VII Moscow International Conference on Operations Research (ORM2013)**, Dorodnicyn Computing Center of RAS (CC of RAS) and Lomonosov Moscow State University (MSU), Moscow, Russian Federation. (Jan. 2013, p. 117)
Description: The conference will bring together scientists from all over the world to discuss theoretical aspects and various applications of operations research.
Language: Working language of the conference is English. Some sections might be in Russian.
Information: `http://io.cs.msu.su/`.

18–20 **2013 Fall Central Section Meeting**, Washington University, St. Louis, Missouri. (Sept. 2012, p. 1176)
Information: `http://www.ams.org/meetings/sectional/sectional.html`.

* 19–20 **The 23rd annual Route 81 Conference on Commutative Algebra and Algebraic Geometry**, Syracuse University, Syracuse, New York.
Description: The Route 81 Conference on Commutative Algebra and Algebraic Geometry rotates between the campuses of Cornell University (Ithaca), Queen's University (Kingston), and Syracuse University (Syracuse), along the Route 81 corridor in New York State. This year's conference will feature 6-10 talks of approximately one hour. Persons interested in giving a talk are invited to submit a title and abstract to one of the organizers. There is no formal registration process, but it would be helpful if you would let the organizers know if you plan to attend.
Information: `http://www.commalg.org/Rte81-2013/`.

21–25 **ICERM Workshop: Topology, Geometry and Group Theory, Informed by Experiment**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 117)

Description: The mathematical focus of this workshop will include all aspects of the topology and geometry of low-dimensional manifolds and geometric group theory. It has been understood for over a century that these subjects are tightly connected, but the connections have become even deeper as the subjects have matured. Recent advances have given dramatic evidence of this. The workshop aims to further extend the interplay between these subjects.
Information: `http://icerm.brown.edu/sp-f13-w2`.

21–25 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Sustainability of Aquatic Ecosystem Networks**, AARMS, Fredericton, New Brunswick, Canada. (Sept. 2012, p. 1176)
Description: The Canadian landscape is dotted with thousands of lakes, mighty rivers and uncountable streams run through it, and three oceans border it. For many decades, Canadians have taken clean and available water for granted: for transport and hydropower, for consumption and recreation. But the impact of human activities is clearly visible: many rivers are polluted and their flow regime altered; algal blooms destroy lake ecosystems; invasive species threaten native species assemblages, oceans are overfished. Many initiatives are under way to understand and manage aquatic ecosystems in a sustainable way.
Information: `http://www.crm.umontreal.ca/act/theme/theme_2013_1_en/ecosystem_network13_e.php`

21–December 20 **Mathematics for the Fluid Earth**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Dec. 2012, p. 1597)
Description: The fluid Earth is an excellent example of a forced, dissipative non-equilibrium system dominated by nonlinear processes and featuring multi-scale interactions, so that its understanding can be approached using the tools of dynamical systems theory and non-equilibrium statistical mechanics. The purpose of this programme is to bring together scientists from very different perspectives in models of the dynamics of the fluid components of the Earth system.
Aim: This programme aims to prove that there is a close connection between "core" questions and problems of pure and applied mathematics and "core" questions of geophysical fluid dynamics relevant for the investigation of the climate system and of its component.'
Themes: The programme features three main macro-themes of interest: a) Dynamical Systems and Statistical Mechanics; b) Extreme Events; c) Partial Differential Equations. Each theme has a huge potential for future breakthroughs at the boundary between mathematics and natural science.
Information: `http://www.newton.ac.uk/programmes/MFE/`.

23–25 **International Conference in Modeling Health Advances ICMHA 2013**, Berkeley, California. (Mar. 2013, p. 363)
Description: Modeling is important because it gives important insight into the method of treatment. The conference ICMHA'13 is held under the World Congress on Engineering and Computer Science, WCECS 2013.
Organizer: The WCECS 2013 is organized by the International Association of Engineers (IAENG), a non-profit international association for the engineers and the computer scientists.
Information: `http://www.jaeng.org/WCECS2013`.

24 **3rd IMA Mathematics in Defence**, QinetiQ, Malvern, United Kingdom. (May 2013, p. 654)
Description: This conference brings together a wide variety of mathematical methods with defence and security applications. The conference programme will include keynote speakers, contributed presentations and poster sessions as well as refreshment breaks for informal discussions. It is intended for mathematicians, scientists and engineers from industry and academia, as well as government and military personnel who have an interest in how mathematics can be applied to defence problems.
Information: `http://www.ima.org.uk/conferences/conferences_calendar/3rd_mathematics_in_defence.cfm`.

28–31 **Groups, Group Rings, and Related Topics GGRRT 2013**, United Arab Emirates University, Al Ain, United Arab Emirates. (May 2013, p. 654)
Description: The conference will include talks given by well-known invited algebraists and a poster session. In parallel, a workshop on GAP (Groups, Algorithms, and Programming) System for Computational Discrete Algebra will be given by the GAP Development Group of St. Andrews University (UK). Conference proceedings will be electronically edited by the scientific committee. In addition, selected peer-reviewed papers will be published in a special edition of the *International Journal of Group Theory*. The social activities will include a short trip to Jebel Hafeet, a conference dinner, and a trip to Dubai ending with a dinner on a boat cruising along Dubai Creek.
Registration and abstract submission: Must be before September 15th, 2013. A discount will be given for early registration (before June 15th, 2013).
Information: `http://www.cos.uaeu.ac.ae/department/mathematical/conferences/GGRRT_2013/`.

28–November 9 **Lévy Processes and Self-similarity 2013**, Tunis, Tunisia. (Feb. 2013, p. 264)
Description: A CIMPA school will be coupled with a conference under the name "Lévy Processes and Self-similarity 2013". The conference is a follow up to those organized in Clermont-Ferrand (2002), Toulouse (2005), Angers (2009) and Le Touquet-Paris-Plage (2011).
Organizers: Lévy and self-similar processes will be studied under many aspects through a series of 5 lectures: Philippe Biane, Free probability and free Lévy processes; Loïc Chaumont, An introduction to self-similar processes; Sonia Fourati, Complex analysis and exit problem for Lévy processes; Jean Jacod, Lévy Processes and statistics; René Schilling, Probabilistic and analytic aspects of subordination. The conference Lévy Processes and Self-similarity will be held during the second week.
Information: `http://levy-autosimilarity-tunis2013.math.cnrs.fr/index.html`.

November 2013

2–3 **2013 Western Fall Section Meeting**, University of California Riverside, Riverside, California. (Sept. 2012, p. 1176)
Information: `http://www.ams.org/meetings/sectional/sectional.html`.

* 4–8 **Batteries and Fuel Cells**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: An energy economy fueled by renewable resources will require significant improvement in existing materials for energy conversion and storage. It is the goal of this workshop to bring together mathematicians, physicists, computer scientists, materials scientists and engineers who work in the area of batteries and fuel cells to spark collaborations across disciplines and seed new interdisciplinary research directions. This workshop will include a poster session; a request for posters will be sent to registered participants in advance of the workshop. An application and registration form are available online.
Application deadline: September 9, 2013.
Information: `http://www.ipam.ucla.edu/programs/msews3/`.

4–8 **Biodiversity and Environment: Viability and Dynamic Games Perspectives**, Centre de Recherches Mathématiques, Montréal, Canada. (Dec. 2012, p. 1596)
Description: Although alarming news is accumulating by the day on the impact of human activities on biodiversity, ecosystems and climate change, the response by the international community has not yet been up to the faced challenges. The pursuit of self-interest

has often been pointed out as a major obstacle to reach the much-needed global or regional agreements to tackle these problems. Another difficulty in dealing with these issues is that they are of the long-term variety and involve a high degree of uncertainty.
Support: Financial support is available.
Information: `http://www.crm.math.ca/Biodiversity2013/`.

09–16 (NEW DATE) **International Conference on Fractals and Wavelets**, Rajagiri School of Engineering & Technology Kakkanad Cochin, Kerala, India. (Feb. 2013, p. 264)
Conference focus on following areas: Fractals, self similarity, holomorphic dynamics, wavelets, image processing, signal processing.
Information: `http://rajagiritech.ac.in`.

10–15 **Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Current Challenges for Mathematical Modelling of Cyclic Populations**, BIRS, Banff, Canada. (Sept. 2012, p. 1176)
Description: We propose to bring together ecologists and mathematicians with expertise in cyclic populations to discuss recent advances in our theoretical understanding of the causes and implications of population cycles from both the ecological and mathematical points of view.
Information: `http://www.birs.ca/events/2013/5-day-workshops/13w5151`.

11–14 **SIAM Conference on Geometric and Physical Modeling (GD/SPM13)**, The Curtis, A DoubleTree by Hilton Hotel, Denver, Colorado. (May 2013, p. 654)
Description: This conference is sponsored by the SIAM Activity Group on Geometric Design, incorporating the 2013 SIAM Conference on Geometric Design and the 2013 Symposium on Solid and Physical Modeling.
Information: `http://www.siam.org/meetings/gdspm13/`.

11–15 **Mal'tsev Meeting 13**, Sobolev Institute of Mathematics SB RAS, Novosibirsk, Russia. (May 2013, p. 654)
Description: Mal'tsev Meeting is an annual conference on algebra, mathematical logic, and their applications. In 2013, the event is dedicated to an anniversary of Professor Larisa L. Maksimova.
Topics: Include nonclassical logics, computability, theories of groups, rings, and other classical algebras, model theory and universal algebra, applications in computer science, and other related areas of mathematics.
Information: `http://www.math.nsc.ru/conference/malmeet/13/index.html`.

12–14 **2013 IEEE International Conference on Technologies for Homeland Security (IEEE HST.13)**, The Westin, Waltham, Boston, 70 Third Avenue, Waltham, Massachusetts 02451. (Apr. 2013, p. 515)
Description: The meeting will bring together innovators from leading academic, industry, business, homeland security centers of excellence, and government programs to provide a forum to discuss ideas, concepts, and experimental results. Produced by IEEE with technical support from DHS S&T, IEEE Boston Section, and IEEE-USA and organizational support from MIT Lincoln Laboratory, Raytheon, Battelle, and MITRE, this year's event will once again showcase selected technical paper and posters highlighting emerging technologies in the areas of cyber security, attack and disaster preparation, recovery, and response, land and maritime border security and biometrics & forensics.
Information: `http://ieee-hst.org`.

12–14 **The Second International Conference on Informatics Engineering & Information Science (ICIEIS2013)**, University Technology Malaysia (UTM), Kuala Lumpur, Malaysia. (Dec. 2012, p. 1597)
Description: Researchers are encouraged to submit their work electronically. All papers will be fully refereed by a minimum of two specialized referees. Before final acceptance, all referees comments must be considered.
Important dates: Submission Deadline: August 1, 2013. Notification of Acceptance: August 20, 2013. Camera Ready Submission: August 30, 2013. Registration: September 2, 2013.
Information: `http://sdiwc.net/conferences/2013/icieis2013/`.

* 13–15 **School on Quantum Ergodicity and Harmonic Analysis (Part III)**, Philipps University, Marburg, Germany.
Description: This school is aimed at doctoral students and also welcomes more experienced researchers. Its third part will consist of four lecture series: N. Anantharaman: Entropy and the localization of eigenfunctions; J. Hilgert: Introduction to quantum ergodicity and related topics; S. Nonnenmacher: Resonances in chaotic scattering: a semiclassical gap in terms of topological pressure; R. Schubert: On the rate of quantum ergodicity. This activity is a continuation of events held in Göttingen in January 2013 and in Marburg in September 2012. It can be attended without earlier participation.
Support: Finanical support can be provided.
Information: `http://www.uni-math.gwdg.de/QEMarburg2013`.

* 15 (NEW DATE) **Information, Instability and Fragility in Networks: Methods and Applications**, University of Colorado, Boulder, Colorado.
Description: The recent financial crisis raised the specter of cascading disruptions across financial institutions, due to their growing interconnectedness and the speed at which disruptions may propagate across them. Quantitative "Connectionist" research in the physical sciences, engineering and information theory has modeled analogous phenomena, using techniques that are less familiar to economists, financial researchers and regulators and social scientists in general. This conference will bring the seemingly disparate researchers together, in order to share ideas and jump start future collaborations. Early researchers coped with the limited micro-level data about large networks by adopting information-theoretic estimation techniques (e.g., the maximum entropy method). The conference is especially interested in papers employing information-theoretic, Bayesian techniques for additional purposes.
Information: `http://www.american.edu/cas/economics/info-metrics/workshop/conference-2013-fall.cfm`.

* 18–22 **Energy Conservation and Waste Heat Recovery**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: A most effective, though still underestimated, issue in dealing with the energy requirements of modern societies concerns the conservation of energy. It is the goal of this workshop to bring together mathematicians, physicists, computer scientists, materials scientists and engineers who work in the area of energy conservation and waste heat recovery. An application and registration form is available online.
Organizing Committee: Giulia Galli (University of California, Davis), Richard James (University of Minnesota, Twin Cities), Jennifer Lukes (University of Pennsylvania), and Matthias Scheffler (Fritz-Haber-Institut der Max-Planck-Gesellschaft).
Information: `http://www.ipam.ucla.edu/programs/msews4/`.

18–22 **Evolution Problems in General Relativity**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1176)
Description: With cosmic censorship, the formation of black holes, and the stability of Kerr black holes as focus problems, the study of the evolution of solutions of Einstein's equations has made dramatic progress in recent years. In this workshop, we highlight some of this recent development, and examine the major areas in which future progress is likely.
Information: `http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9554`.

18–22 **ICERM Workshop: Geometric Structures in Low-Dimensional Dynamics**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 117)

Description: This workshop will present topics in low-dimensional dynamics such as billiards, flows on flat surfaces, dynamics on moduli spaces, and piecewise isometric maps. One theme in the workshop will be the appearance of geometric structures such as hyperbolic space and Teichmüller space in connection with dynamical systems which are basically defined in terms of the Euclidean plane. Computer experiments are common in these areas, and will be discussed, but the emphasis will be on the mathematics that comes out of the experiments.

Information: `http://icerm.brown.edu/sp-f13-w3`.

19–21 **Gulf International Conference on Applied Mathematics (GICAM13)**, Mubarak Al-Abdullah Al-Jaber Area, Kuwait. (Feb. 2013, p. 264)

Description: This is a conference on applied mathematics organized and hosted by the Department of Mathematics & Natural Sciences at the Gulf University for Science & Technology. The objective is to bring together applied mathematicians and other researchers using mathematics as a problem solving tool. Some of the major areas of interest are mathematical biology, fluid mechanics, mathematics of finance & economics, numerical analysis and computational science.

Information: `http://conferences.gust.edu.kw`.

* 24–29 **II International Conference on Applied Mathematics and Informatics - ICAMI 2013**, San Andres Island, Colombia.

Description: This conference is organized every three years (starting from 2010) in the region of Latin America and the Caribbean as an official event of the REALMA Network (Réseau Europa–Amérique Latine en Maths Appliques, `http://www.realma.org/`) and targets to involve local researchers who have fewer opportunities to attend similar conferences held in Europe and USA.

Main streams: Applied analysis and geometry; applied probability, statistics, and stochastic processes; continuous and discrete dynamic systems; game theory and other economics applications; mathematical epidemiology and biosciences; mathematical geosciences; numerical methods and software tools; operations research, optimization methods and applications; partial differential equations and applications; robotics and mechanical engineering; uncertainty quantification (UQ) and visualization in scientific computing.

Deadline: For abstract submission: June 20, 2013.

Information: `http://matematicas.univalle.edu.co/icami/2013/`.

* 24–29 **Multi-scale and Multi-field Representations of Condensed Matter Behavior**, Centro di Ricerca Matematica "Ennio De Giorgi", Piazza dei Cavalieri 3, Pisa, Italy.

Description: The School will introduce and discuss recent trends in the theoretical and computational approaches for the modelling of condensed matter. There will be special emphasis on describing the various ways events at finer scales in both space and time affect the macroscopic behaviour of matter at the macroscopic scales. Topics in continuum mechanics, theory of PDEs, stochastic calculus, and scientific computing will be addressed. The School will be a unique interdisciplinary opportunity to foster interactions among scholars coming from different scientific environments. The list of lecturers is available on the website.

Registration: Is free but participants are requested to register on the website. Some funds will be made available to offer financial support to a number of selected young researchers and students for their participation in the School. Applications can be made online through the website.

Deadlines: For applications for financial support: October 31, 2013. Registration: November 18, 2013.

Information: `http://www.crm.sns.it/event/280/`.

26–28 **International Conference on Pure and Applied Mathematics, ICPAM-LAE 2013**, Png University of Technology, Lae, Morobe Province, Papua New Guinea. (Sept. 2012, p. 1176)

Description: The objective of the ICPAM-LAE, 2013 is to bring together international team of mathematicians that will contribute to the development of Pure and Applied Mathematics in Papua New Guinea. The conference aims at bringing together experts, who are already practicing in different fields of pure and applied mathematics, as well as researchers, undergraduates and postgraduate students from around the globe to discuss mathematical questions, exchange high level knowledge of methods and investigate diverse applications of Pure and Applied Mathematics to domains such as astronomy, biology, education, engineering, geosciences, security, health care, medicine etc. Academia and industries are invited to participate. Mathematics Educationists are also welcome.

Information: Please contact: `journal@cms.unitech.ac.pg`; `http://www.unitech.ac.pg/`.

December 2013

* 7–8 **Infinite-Dimensional Geometry**, University of California, Berkeley (740 Evans Hall), California.

Description: The purpose of this workshop is to gather researchers working in various areas of geometry in infinite dimensions in order to facilitate collaborations and sharing of ideas.

Topics: Represented include optimal transport and geometries on densities, metrics on shape spaces, Euler-Arnold equations on diffeomorphism groups, the universal Teichmuller space, geometry of random Riemann surfaces, metrics on spaces of metrics, and related areas.

Funded: By an NSF grant.

Information: `http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm10168.`

7–11 **"ATCM+TIME 2013": A joint session of 18th Asian Technology Conference in Mathematics and 6th Technology & Innovations in Mathematics Education**, Department of Mathematics, Indian Institute of Technology, Powai, Mumbai 400076, India. (Mar. 2013, p. 363)

Description: The ATCM conferences are international conference addressing technology-based issues in all Mathematical Sciences. The 17th ATCM December 16–20, 2012, was held at SSR University, Bangkok, Thailand. About 400 participants coming from over 30 countries around the world participated in the conference. The TIME conferences are national (Indian) conferences held every two years. TIME conferences serve a dual role: as a forum in which mathematics educators and teachers will come together to discuss and to probe major issues associated with the integration of technology in mathematics teaching and learning, and as a place where they can share their perspectives, personal experiences, and innovative teaching practices.

Information: `http://atcm.mathandtech.org` and `http://www.math.iitb.ac.in/TIME2013`.

* 16–18 **International Conference on Role of Statistics in the Advancement of Science and Technology**, Department of Statistics, University of Pune, Pune, Maharashtra, India.

Description: The Department of Statistics, University of Pune is organizing "Diamond Jubilee Year & International Year of Statistics Conference" to commemorate 60 years of establishment.

Aim: To explore the role of statistics in the advancement of science and technology.

Topics: Statistical inference, inference in stochastic processes, statistical computing, biostatistics, reliability, survival analysis, industrial statistics, actuarial, financial statistics, data mining, probability theory, decision theory, design of experiments, distribution theory, econometrics, multivariate analysis, neural networks, nonparametric inference, operations research, queuing theory, simulation methods,

statistical genetics, statistical quality control, survey sampling, time series analysis, etc.
Information: http://stats.unipune.ac.in/Conf13.html.

* 16–19 **International Conference on Advances in Applied Mathematics**, Hammamet, Tunisia.
Description: The Tunisian Association of Applied Mathematics and Industrial organizes its first conference in Applied Mathematics "ICAAM 2023". The purpose of this conference is to highlight some of the major theoretical advances and applications in the fields of: Spectral theory, operator theory, optimization, numerical analysis, partial differential equations, ordinary differential equations, control theory, dynamical systems, nonlinear systems and matrix, probability and statistics.
Information: http://sites.google.com/site/icaam2013/.

16–20 **Fundamental Groups in Arithmetic and Algebraic Geometry**, Centro di Ricerca Matematica Ennio De Giorgi, Pisa, Italy. (Mar. 2013, p. 363)
Description: The study of fundamental groups of algebraic varieties has been an important theme in algebraic geometry for a long time. With the introduction of purely algebraic-geometric variants, due to Grothendieck, Deligne, Nori and others, it has become crucial in arithmetic geometry, revealing deep connections with Galois theory and algebraic number theory.
Purpose: Of this conference is to present a wide range of recent relevant advances, in complex geometry, algebraic geometry in positive characteristic and in arithmetic geometry. We aim at gathering experts in different aspects of this vast subject, thus painting a multifaceted yet unified picture of it.
Information: http://www.crm.sns.it/event/281/.

* 16–20 **The XXIVth Edition of the International Workshop on Operator Theory and its Applications (IWOTA)**, Indian Institute of Sciences, Bangalore, India.
Description: As usual there will be special sessions at IWOTA 2013. Proposals should be submitted to iwota2013@gmail.com and should contain a brief description of the session and a preliminary list of speakers and tentative lecture titles. We plan to have at least eight special sessions and each session will have between six to eight hours of time.
Information: The webpage will soon have information about registration, registration fee, hotel booking etc. There is a rudimentary website at the address http://math.iisc.ernet.in/~iwota2013.

* 17–20 **Marrakesh International Conference on Probability and Statistics (MICPS-2013)**, Marrakesh, Morocco.
Organizing Committee: M. Eddahbi, K. Es-Sebaiy, I. Ouassou, Y. Ouknine and M. Rachdi.
Registration and submission: For all the actions related to the MICPS-2013 (abstract submission, registration, conference fee, etc) please check the conference website.
Accommodation/Transportation: Special prices have been arranged with some hotels for MICPS 2013 participants.
Information: http://www.ensa.ac.ma/micps2013/; email: k.essebaiy@uca.ma.

18–20 **6th Indian International Conference on Artificial Intelligence**, Tumkur (near Bangalore), India. (May 2013, p. 655)
Description: The 2013 International Conference on Advances in Data Mining and Security Informatics (DMSI-13) and the 2013 International Conference on Image, Video and Signal Processing (IVSP-13) will also be held at the same time and place. We invite draft paper submissions. IICAI is a series of high quality technical events in Artificial Intelligence (AI) and is also one of the major AI events in the world. The conference will be held every two years to make it an ideal platform for people to share views and experiences in AI and related areas.
Information: For more details visit: http://www.iiconference.org.

* 18–21 **HiPC 2013: 20th IEEE International Conference on High Performance Computing**, Hyderabad, India.
Description: You are invited to submit original unpublished research work that demonstrates current research in all areas of high performance computing including design and analysis of parallel and distributed systems, embedded systems, and their applications in scientific, engineering, and commercial areas. All accepted papers will be published in printed conference books/proceedings (ISBN) or on a CD. In addition, please assist in printing the CFP and displaying it on your organization's message boards. The details of CFP (call for papers) can be found at http://www.hipc.org/hipc2013/papers.php. In addition to technical sessions consisting of contributed papers, the conference will include invited presentations, a student research symposium, tutorials, and vendor presentations in the industry, user and research symposium. Further details about call for student research symposium, workshops, tutorials, and exhibits, as well as submission guidelines are available at the conference website.
General Co-Chairs: Badrinath Ramamurthy, HP, India; Rama Govindaraju, Google, California, USA.
Vice-General Chair: Jigar Halani, Wipro, India.
Deadline: Paper submission: May 16, 2013.
Information: http://www.hipc.org.

* 21–22 **The International Congress on Science and Technology**, Allahabad, U.P., India.
Description: The ICST-2013 is organized by the CWS, a non-profit society for the scientists and the technocrats and will take place in Allahabad, U.P., INDIA, from Dec. 21-22, 2013. The conference has the focus on the current trends on frontier topics of the science and technology (Applied Engineering) subjects. The ICST conferences serve as good platforms for our members and the entire science and technological community to meet with each other and to exchange ideas.
Information: http://sites.google.com/site/intcongressonsciandtech/.

* 21–23 **7th International Conference of IMBIC on "Mathematical Sciences for Advancement of Science and Technology" (MSAST 2013)**, Hotel Indismart, Kolkata, India.
Description: The main objective of the conference is to bring specialized topics in mathematics, statistics, computer science, information technology, bioinformatics and closely related interdisciplinary areas to the forefront. Original full papers are invited. All papers are to be screened and accepted papers will be published in the *Proceedings of IMBIC*, Volume 2 (2013), having ISBN 978-81-925832-1-1, except for a few full scientific papers of high quality, which may be published in the highly acclaimed series of monographs of IMBIC in Volume 2 (2014).
Contact: All correspondence in respect to the conference is to be addressed to Dr. Avishek Adhikari, Convenor MSAST 2013 & Secretary, IMBIC; email: msast.paper@gmail.com; http://www.isical.ac.in/~avishek_r/.
Information: http://www.indismart.in/kol-index.php; http://www.imbic.org/forthcoming.html.

28–30 **3rd International Conference on Mathematics & Information Science (ICMIS 2013)**, Luxor, Egypt. (Oct. 2012, p. 1303)
Description: The conference will feature advances in mathematical science and technology presented by leading African and international researchers. The conference will provide the opportunity to showcase research in mathematics, theoretical physics and information science and technology to engender dialogue and collaboration between Egyptian and international researchers. The conference is part of a series of conferences dedicated to bringing top scientists and technologists to Egypt thereby helping to raise Egyptian science and technology to the highest international standard, raise awareness of governments and industry in Egypt of

the importance and excitement of new research and development in technologies, and engender collaborations and research exchanges.
Grants: Some grants for young and early stage researchers are available.
Information: http://conf.naturalspublishing.com/.

January 2014

5–7 **ACM-SIAM Symposium on Discrete Algorithms (SODA14), being held with Analytic Algorithmics and Combinatorics (ANALCO14) and Algorithm Engineering and Experiments (ALENEX14)**, Hilton Portland & Executive Tower, Portland, Oregon. (Dec. 2012, p. 1597)
Information: Further information on SODA14, ALENEX14 and ANALCO14 will be posted at http://www.siam.org/meetings/da14/ in April, 2013.

* 6–10 **Mathematics of Social Learning**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: The goal of this workshop is to bring together mathematicians, physicists, and social, information, and computer scientists to explore the dynamics of social learning and cultural evolution. Of particular interest will be ways of using data from social media and online experiments to address questions of interest.
Deadline: An application and registration form is available online. Application deadline: November 11, 2013.
Information: http://www.ipam.ucla.edu/programs/sl2014/.

6–July 4 **Free Boundary Problems and Related Topics**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Dec. 2012, p. 1597)
Description: Free boundary problems are today considered as one of the most important directions in the mainstream of the analysis of partial differential equations (PDEs), with an abundance of applications in various sciences and real world problems. In the last two decades, various new ideas, techniques, and methods have been developed, and new important, challenging problems in physics, engineering, industry, finance, biology, and other areas have arisen. The topics of this programme are directed towards theory, numerics and applications. The study of free boundary problems is an extremely broad topic due to the abundance of applications. This breadth presents challenges and opportunities! Many problems treated by applied scientists and numerical analysts are not well known amongst theoretical people, and vice versa. The aim of this programme is to enhance links and unifying techniques by bringing together the relevant specialists.
Information: http://www.newton.ac.uk/programmes/FRB/.

* 15–18 **Joint Mathematics Meetings**, Baltimore, Maryland.
Information: http://www.ams.org/meetings/national/national.

* 16–18 **Mathematical Challenges in Ophthalmology**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: Ophthalmology has become increasingly subspecialized and technologically advanced, making it impossible to be an expert in every area and highlighting the need for multi-disciplinary collaborations with engineers and mathematicians. The goal of this workshop is to encourage communication between engineers, mathematicians, scientists, and clinicians to improve patient care and scientific advancement. The integration of new imaging technology allows visualization down to the cellular level, but objectivity of evaluation and automated analysis still need more refinement. The incorporation of intraoperative imaging technology would be the beginning of a new surgical era in ophthalmology. Robotics in ophthalmic surgery is also on the horizon. It would reduce human error, improve precision, and increase surgical capabilities. An application and registration form are available online.
Information: http://www.ipam.ucla.edu/programs/mco2014/.

* 20–23 **International Conference on Recent Advances in Mathematics (ICRAM 2014)**, Department of Mathematics, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur Maharashtra State, India.
Description: The conference schedule includes plenary talks, invited talks on current areas of research followed by a large number of paper and poster presentations.
Aim: The main aim of the conference is to promote, encourage, discuss the latest developments and research in the field of Mathematics and its applications and bring together researchers in the different fields. The conference is broad-based on (i) pure mathematics, algebra, algebraic geometry, mathematical analysis, number theory, numerical analysis & scientific computing, topology and differential equation, operations research and statistics (iii) mathematical physics, general relativity and cosmology, high energy physics, quantum mechanics.
Information: http://www.icram2014.com.

* 20–24 **An international symposium on orthogonality and quadrature (ORTHOQUAD 2014)**, Puerto de la Cruz, Tenerife, Canary Islands, Spain.
Description: This is an international conference in memory of Prof. Dr. Pablo González Vera, Professor of Applied Mathematics at the University of La Laguna (Canary Islands), who passed away on July 11, 2012. Professor González Vera was a recognized specialist in approximation theory, orthogonal polynomials and quadrature formulae, and was author of more than one hundred fifty papers published in prestigious international journals in the area of applied mathematics. He also wrote several books, among which specially stands "Orthogonal Rational Functions", published by Cambridge University Press, and written in collaboration with Adhemar Bultheel (KU Leuven, Belgium), Erik Hendriksen (Netherlands) and Olav Njastad (Univ. of Trondheim). In this sense, the main topics of the conference will be orthogonality and quadrature, but other topics in approximation theory, special functions and related issues are also within the scope of the conference.
Information: http://gama.uc3m.es/pablo/.

* 20–24 **ICERM Topical Workshop: From the Clinic to Partial Differential Equations and Back: Emerging challenges for Cardiovascular Mathematics**, ICERM, Providence, Rhode Island.
Description: Mathematical models have been giving remarkable contributions in advancing knowledge and supporting decisions in several branches of medicine. The goal of this workshop is to foster collaboration between mathematicians and medical doctors on modeling cardiovascular system. It will organized into two lines: "Core topics" are up-to-date research areas in mathematics and scientific computing that still present several open exciting challenges, which can require developing new numerical models, computational approaches and validation techniques; "New challenges" are a set of cardiovascular (in broad sense) problems and diseases that have not been attacked extensively with numerical tools. The workshop will be based on round-table discussions in smaller groups and lectures.
Information: http://icerm.brown.edu/tw14-1-pdecm.

20–May 23 **Algebraic Topology Program**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1482)
Description: Algebraic topology touches almost every branch of modern mathematics. Algebra, geometry, topology, analysis, algebraic geometry, and number theory all influence and in turn are influenced by the methods of algebraic topology. The goals of this 2014 program at MSRI are: Bring together algebraic topology researchers from all subdisciplines, reconnecting the pieces of the field, identify the fundamental problems and goals in the field, uncovering the broader themes and connections, connect young researchers with

the field, broadening their perspective and introducing them to the myriad approaches and techniques.

Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm8964.

20–May 23 **Model Theory and Number Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1177)
Description: The program aims to further the flourishing interaction between model theory and other parts of mathematics, especially number theory and arithmetic geometry. At present the model theoretical tools in use arise primarily from geometric stability theory and o-minimality. Current areas of lively interaction include motivic integration, valued fields, diophantine geometry, and algebraic dynamics.
Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm146.

23–24 **Connections for Women: Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1177)
Description: This two-day workshop will consist of short courses given by prominent female mathematicians in the field. These introductory courses will be appropriate for graduate students, post-docs, and researchers in related areas. The workshop will also include a panel discussion featuring successful women at various stages in their mathematical careers.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9545

* 27–30 **Symmetries, Differential Equations and Applications (SDEA-II)**, Center for Advanced Mathematics & Physics (CAMP), National University of Sciences & Technology (NUST), Campus H - 12, Islamabad, 44000, Pakistan.
Description: Differential equation is one of the important branches of Mathematics that helps in understanding the dynamics of real-life problems that appear in miscellaneous fields of science, e.g., Physics, Chemistry, Biology, etc. Over the last two decades there has been an enormous increase in the use of Lie and Noether symmetries to solve differential equations. The conference is aimed to provide a unique platform for young researchers, faculty and especially students to interact/collaborate with distinguished researchers from all over the world working in the area of symmetries, conservation laws, bi-Hamiltonians, moving frames to study underlying geometrical structures and integrable properties of differential equations.
Information: http://sdea2.nust.edu.pk/.

27–31 **Introductory Workshop: Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1177)
Description: Algebraic topology is a rich, vibrant field with close connections to many branches of mathematics. This workshop will describe the state of the field, focusing on major programs, open problems, exciting new tools, and cutting edge techniques.
Information: http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9546.

* 27–31 **Rough Paths: Theory and Applications**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: The theory of rough paths has established itself as a powerful tool to analyze a variety of stochastic systems that are too “rough” for their solutions to exist in the class of functions that can be handled by classical analytical methods. The power of the theory resides in its ability to cleanly separate the probabilistic components from their purely analytic aspects. Recently, the theory has seen an explosion of new results that caused its scope to expand considerably. This workshop will bring together experts in the theory of rough paths with researchers working in related areas of mathematics (probability, PDEs/SDEs, analysis, etc) and sciences in general. An application and registration form are available online.
Information: http://www.ipam.ucla.edu/programs/rp2014/.

February 2014

3–7 **Introductory Workshop: Model Theory, Arithmetic Geometry and Number Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1482)
Description: Model theory is a branch of mathematical logic whose structural techniques have proven to be remarkably useful in arithmetic geometry and number theory. We will introduce in this workshop some of the main themes of the programme covering such topics as Additive Combinatorics, Algebraic Dynamics, Berkovich Spaces, and the Pink-Zilber Conjectures. Tutorials will be given by both model theorists and experts in the relevant field of application. The workshop will also include “state of the art” lectures on the programme topics, indicating recent results as well as directions for future work.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9549.

3–May 9 **ICERM Semester Program on “Network Science and Graph Algorithms”**, ICERM, Providence, Rhode Island. (Jan. 2013, p. 117)
Description: The study of computational problems on graphs has long been a central area of research in computer science. However, recent years have seen qualitative changes in both the problems to be solved and the tools available to do so. Application areas such as computational biology, the Web, social networks, and machine learning give rise to large graphs and complex statistical questions that demand new algorithmic ideas and computational models. At the same time, techniques such as semidefinite programming and combinatorial preconditioners have been emerging for addressing these challenges. There will be four international conferences associated with this program, including an applications-oriented opening event.
Information: http://icerm.brown.edu/sp-s14.

10–11 **Connections for Women: Model Theory and its interactions with number theory and arithmetic geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1177)
Description: The development of model theory has always been influenced by its potential applications. Recent years have seen a remarkable flowering of that development, with many exciting applications of model theory in number theory and algebraic geometry. The introductory workshop will aim to increase these interactions by exposing the techniques of model theory to the number theorists and algebraic geometers, and the problems of number theory and algebraic geometry to the model theorists. The Connections for Women workshop will focus on presenting current research on the borders of these subjects, with particular emphasis on the contributions of women. In addition, there will be some social occasions to allow young women and men to make connections with established researchers, and a panel discussion addressing the challenges faced by all young researchers, but especially by women, in establishing a career in mathematics.
Information: email: chris@msri.org; http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9548.

* 10–14 **ICERM Workshop: Semidefinite Programming and Graph Algorithms**, ICERM, Providence, Rhode Island.
Description: Semidefinite programming is playing an ever increasing role in many areas of computer science and mathematics, including complexity theory, approximation algorithms for hard graph problems, discrete geometry, machine learning, and extremal combinatorics. This workshop will bring together researchers from these different fields. The goal is to explore connections, learn and share techniques, and build bridges.
Information: http://icerm.brown.edu/sp-s14-w1.

* 10–14 **Translating Cancer Data and Models to Clinical Practice**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

Description: This workshop will emphasize an integrated approach to understanding cancer initiation, progression, metastasis, and treatment. Proposed participants will include a number of clinicians and experimentalists whose approach and research may complement and motivate new mathematical and physical modeling, as well as empirical or clinical investigations. Our ultimate goals will be to critically examine and discuss approaches for improving clinical standards of care. and to foster new investigative directions in applied cancer research that involve the right level of detail in emerging mathematical and physical approaches. An application and registration form are available online.

Information: `http://www.ipam.ucla.edu/programs/cdm2014/`.

* 24–28 **Stochastic Gradient Methods**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

Description: This workshop will address various topics in the theory, implementation, and practice of SG methods, possibly including the following: applications to nonconvex problems and regularized objectives; parallel implementations; hybridization of SG methods with other optimization techniques; and use of SG methods in deep learning, latent variable models, and other settings. An application and registration form are available online.

Information: `http://www.ipam.ucla.edu/programs/sgm2014/`.

March 2014

* 3–7 **AIM Workshop: Postcritically finite maps in complex and arithmetic dynamics**, American Institute of Mathematics, Palo Alto, California.

Description: This workshop, sponsored by AIM and the NSF, will be devoted to questions relating to postcritically finite (PCF) rational maps.

Information: `http://www.aimath.org/ARCC/workshops/finitedynamics.html`.

* 4–7 **11th German Probability and Statistics Days 2014 - Ulmer Stochastik-Tage**, University Ulm, Ulm, Germany.

Description: The venue is at the University of Ulm. In the tradition of the previous conferences, this meeting provides an international forum for presentation and discussion of new results in the area of probability and statistics.

Speakers: The plenary speakers of the conference will be: Jianqing Fan (Princeton), Geoffrey Grimmett (Cambridge), Jean-Franis Le Gall (Paris), Alexandre Tsybakov (Paris). Contributed talks will be given in 17 sections devoted to specific topics; the highlight of each section will be one invited main talk. Over the last years, the "Stochastik-Tage" organized biannually have been attracting an increasing number of participants from abroad.

Language: English.

Information: `http://www.gpsd-ulm2014.de`.

10–26 **School and Workshop on Classification and Regression Trees**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (May. 2013, p. 655)

Description: Classification and regression trees are an integral part of the toolbox of data mining, machine learning, and statistics. The year 2013 marks the fiftieth anniversary of the publication of the first journal article on the subject. New techniques have added capabilities that far surpass the early methods. Modern classification trees can partition the data with linear splits on subsets of variables and fit nearest-neighbor, kernel-density, and other models in the partitions. Regression trees can fit almost every kind of traditional statistical model, including least-squares, quantile, logistic, Poisson and proportional hazards models, as well as models for censored, longitudinal and multi-response data. The purpose of the workshop is to bring together current experts in the field to discuss recent developments and generate ideas for future research. The purpose of the school is to introduce the subject to other researchers and practitioners who are interested to learn the techniques.

Information: `http://www2.ims.nus.edu.sg/Programs/014swclass/index.php`.

* 17–21 **ICERM Workshop: Stochastic Graph Models**, ICERM, Providence, Rhode Island.

Description: Random graphs, stochastic processes on graphs and algorithms for computations on these structures continue to play a dominant role in algorithmic research and discrete mathematics, with recent applications ranging from web search and recommendation engines to social networks and system biology. This workshop will be an opportunity for researchers from diverse fields to get together and share problems and techniques for handling and analyzing graphs structures. The connections—mathematical, computational, and practical—that arise between these seemingly diverse problems and approaches will be emphasized.

Information: `http://icerm.brown.edu/sp-s14-w2`.

* 21–23 **Sectional Meeting**, University of Tennessee, Knoxville, Knoxville, Tennessee.

Description: 2014 Southeastern Spring Sectional Meeting.

Information: `http://www.ams.org/meetings/sectional/sectional.html`.

24–April 17 **Mathematical, Statistical and Computational Aspects of the New Science of Metagenomics**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2013, p. 363)

Description: Metagenomics is the study of the total genomic content of microbial communities. DNA material is sampled collectively from the microorganisms that populate the environment of interest. The extracted DNA sequences are then used to profile the environment and its biodiversity, its dominant microbial classes or biological functions, and whether and how this profile differs from those of other environments. This research programme will bring together leading expertise in the multiple disciplines involved, including mathematics, computer science, probability and statistics, biomedical research and biology. The brief of the programme will be to explore the major current analytical and computational open problems in metagenomics, and to identify opportunities for application and development of theory and methods, with an emphasis on synergy between disciplines. Several workshops will take place during the programme. For full details please see: `http://www.newton.ac.uk/events.html`.

Information: `http://www.newton.ac.uk/programmes/MTG/index.html`.

* 29–30 **Sectional Meeting**, University of Maryland, Baltimore County, Baltimore, Maryland.

Description: 2014 Spring Eastern Sectional Meeting.

Information: `http://www.ams.org/meetings/sectional/sectional.html`.

31–April 3 **SIAM Conference on Uncertainty Quantification (UQ14)**, Hyatt Regency Savannah, Savannah, Georgia. (Dec. 2012, p. 1597)

Description: The call for submissions will be available at: `http://www.siam.org/meetings/uq14/` in early April, 2013.

Information: `http://www.siam.org/meetings/uq14/`.

April 2014

* 5–6 **Sectional Meeting**, University of New Mexico, Albuquerque, New Mexico.

Description: 2014 Western Spring Sectional Meeting.

Information: `http://www.ams.org/meetings/sectional/sectional.html`.

* 7–11 **AIM Workshop: The many facets of the Maslov index**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the Maslov index, a collective name for many related invariants counting the jumps of functions, starting in the 19th century with the principal value of the complex logarithm.
Information: `http://www.aimath.org/ARCC/workshops/maslov.html`.

* 7–11 **ICERM Workshop: Electrical Flows, Graph Laplacians, and Algorithms: Spectral Graph Theory and Beyond**, ICERM, Providence, Rhode Island.
Description: Spectral graph theory, which studies how the eigenvalues and eigenvectors of the graph Laplacian and other related matrices interact with the combinatorial structure of a graph, is a classical tool in both the theory and practice of algorithm design. The success of this approach has been rooted in the efficiency with which eigenvalues and eigenvectors can be computed and in the large number of ways that a graph's properties are connected to the Laplacian's spectrum, particularly to the value of its second smallest eigenvalue $\lambda 2$. While the eigenvalues and eigenvectors of the Laplacian capture a striking amount of the structure of the graph, they do not capture it all. Recent work suggests that we have only scratched the surface of what can be done if we are to broaden our investigation to include more general linear-algebraic properties of the matrices we associate to graphs. The workshop will bring researchers together to study and advance this emerging frontier in algorithmic graph theory.
Information: `http://icerm.brown.edu/sp-s14-w3`.

7–11 **Reimagining the Foundations of Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California. (May 2013, p. 719)
Description: Recent innovations in higher category theory have unlocked the potential to reimagine the basic tools and constructions in algebraic topology. This workshop will explore the interplay between these higher and ∞-categorical techniques with classical algebraic topology, playing each off of the other and returning the field to conceptual, geometrical intuition.
Information: `http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9550`.

* 11–13, 2014 **Sectional Meeting**, Texas Tech University, Lubbock, Texas.
Description: 2014 Spring Central Sectional Meeting.
Information: `http://www.ams.org/meetings/sectional/sectional.html`.

22–May 16 **Advanced Monte Carlo Methods for Complex Inference Problems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2013, p. 364)
Description: In recent years there has been an explosion of complex data-sets in areas as diverse as Bioinformatics, Ecology, Epidemiology, Finance and Population genetics. In a wide variety of these applications, the stochastic models devised to realistically represent the data-generating processes are very high-dimensional and the only computationally feasible and accurate way to perform statistical inference is with Monte Carlo. The focus of this programme is on recent innovations in the field of Monte Carlo methods for inference in complex and intractable statistical problems. It will take up the following research threads: Approximate Bayesian Computation; SMC and Markov Chain Monte Carlo and their integration; and recent theoretical advancements underpinning these areas. Several workshops will take place during the programme. For full details please see `http://www.newton.ac.uk/events.html`.
Information: `http://www.newton.ac.uk/programmes/MCM/index.html`.

May 2014

12–14 **SIAM Conference on Imaging Science (IS14)**, Hong Kong Baptist University, Hong Kong, China. (Aug. 2012, p. 1021)
Description: The interdisciplinary field of imaging science is experiencing tremendous growth. New devices capable of imaging objects and structures from nanoscale to the astronomical scale are continuously being developed and improved, and as result, the reach of science and medicine has been extended in exciting and unexpected ways. The impact of this technology has been to generate new challenges associated with the problems of formation, acquisition, compression, transmission, and analysis of images. By their very nature, these challenges cut across the disciplines of physics, engineering, mathematics, biology, medicine, and statistics. While the primary purpose of this conference is to focus on mathematical issues, the other facets of imaging, such as biomedical and engineering aspects, for example, will also play an important role.
Information: `http://www.siam.org/meetings/is14/`.

* 12–16 **ICERM Topical Workshop: Robust Discretization and Fast Solvers for Computable Multi-Physics Models**, ICERM, Providence, Rhode Island.
Description: This workshop will gather together experts in the core related fields in applied and computational mathematics to exchange ideas regarding the development of robust and efficient numerical schemes that preserve the key physics of these models, and to study the development of fast and efficient linear and nonlinear solvers that are scalable and optimal. This workshop will also target young researchers and members of under-represented groups to help launch their research in this area.
Information: `http://icerm.brown.edu/tw14-2-cmpm`.

12–16 **Model Theory in Geometry and Arithmetic**, Mathematical Sciences Research Institute, Berkeley, California. (June/July 2012, p. 870)
Description: The workshop will feature talks in a range of topics where model theory interacts with other parts of mathematics, especially number theory and arithmetic geometry, including: motivic integration, algebraic dynamics, diophantine geometry, and valued fields.
Information: `http://www.msri.org/web/msri/scientific/workshops/programmatic-workshops/show/-/event/Wm9547`.

* 19–23 **Representations of reductive groups: A conference dedicated to David Vogan on his 60th birthday**, MIT, Cambridge, Massachusetts.
Description: The conference will address recent developments in the representation theory of reductive Lie groups and algebraic groups over finite and local fields, as well as connections of this theory with other subjects, such as number theory, automorphic forms, algebraic geometry and combinatorics. It will be an occasion to celebrate the 60th birthday of David Vogan, who has inspired and shaped the development of this field for almost 40 years.
Information: `http://math.mit.edu/conferences/Vogan/`.

* 26–29 **VI Workshop on Dynamical Systems: On the occasion of Marco Antonio Teixeira's 70th birthday (MAT70)**, Campinas, SP, Brazil.
Description: In 2014 we wish to celebrate Marco Antonio Teixeira's 70th birthday and his significant mathematical contribution. With this in mind, we wish to honor him with a Scientific Conference.
Information: `http://www.mat70.com/`.

26–30 **Constructive Functions 2014**, Vanderbilt University, Nashville, Tennessee. (May 2013, p. 655)
Description: The focus of this conference is on all aspects of constructive function theory, from asymptotics to zero distribution, and on minimum energy problems on manifolds. The conference will honor the 70th birthday of Ed Saff.

Information: `http://www.math.vanderbilt.edu/~constructive2014/`.

* 28–30 **IWCIA 2014 – 16th International Workshop on Combinatorial Image Analysis**, Brno University of Technology, Technická 2, Brno, Czech Republic.
Description: The 16th International Workshop on Combinatorial Image Analysis will be hosted by the Brno University of Technology, Faculty of Mechanical Engineering. The researchers from all areas of image analysis and its applications are cordially invited to participate.
Information: `http://iwcia2014.fme.vutbr.cz/`.

June 2014

2–5 **VI Workshop on Dynamical Systems: On the occasion of Marco Antonio Teixeira's 70th birthday (MAT70)**, Águas de Lindóia, Sao Paulo, Brazil.
Description: In 2014 we wish to celebrate Marco Antonio Teixeira's 70th birthday and his significant mathematical contribution. With this in mind, we wish to honor him with a Scientific Conference to be held in a small tourist town in the interior of the state of São Paulo, Águas de Lindóia, from June 2–5, 2014.
Main topics: Non-Smooth Dynamical Systems and Conservative/Reversible Dynamical Systems.
Information: `http://www.mat70.com/`.

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.

* 9–13 **AIM Workshop: The Cauchy-Riemann equations in several variables**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will focus on the many interesting questions that remain about the interaction between estimates for solutions of the Cauchy-Riemann equations and the behavior of the Bergman kernel associated to the given norm.
Information: `http://www.aimath.org/ARCC/workshops/crscv.html`.

* 9–13 **String Math 2014**, University of Alberta, Edmonton, Alberta, Canada.
Description: University of Alberta is hosting the fourth annual meeting of the String Math series of conferences in June 2014. The main goal of the conference is to bring together mathematicians and physicists who work on ideas related to string theory. String theory, as well as quantum field theory, has contributed a series of profound ideas which gave rise to entirely new mathematical fields and revitalized older ones. By now there is a large and rapidly growing number of both mathematicians and physicists working at the string-theoretic interface between the two academic fields. The influence flows in both directions, with mathematical techniques and ideas contributing crucially to major advances in string theory.
Information: `http://sites.google.com/a/ualberta.ca/stringmath2014/`.

* 9–13 **Tenth edition of the Advanced Course in Operator Theory and Complex Analysis**, Sevilla, Spain.
Invited speakers: Filippo Bracci, Universita di Roma "Tor Vergata", Italy; James Brennan, University of Kentucky, Kentucky; Yurii Lyubarskii, NTNU, Trondheim, Norway; Alexander Olevskii, Tel Aviv University, Israel; Tatiana Smirnova-Nagnibeda, Universite de Geneve, Switzerland.
Information: You can find further information about the courses at `http://congreso.us.es/ceacyto/2013`. Apart of attending the course, you may also have the opportunity to deliver a contributed talk.

9–July 4 **Interactions between Dynamics of Group Actions and Number Theory**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.
Description: In the last decade there have been several important breakthroughs in number theory and diophantine geometry, where progress on long-standing open problems has been achieved by utilising ideas originated in the theory of dynamical systems on homogeneous spaces. Dynamical systems techniques are applicable to a wide range of number-theoretic objects that have many symmetries.
Aim: Of this programme is to bring together researchers working in number theory and homogeneous dynamics to discuss the recent developments and open problems that lie at the crossroads of these fields and to encourage more interaction among people working in these diverse areas. Several workshops will take place during the programme. For full details please see: `http://www.newton.ac.uk/events.html`.
Information: `http://www.newton.ac.uk/programmes/GAN/index.html`.

* 23–25 **17th Conference on Integer Programming and Combinatorial Optimization (IPCO 2014)**, University of Bonn, Bonn, Germany.
Description: The IPCO-conference is a forum for researchers and practitioners working on various aspects of integer programming and combinatorial optimization. The aim is to present recent developments in theory, computation, and applications in these areas.
Information: `http://www.or.uni-bonn.de/ipco/`.

* 23–27 **What Next? The mathematical legacy of Bill Thurston**, Cornell University, Ithaca, New York.
Description: This conference will celebrate the profound influence of Bill Thurston's work on the entire mathematical community. Thurston made fundamental contributions to topology, geometry, and dynamical systems. But beyond these specific accomplishments he introduced new ways of thinking about and of seeing mathematics. He discovered connections between disciplines which led to the creation of entirely new fields. The goal of this meeting is to bring together mathematicians from a broad spectrum of areas to describe recent advances and explore future directions motivated by Thurston's transformative ideas.
Organizers: Dave Gabai, John Hubbard, Steve Kerckhoff, John Smillie, DylanThurston and Karen Vogtmann.
Information: `http://www.math.cornell.edu/~festival`.

23–28 **6th International Conference on Advanced Computational Methods in Engineering**, NH Gent Belfort, Gent, Belgium.
Description: ACOMEN 2014 is the 6th event in a successful series of interdisciplinary international conferences, which aims to bring together a diverse community of mathematicians, engineers, and physicists involved in applied sciences, mathematics and developing advanced computational methods. The main topics of ACOMEN include but are not limited to: applied mathematics, numerical analysis and computational mathematics, financial mathematics, optimization and optimal control, inverse problems, computational finance, computational electromagnetism, fluid dynamics, heat transfer and porous media flow, computational chemistry, computational biology and medicine, computational geosciences high-scale and parallel computing, software for scientific computations.
Information: `http://www.acomen.ugent.be`.

29–July 3 **26th International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC)**, DePaul University, Chicago, Illinois.
Topics: Include all aspects of combinatorics and their relations with other parts of mathematics, physics, computer science, and biology. The conference will include invited lectures, contributed presentations, poster sessions, and software demonstrations. There will be no parallel sessions.
Information: `http://sites.google.com/site/fpsac2014/`.

July 2014

* 7–11 **10th AIMS Conference on Dynamical Systems, Differential Equations and Applications**, Universidad Autónoma de Madrid, Madrid, Spain.
Description: Hosted by the Instituto de Ciencias Matemáticas (ICMAT) and the Universidad Autónoma de Madrid (UAM).
Main Speakers: Nalini Anantharaman (France), Diego Córdoba (Spain), Ingrid Daubechies (USA), Weinan E (USA), Charles L. Fefferman (USA), Bernold Fiedler (Germany), Zhiming Ma (China), Philip Maini (UK), Sylvia Serfaty (France), Carles Simó (Spain), Cedric Villani (France), Amie Wilkinson (USA).
Organizers: Manuel de León (chair), mdeleon@icmat.es and Shou-chuan Hu (chair), shu@missouristate.edu.
Information: http://www.aimsciences.org/conferences/2014/index.html.

* 14–18 **AIM Workshop: Mori program for Brauer log pairs in dimension three**, American Institute of Mathematics, Palo Alto, California.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the Mori program for Brauer log pairs in dimension three.
Information: http://www.aimath.org/ARCC/workshops/moribrauerlog.html.

14–18 **The 30th International Colloquium on Group Theoretical Methods in Physics**, Ghent University, Ghent, Belgium.
Description: The ICGTPM series is traditionally dedicated to the application of symmetry and group theoretical methods in physics, chemistry and mathematics, and to the development of mathematical tools and theories for progress in group theory and symmetries. Over the years, it has further broadened and diversified due to the successful application of group theoretical, geometric and algebraic methods in life sciences and other areas. The conference has an interdisciplinary character. It aims at bringing together experts and young researchers from different fields encouraging cross disciplinary interactions.
Information: http://www.group30.ugent.be.

14–August 8 **Theory of Water Waves**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.
Description: Water waves impact every aspect of life on the planet. At smaller length scales the ripples driven by surface tension affect remote sensing. At intermediate length scales waves in the mid-ocean affect shipping and near the shoreline they control the coastal morphology and the ability to navigate along shore. At larger length scales waves such as tsunamis and hurricane-generated waves can cause devastation on a global scale. Across all length scales an exchange of momentum and thermal energy between ocean and atmosphere occurs affecting the global weather system and the climate. From a mathematical viewpoint water waves pose rich challenges. New methodologies are emerging and computational approaches are becoming much more sophisticated.
Themes: Covered in this conference include: The initial-value problem (IVP); Existence and classification of waves; Linear and nonlinear stability of waves; Dynamical systems and geometric techniques; Beyond irrotational flow.
Information: http://www.newton.ac.uk/programmes/TWW/.

21–August 15 **Quantum Control Engineering: Mathematical Principles and Applications**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.
Description: We are currently entering a new technological era in which we are able to build systems whose performance is limited by quantum physical effects and in which it may be possible to exploit non-classical phenomena in novel ways. To this end, there has been considerable recent interest in engineering quantum systems and at the heart of this is the development of a quantum control theory dedicated to extending classical control to the quantum domain. Examples already utilizing control of one sort or another include quantum electromechanical systems, quantum dots, cooper-pair boxes, superconducting interference devices, ion traps, as well as a large selection of optical devices. It is clear that a mathematical framework is essential for the future development of quantum control as an engineering discipline. The aim of the programme is to bring together experimentalists and theoreticians working in quantum engineering to identify the core mathematical issues and challenges ahead.
Information: http://www.newton.ac.uk/programmes/QCE/.

August 2014

* 4–9 **10th International Conference on Clifford Algebras and their Applications in Mathematical Physics (ICCA10)**, University of Tartu, Tartu, Estonia.
Description: The aim of the ICCA10 is to bring together the leading scientists in the field of Clifford algebras, differential geometry and their various applications in mathematics, physics, engineering and other applied sciences. We invite you to participate in the exchange of the latest results in research and application.
Information: http://icca10.ut.ee.

* 11–14 **SIAM Conference on Nonlinear Waves and Coherent Structures (NW14)**, Churchill College, University of Cambridge, Cambridge, United Kingdom.
Description: The call for submissions will be linked from http://www.siam.org/meetings/nw14/ in October 2013.
Information: http://www.siam.org/meetings/nw14/.

11–December 12 **New geometric methods in number theory and automorphic forms**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The branches of number theory most directly related to the arithmetic of automorphic forms have seen much recent progress, with the resolution of many longstanding conjectures. These breakthroughs have largely been achieved by the discovery of new geometric techniques and insights. The goal of this program is to highlight new geometric structures and new questions of a geometric nature which seem most crucial for further development. In particular, the program will emphasize geometric questions arising in the study of Shimura varieties, the p-adic Langlands program, and periods of automorphic forms.
Information: http://www.msri.org/web/msri/scientific/programs/show-/event/Pm8996.

14–15 **Connections for Women: New Geometric Methods in Number Theory and Automorphic Forms**, Mathematical Sciences Research Institute, Berkeley, California.
Description: This 2-day workshop will showcase the contributions of female mathematicians to the three main themes of the associated MSRI program: Shimura varieties, p-adic automorphic forms, periods and L-functions. It will bring together women who are working in these areas in all stages of their careers, featuring lectures by both established leaders and emerging researchers. In addition, there will be a poster session open to all participants and an informal panel discussion on career issues.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9806.

18–December 19 **Geometric Representation Theory**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The fundamental aims of geometric representation theory are to uncover the deeper geometric and categorical structures underlying the familiar objects of representation theory and harmonic analysis, and to apply the resulting insights to the resolution of classical problems. One of the main sources of inspiration for the field is the Langlands philosophy, a vast nonabelian generalization of the Fourier transform of classical harmonic analysis, which serves as a visionary roadmap for the subject and places it at the heart of number theory. A primary goal of the proposed MSRI program is to explore the potential impact of geometric methods and

ideas in the Langlands program by bringing together researchers working in the diverse areas impacted by the Langlands philosophy, with a particular emphasis on representation theory over local fields.
Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm8951.

September 2014

2–5 **Introductory Workshop: Geometric Representation Theory**, Mathematical Sciences Research Institute, Berkeley, California.
Description: Geometric Representation Theory is a very active field, at the center of recent advances in Number Theory and Theoretical Physics. The principal goal of the Introductory Workshop will be to provide a gateway for graduate students and new post-docs to the rich and exciting, but potentially daunting, world of geometric representation theory. The aim is to explore some of the fundamental tools and ideas needed to work in the subject, helping build a cohort of young researchers versed in the geometric and physical sides of the Langlands philosophy.
Information: http://www.msri.org/web/msri/scientific/workshops/all-workshops/show/-/event/Wm9804.

* 20–21 **Sectional Meeting**, University of Wisconsin-Eau Claire, Eau Claire, Wisconsin.
Description: 2014 Central Fall Section Meeting.
Information: http://www.ams.org/meetings/sectional/sectional.html.

October 2014

* 18–19 **Sectional Meeting**, Dalhousie University, Halifax, Canada.
Description: 2014 Fall Eastern Sectional Meeting.
Information: http://www.ams.org/meetings/sectional/sectional.html.

* 25–26 **Sectional Meeting**, San Francisco State University, San Francisco, California.
Description: 2014 Fall Western Section Meeting.
Information: http://www.ams.org/meetings/sectional/sectional.html.

November 2014

* 8–9 **Sectional Meeting**, University of North Carolina, Greensboro, North Carolina.
Description: 2014 Fall Southeastern Section Meeting.
Information: http://www.ams.org/meetings/sectional/sectional.html.

11–January 25 **Inverse Moment Problems: The Crossroads of Analysis, Algebra, Discrete Geometry and Combinatorics**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Description: Applications of moments of measures in polynomial optimization led to a number of breakthroughs in optimization and real algebraic geometry, as well as to better understanding of ways to encode measures. Other similar threads are recently seen in the theory of integration on polytopes and counting of integer points in polytopes, as well as in quantum computing. The aim of the program is to futher investigate relations between these topics and inverse moment problems, i.e., questions of reconstructing measures from a set of its moments, which are traditionally attacked by purely analytic tools. Activities will include two 4–5 day research conferences, one quantum computing workshop, and one graduate student winter school/workshops.
Information: http://www2.ims.nus.edu.sg/Programs/014inverse/index.php.

January 2015

5–June 26 **Periodic and Ergodic Spectral Problems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.
Description: The main objective of the programme is to bring together specialists in three major themes: periodic, almost-periodic, and random operators, to discuss recent developments and deep connections between the methods intrinsic for each of these research areas. Operators on manifolds or graphs and more general ergodic operators will also be considered, as well as problems that lie at the interface of the main topics (e.g. "sheared" periodic operators), and applications in other areas of mathematics (e.g. geometry). At the beginning of the programme, there will be a two-week long instructional conference with six mini-courses of about ten lectures each, which will be designed for students and non-specialists. Further there will be three workshops evenly spread over the period of the programme to cover more advanced results, each centred on one of the main themes. Several workshops will take place during the programme. For full details please see http://www.newton.ac.uk/events.html.
Information: http://www.newton.ac.uk/programmes/PEP/.

12–May 22 **Dynamics on Moduli Spaces of Geometric Structures Program**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The program will focus on the deformation theory of geometric structures on manifolds, and the resulting geometry and dynamics. This subject is formally a subfield of differential geometry and topology, with a heavy infusion of Lie theory. Its richness stems from close relations to dynamical systems, algebraic geometry, representation theory, Lie theory, partial differential equations, number theory, and complex analysis.
Information: http://www.msri.org/web/msri/scientific/programs/show/-/event/Pm9002.

12–July 3 **Random Geometry**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.
Description: A new frontier has emerged at the interface between probability, geometry, and analysis, with a central target to produce a coherent theory of the geometry of random structures. The principal question is the following: within a given structure, what is the interplay between randomness and geometry? More precisely, does the geometry appear to be random at every scale (i.e. fractal), or do fluctuations "average out" at sufficiently large scales? Can the global geometry be described by taking a suitable scaling limit that allows for concrete computations? The goal of the programme is to gather experts from probability, geometry, analysis and other connected areas, in order to study aspects of this question in some paradigmatic situations. Several workshops will take place during the programme. For full details please see http://www.newton.ac.uk/events.html.
Information: http://www.newton.ac.uk/programmes/RGM/index.html.

September 2015

1–August 31 **Call for Research Programmes 2015-2016**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.
Description: The CRM invites proposals for Research Programmes during the academic year 2015–2016 in any branch of mathematics and its applications. CRM Research Programmes consist of periods ranging between two to five months of intensive research in a given area of mathematics and its applications. Researchers from different institutions are brought together to work on open problems and to analyze the state and perspectives of their area.
Deadlines for submission of proposals: November 29, 2013, for preliminary proposals and October 25, 2013, for final proposals.
Information: http://www.crm.cat/en/Pages/DetallCrida.aspx?ItemID=7.

63 Years Since ENIAC Broke the Ice

The cover displays two examples of the use of computers to predict weather. The one at upper left is a figure taken directly from the 1950 *Tellus* paper "Numerical integration of the barotropic vorticity equation" by Jule Charney, Ragnar Fjørtoft, and John von Neumann. This paper describes the very first attempt to gauge the plausibility of weather prediction by electronic computer, on the ENIAC computer at the Aberdeen Ballistic Research Laboratories. The second example shows the result of an emulation of this original computation, run on a mobile phone a few years ago by Peter Lynch, the author of a review of a book on mathematics and weather prediction in this issue.

The computation by Charney et al. started by recording weather data manually on a 19×16 grid covering much of North America, and then advanced through eight three-hour steps to yield a one-day forecast. It took about three months to set up the machine and about twenty-four hours to run. Of course this pioneering run required a great deal of experiment, and the machine was almost unbelievably awkward to work with. But nonetheless encouraging—meteorology has never looked back. This first effort required a lot of overhead that was already unnecessary a short time later. After the run, the grid data output by the machine was then recorded, again presumably by hand, as smooth contour lines which, roughly speaking, measured pressure.

The program, originally written by Lynch in Matlab, was translated into a version of Java by his son Owen. The original data used by Charney et al. was not available, but around 2000 NCEP-NCAR had performed a reanalysis of weather data for the preceding fifty years, and Lynch relied on this, using the same grid as the earlier project. PHONIAC executed the main loop of the twenty-four-hour forecast in less than one second. The graphic was of course also produced by machine, and in spite of appearance contains as much information as the earlier smooth graphs.

Lynch comments:

> The first computer forecast was made using an equation called the barotropic vorticity equation (BVE).
>
> The term "barotropic" means that the atmosphere is represented by a single layer of fluid. Under appropriate approximations, it is possible to show that the "absolute vorticity" is conserved. That is, the sum of planetary vorticity f (spin due to the earth's rotation) and relative vorticity ζ (spin due to the motion of the fluid) keeps its original value as a parcel of fluid moves along. Therefore the equation to be solved is
>
> $$(D/Dt)(f + \zeta) = 0$$
>
> where D/Dt is the Lagrangian derivative (i.e., follows the flow). This is nonlinear, making the problem difficult. The equation enables us to predict the vorticity ζ (of course f is constant in time).
>
> Due to balance in the atmosphere, the vorticity ζ and the pressure p are intimately connected, and we can get p from ζ. For technical reasons, we use the height of a fixed pressure surface, rather than the pressure of a fixed height surface.
>
> So, instead of specifying pressure at 5.5 km, we talk about the height of the 500 hPa (hectoPascal or millibar) surface, typically about 5,500 meters. The choice of 500 hPa is made because it is, in a sense, half way up: about fifty percent of the mass of the atmosphere is below and fifty percent above. Also, the divergence is small there (which is one of the key approximations made in getting the BVE equation).
>
> The heavy lines on the *Tellus* plots show the height of the 500 hPa surface. The height pattern shows where the main features of high and low pressure (or maximum and minimum heights of the pressure surface) are located. These are related to the weather patterns (in simple terms, high pressure good, low pressure bad; but it's more complicated).

A firsthand account of the ENIAC project can be found in the article "The ENIAC computations of 1950" in volume 60 (1979) of the *Bulletin* of the American Meteorological Society (the other AMS), by G. W. Platzman. You can find an account of what went into the phone program in the article "Forecasts by PHONIAC" in the November 2008 issue of the journal *Weather*.

The article by Charney et al. was published in volume 2 of the journal *Tellus*, and we wish to thank the journal for permission to use it. We also wish to thank Peter Lynch for much help and advice. The photograph of the mobile phone was taken from `http://commons.wikimedia.org/wiki/File:Nokia6300-2008-04-23.jpg`.

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

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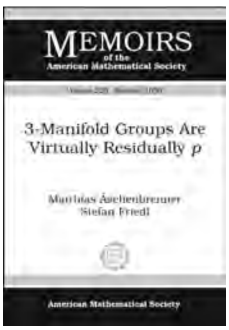
Algebra and Algebraic Geometry



3-Manifold Groups Are Virtually Residually p

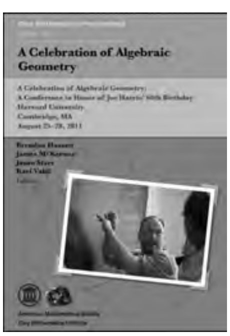
Matthias Aschenbrenner, *University of California, Los Angeles, CA*, and **Stefan Friedl**, *University of Koln, Germany*

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

Contents: Introduction; Preliminaries; Embedding theorems for p-Groups; Residual properties of graphs of groups; Proof of the main results; The case of graph manifolds; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 225, Number 1058

August 2013, 100 pages, Softcover, ISBN: 978-0-8218-8801-8, LC 2013018350, 2010 *Mathematics Subject Classification:* 20E26, 57M05; 20E06, 20E22, **Individual member US$41.40**, List US$69, Institutional member US$55.20, Order code MEMO/225/1058



A Celebration of Algebraic Geometry

Brendan Hassett, *Rice University, Houston, TX*, **James McKernan**, *Massachusetts Institute of Technology, Cambridge, MA*, **Jason Starr**, *Stony Brook University, NY*, and **Ravi Vakil**, *Stanford University, CA*, Editors

This volume resulted from the conference A Celebration of Algebraic Geometry, which was held at Harvard University from August 25–28, 2011, in honor of Joe Harris' 60th birthday. Harris is famous around the world for his lively textbooks and enthusiastic teaching, as well as for his seminal research contributions. The articles are written in this spirit: clear, original, engaging, enlivened by examples, and accessible to young mathematicians.

The articles in this volume focus on the moduli space of curves and more general varieties, commutative algebra, invariant theory, enumerative geometry both classical and modern, rationally connected and Fano varieties, Hodge theory and abelian varieties, and Calabi-Yau and hyperkähler manifolds. Taken together, they present a comprehensive view of the long frontier of current knowledge in algebraic geometry.

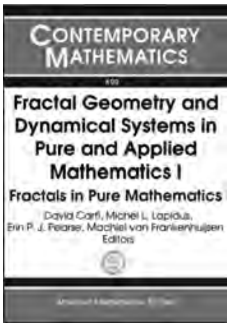
Titles in this series are co-published with the Clay Mathematics Institute (Cambridge, MA).

Contents: C. Araujo and **A.-M. Castravet**, Classification of 2-Fano manifolds with high index; **A. Beauville**, Abelian varieties associated to Gaussian lattices; **L. Caporaso**, Rank of divisors on graphs: An algebro-geometric analysis; **S. Casalaina-Martin**, A tour of stable reduction with applications; **S. Cautis**, The solvable monodromy extension property and varieties of log general type; **D. Chen**, **G. Farkas**, and **I. Morrison**, Effective divisors on moduli spaces of curves and abelian varieties; **X. Chen**, Rational self maps of Calabi-Yau manifolds; **C. Ciliberto**, **B. Harbourne**, **R. Miranda**, and **J. Roé**, Variations on Nagata's conjecture; **I. Coskun**, Symplectic restriction varieties and geometric branching rules; **D. Edidin**, Riemann-Roch for Deligne-Mumford stacks; **D. Eisenbud** and **B. Ulrich**, The regularity of the conductor; **M. Fedorchuk** and **D. I. Smyth**, Stability of genus five canonical curves; **T. Graber** and **J. M. Starr**, Restriction of sections for families of abelian varieties; **M. Green** and **P. Griffiths**, Correspondence and cycle spaces: A result comparing their cohomologies; **S. Grushevsky** and **K. Hulek**, Geometry of theta divisors–A survey; **J. L. Kass**, Singular curves and their compactified Jacobians; **S. L. Kleiman** and **V. V. Shende**, On the Göttsche threshold (with an appendix by I. Tyomkin); **S. L. Kleiman**, Curve counting à la Göttsche; **S. H Lee** and **R. Vakil**, Mnëv-Sturmfels universality for schemes; **D. Maulik** and **R. Pandharipande**, Gromov-Witten theory and Noether-Lefschetz theory; **J. Migliore** and **U. Nagel**, Numerical Macaulification; **M. Mustaţă**, The non-nef locus in positive characteristic; **K. G. O'Grady**, Pairwise incident planes and hyperkähler four-folds; **M. Popa**, Derived equivalence and non-vanishing loci; **J. Starr**, Degenerations of rationally connected varieties and PAC fields; **C. Voisin**, Remarks on curve classes on rationally connected varieties.

Clay Mathematics Proceedings, Volume 18

September 2013, 599 pages, Softcover, ISBN: 978-0-8218-8983-1, LC 2013014118, 2010 *Mathematics Subject Classification:* 14C30, 14D22, 14H45, 14J28, 14K10, 14N15, 14N20, **AMS members US$119.20**, List US$149, Order code CMIP/18

Analysis



Fractal Geometry and Dynamical Systems in Pure and Applied Mathematics I

Fractals in Pure Mathematics

David Carfì, *University of Messina, Italy*, **Michel L. Lapidus**, *University of California, Riverside, CA*, **Erin P. J. Pearse**, *California Polytechnic State University, San Luis Obispo, CA*, and **Machiel van Frankenhuijsen**, *Utah Valley University, Orem, UT*, Editors

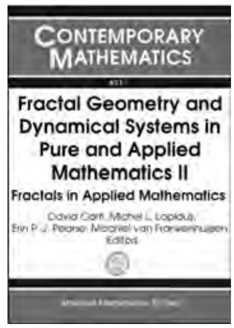
This volume contains the proceedings from three conferences: the PISRS 2011 International Conference on Analysis, Fractal Geometry, Dynamical Systems and Economics, held November 8–12, 2011 in Messina, Italy; the AMS Special Session on Fractal Geometry in Pure and Applied Mathematics, in memory of Benoît Mandelbrot, held January 4–7, 2012, in Boston, MA; and the AMS Special Session on Geometry and Analysis on Fractal Spaces, held March 3–4, 2012, in Honolulu, HI.

Articles in this volume cover fractal geometry (and some aspects of dynamical systems) in pure mathematics. Also included are articles discussing a variety of connections of fractal geometry with other fields of mathematics, including probability theory, number theory, geometric measure theory, partial differential equations, global analysis on non-smooth spaces, harmonic analysis and spectral geometry.

The companion volume (Contemporary Mathematics, Volume 601) focuses on applications of fractal geometry and dynamical systems to other sciences, including physics, engineering, computer science, economics, and finance.

Contemporary Mathematics, Volume 600

November 2013, approximately 398 pages, Softcover, ISBN: 978-0-8218-9147-6, LC 2013013894, 2010 *Mathematics Subject Classification:* 28A12, 28A78, 28A80, 11M26, 11M41, 37A45, 37C45, 37F10, 58B20, 58C40, **AMS members US$98.40**, List US$123, Order code CONM/600



Fractal Geometry and Dynamical Systems in Pure and Applied Mathematics II

Fractals in Applied Mathematics

David Carfì, *University of Messina, Italy*, **Michel L. Lapidus**, *University of California, Riverside, CA*, **Erin P. J. Pearse**, *California Polytechnic State University, San Luis Obispo, CA*, and **Machiel van Frankenhuijsen**, *Utah Valley University, Orem, UT*, Editors

This volume contains the proceedings from three conferences: the PISRS 2011 International Conference on Analysis, Fractal Geometry, Dynamical Systems and Economics, held November 8–12, 2011 in Messina, Italy; the AMS Special Session on Fractal Geometry in Pure and Applied Mathematics, in memory of Benoît Mandelbrot, held January 4–7, 2012, in Boston, MA; and the AMS Special Session on Geometry and Analysis on Fractal Spaces, held March 3–4, 2012, in Honolulu, HI.

Articles in this volume cover fractal geometry and various aspects of dynamical systems in applied mathematics and the applications to other sciences. Also included are articles discussing a variety of connections between these subjects and various areas of physics, engineering, computer science, technology, economics and finance, as well as of mathematics (including probability theory in relation with statistical physics and heat kernel estimates, geometric measure theory, partial differential equations in relation with condensed matter physics, global analysis on non-smooth spaces, the theory of billiards, harmonic analysis and spectral geometry).

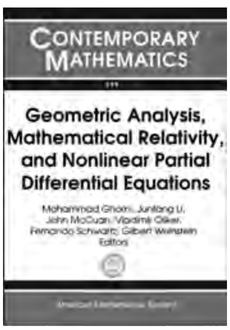
The companion volume (Contemporary Mathematics, Volume 600) focuses on the more mathematical aspects of fractal geometry and dynamical systems.

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

N. Kajino, Non-regularly varying and nonperiodic oscillation of the on-diagonal heat kernels on self-similar fractals; **T. Kennedy** and **G. F. Lawler**, Lattice effects in the scaling limit of the two-dimensional self-avoiding walk; **R. Kesler** and **B. Steinhurst**, The Casimir effect on Laakso spaces; **N. Lal** and **M. L. Lapidus**, The decimation method for Laplacians on fractals: Spectra and complex dynamics; **M. L. Lapidus** and **R. G. Niemeyer**, The current state of fractal billiards; **C. Lévy-Leduc** and **M. S. Taqqu**, Long-range dependence and the rank of decompositions; **B. Li**, **N.-R. Shieh**, and **Y. Xiao**, Hitting probabilities of the random covering sets; **Y. Naito**, **M. Pašić**, **S. Tanaka**, and **D. Žubrinić**, Fractal oscillations near domain boundary of radially symmetric solutions of p-Laplace equations; **J. R. Quinn**, Applications of the contraction mapping principle; **D. Schilirò**, Economics and psychology. Perfect rationality versus bounded rationality.

Contemporary Mathematics, Volume 601

November 2013, approximately 371 pages, Softcover, ISBN: 978-0-8218-9148-3, LC 2013013894, 2010 *Mathematics Subject Classification:* 28A80, 37D50, 37F10, 58J35, 58J50, 58J65, 60J45, 60K35, 81Q35, 91G80, **AMS members US$98.40**, List US$123, Order code CONM/601



Geometric Analysis, Mathematical Relativity, and Nonlinear Partial Differential Equations

Mohammad Ghomi, *Georgia Institute of Technology, Atlanta, GA*, **Junfang Li**, *University of Alabama at Birmingham, AL*, **John McCuan**, *Georgia Institute of Technology, Atlanta, GA*, **Vladimir Oliker**, *Emory University, Atlanta, GA*, **Fernando Schwartz**, *University of Tennessee, Knoxville, TN*, and **Gilbert Weinstein**, *University of Alabama at Birmingham, AL*, Editors

This volume presents the proceedings of the Southeast Geometry Seminar for the meetings that took place bi-annually between the fall of 2009 and the fall of 2011, at Emory University, Georgia Institute of Technology, University of Alabama Birmingham, and the University of Tennessee. Talks at the seminar are devoted to various aspects of geometric analysis and related fields, in particular, nonlinear partial differential equations, general relativity, and geometric topology.

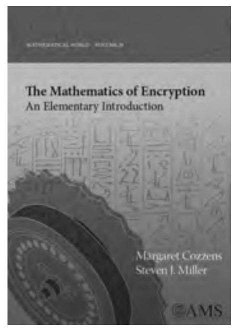
Articles in this volume cover the following topics: a new set of axioms for General Relativity, CR manifolds, the Mañé Conjecture, minimal surfaces, maximal measures, pendant drops, the Funk-Radon-Helgason method, ADM-mass and capacity, and extrinsic curvature in metric spaces.

Contents: **H. L. Bray**, On dark matter, spiral galaxies, and the axioms of general relativity; **S. Chanillo**, **H.-L. Chiu**, and **P. Yang**, Embedded three-dimensional CR manifolds and the non-negativity of Paneitz operators; **A. Figalli** and **L. Rifford**, Aubry sets, Hamilton-Jacobi equations, and the Mañé conjecture; **A. Fraser** and **R. Schoen**, Minimal surfaces and eigenvalue problems; **H. König** and **A. Koldobsky**, On the maximal measure of sections of the n-cube; **J. McCuan**, Extremities of stability for pendant drops; **B. Rubin**, On the Funk-Radon-Helgason inversion method in integral geometry; **F. Schwartz**, Inequalities for the ADM-mass and capacity of asymptotically flat manifolds with minimal boundary; **J. Wong**, Bounded extrinsic curvature of subsets of metric spaces.

Contemporary Mathematics, Volume 599

October 2013, 254 pages, Softcover, ISBN: 978-0-8218-9149-0, LC 2013013611, 2010 *Mathematics Subject Classification:* 53Cxx, 58Jxx, 32V05, 32V20, 44A12, 52A20, 35F21, 49L25, 76D45, 49Q10; 47G10, **AMS members US$71.20**, List US$89, Order code CONM/599

Applications



The Mathematics of Encryption

An Elementary Introduction

Margaret Cozzens, *DIMACS, Rutgers University, Piscataway, NJ*, and **Steven J. Miller**, *Williams College, Williamstown, MA*

How quickly can you compute the remainder when dividing 109837^{97} by 120143? Why would you even want to compute this? And what does this have to do with cryptography?

Modern cryptography lies at the intersection of mathematics and computer sciences, involving number theory, algebra, computational complexity, fast algorithms, and even quantum mechanics. Many people think of codes in terms of spies, but in the information age, highly mathematical codes are used every day by almost everyone, whether at the bank ATM, at the grocery checkout, or at the keyboard when you access your email or purchase products online.

This book provides a historical and mathematical tour of cryptography, from classical ciphers to quantum cryptography. The authors introduce just enough mathematics to explore modern encryption methods, with nothing more than basic algebra and some elementary number theory being necessary. Complete expositions are given of the classical ciphers and the attacks on them, along with a detailed description of the famous Enigma system. The public-key system RSA is described, including a complete mathematical proof that it works. Numerous related topics are covered, such as efficiencies of algorithms, detecting and correcting errors, primality testing and digital signatures. The topics and exposition are carefully chosen to highlight mathematical thinking and problem solving. Each chapter ends with a collection of problems, ranging from straightforward applications to more challenging problems that introduce advanced topics. Unlike many books in the field, this book is aimed at a general liberal arts student, but without losing mathematical completeness.

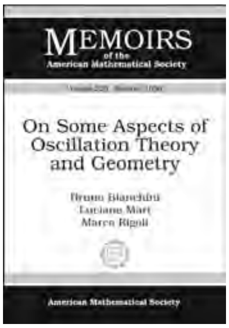
This item will also be of interest to those working in number theory.

Contents: Historical introduction; Classical cryptology: Methods; Enigma and Ultra; Classical cryptography: Attacks I; Classical cryptography: Attacks II; Modern symmetric encryption; Introduction to public-channel cryptography; Public-channel cryptography; Error detecting and correcting codes; Modern cryptography; Primality testing and factorization; Solutions to selected exercises; Bibliography; Index.

Mathematical World, Volume 29

October 2013, approximately 348 pages, Softcover, ISBN: 978-0-8218-8321-1, LC 2013016920, 2010 *Mathematics Subject Classification:* 94A60, 68P25, 01-01, **AMS members US$39.20**, List US$49, Order code MAWRLD/29

Differential Equations



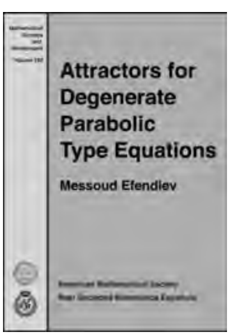
On Some Aspects of Oscillation Theory and Geometry

Bruno Bianchini, *Università degli Studi di Padova, Italy*, **Luciano Mari**, *Universidade Federal do Ceará, Fortaleza, Brazil*, and **Marco Rigoli**, *Università degli Studi di Milano, Italy*

Contents: Introduction; The geometric setting; Some geometric examples related to oscillation theory; On the solutions of the ODE $(vz')' + Avz = 0$; Below the critical curve; Exceeding the critical curve; Much above the critical curve; Bibliography.

Memoirs of the American Mathematical Society, Volume 225, Number 1056

August 2013, 195 pages, Softcover, ISBN: 978-0-8218-8799-8, LC 2013018354, 2010 *Mathematics Subject Classification:* 34K11, 58C40, 35J15; 35J10, 53C21, 57R42, **AMS members US$68.80**, List US$86, Order code MEMO/225/1056



Attractors for Degenerate Parabolic Type Equations

Messoud Efendiev, *Hemholtz Center Munich, Neuherberg, Germany*

This book deals with the long-time behavior of solutions of degenerate parabolic dissipative equations arising in the study of biological, ecological, and physical problems. Examples include porous media equations, p-Laplacian and doubly nonlinear equations, as well as degenerate diffusion equations with chemotaxis and ODE-PDE coupling systems. For the first time, the long-time dynamics of various classes of degenerate parabolic equations, both semilinear and quasilinear, are systematically studied in terms of their global and exponential attractors.

The long-time behavior of many dissipative systems generated by evolution equations of mathematical physics can be described in terms of global attractors. In the case of dissipative PDEs in bounded domains, this attractor usually has finite Hausdorff and fractal dimension. Hence, if the global attractor exists, its defining property guarantees that the dynamical system reduced to the attractor contains all of the nontrivial dynamics of the original system. Moreover, the reduced phase space is really "thinner" than the initial phase space. However, in contrast to nondegenerate parabolic type equations, for a quite large class of degenerate parabolic type equations, their global attractors can have infinite fractal dimension.

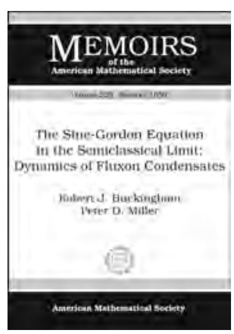
The main goal of the present book is to give a detailed and systematic study of the well-posedness and the dynamics of the semigroup associated to important degenerate parabolic equations in terms of their global and exponential attractors. Fundamental topics include existence of attractors, convergence of the dynamics and the rate of convergence, as well as the determination of the fractal dimension and the Kolmogorov entropy of corresponding attractors. The analysis and results in this book show that there are new effects related to the attractor of such degenerate equations that cannot be observed in the case of nondegenerate equations in bounded domains.

Contents: Auxiliary materials; Global attractors for autonomous evolution equations; Exponential attractors; Porous medium equation in homogeneous media: Long-time dynamics; Porous medium equation in heterogeneous media: Long-time dynamics; Long-time dynamics of p-Laplacian equations: Homogeneous-media; Long-time dynamics of p-Laplacian equations: Heterogeneous media; Doubly nonlinear degenerate parabolic equations; On a class of PDEs with degenerate diffusion and chemotaxis: Autonomous case; On a class of PDEs with degenerate diffusion and chemotaxis: Nonautonomous case; ODE-PDE coupling arising in the modelling of a forest ecosystem; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 192

November 2013, approximately 225 pages, Hardcover, ISBN: 978-1-4704-0985-2, 2010 *Mathematics Subject Classification:* 35K55, 35K59, 35K65, 37L05, 37L30, **AMS members US$76**, List US$95, Order code SURV/192

Mathematical Physics



The Sine-Gordon Equation in the Semiclassical Limit: Dynamics of Fluxon Condensates

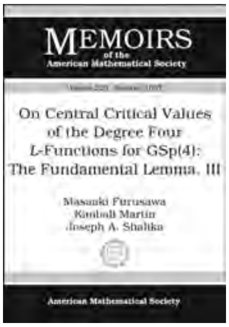
Robert J. Buckingham, *University of Cincinnati, OH*, and **Peter D. Miller**, *University of Michigan, Ann Arbor, MI*

Contents: Introduction; Formulation of the inverse problem for fluxon condensates; Elementary transformations of $\mathbf{J}(w)$; Construction of $g(w)$; Use of $g(w)$; Appendix A. Proofs of propositions concerning initial data; Appendix B. Details of the outer parametrix in cases L and R; Bibliography.

Memoirs of the American Mathematical Society, Volume 225, Number 1059

August 2013, 136 pages, Softcover, ISBN: 978-0-8218-8545-1, LC 2013018560, 2010 *Mathematics Subject Classification:* 35Q51, 35B40, 35Q15, **Individual member US$44.40**, List US$74, Institutional member US$59.20, Order code MEMO/225/1059

Number Theory



On Central Critical Values of the Degree Four L-Functions for GSp (4): The Fundamental Lemma. III

Masaaki Furusawa, *Osaka City University, Japan*, **Kimball Martin**, *University of Oklahoma, Norman, OK*, and **Joseph A. Shalika**

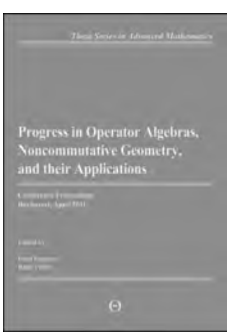
Contents: Introduction; Reduction formulas; Anisotropic Bessel orbital integral; Split Bessel and Novodvorsky orbital integrals; Rankin-Selberg orbital integral; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 225, Number 1057

August 2013, 134 pages, Softcover, ISBN: 978-0-8218-8742-4, LC 2003048027, 2010 *Mathematics Subject Classification:* 11F67; 11F46, **Individual member US$44.40**, List US$74, Institutional member US$59.20, Order code MEMO/225/1057

New AMS-Distributed Publications

Analysis



Progress in Operator Algebras, Noncommutative Geometry, and their Applications

Ionel Popescu and **Radu Purice**, *Romanian Academy, Bucharest, Romania*, Editors

This volume contains a selection of the contributions presented at the Fourth Annual Meeting of the European Noncommutative Geometry Network, held in Bucharest between April 25–30, 2011. Written by leading experts in their field, the articles cover a broad range of subjects including:

- Operator algebras
- Classification and structure
- Cyclic theory and index theory
- Interplay between harmonic analysis and topology
- KK–theory and applications
- Quantum groups
- Algebraic quantum field theory
- Quantum dynamics

This item will also be of interest to those working in mathematical physics.

A publication of the Theta Foundation. Distributed worldwide, except in Romania, by the AMS.

Contents: **R. Conti** and **W. Szymański**, Automorphisms of the Cuntz algebras; **D. E. Evans** and **M. Pugh**, Braided subfactors, spectral measures, planar algebras, and Calabi–Yau algebras associated to $SU(3)$ modular invariants; **A. de Goursac**, Non-formal deformation quantization of abelian supergroups; **A. J. Harju**, On Dirac operators and spectral geometry of compact quantum groups; **J. H. Hong**, **N. S. Larsen**, and **W. Szymański**, The Cuntz algebra $\mathcal{Q}_{\mathbb{N}}$ and C^*-algebras of product systems; **A. J. Lazar**, Centers of C^*-algebras rich in modular ideals; **J. Renault**, Continuous bounded cocycles; **C. Sämann** and **R. J. Szabo**, Quantization of 2-plectic manifolds; **B. Spisso**, First numerical approach to a Grosse-Wulkenhaar model; **J. Zahn**, (Supersymmetric) quantum electrodynamics on Moyal space.

International Book Series of Mathematical Texts

June 2013, 192 pages, Hardcover, ISBN: 978-606-8443-01-0, 2010 *Mathematics Subject Classification:* 00B15, 46-06, 47-06, 81-06, **Individual member US$35.20**, List US$58, Institutional member US$46.40, Order code THETA/18

Number Theory

Diophantine Approximation and Dirichlet Series

Hervé Queffélec and **Martine Queffélec**, *Université de Lille 1, Villeneuve d'Ascq, France*

This self-contained book is intended to be read with profit by beginners as well as researchers. It is devoted to Diophantine approximation, the analytic theory of Dirichlet series, and some connections between these two domains, which often occur through the Kronecker approximation theorem. Accordingly, the book is divided into seven chapters, the first three of which present tools from commutative harmonic analysis, including a sharp form of the uncertainty principle, ergodic theory and Diophantine approximation to be used in the sequel. A presentation of continued fraction expansions, including the mixing property of the Gauss map, is given.

Chapters four and five present the general theory of Dirichlet series, with classes of examples connected to continued fractions, the famous Bohr point of view, and then the use of random Dirichlet series to produce non-trivial extremal examples, including sharp forms of the Bohnenblust–Hille theorem. Chapter six deals with Hardy–Dirichlet spaces, which are new and useful Banach spaces of analytic functions in a half-plane. Finally, chapter seven presents the Bagchi–Voronin universality theorems, for the zeta function, and r-tuples of L-functions. The proofs, which mix hilbertian geometry, complex and harmonic analysis, and ergodic theory, are a very good illustration of the material studied earlier.

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

Contents: A review of commutative harmonic analysis; Ergodic theory and Kronecker's theorems; Diophantine approximation; General properties of Dirichlet series; Probabilistic methods for Dirichlet series; Hardy spaces of Dirichlet series; Voronin type theorems; Index.

Hindustan Book Agency

July 2013, 244 pages, Softcover, ISBN: 978-93-80250-53-3, 2010 *Mathematics Subject Classification:* 11-02, **AMS members US$41.60**, List US$52, Order code HIN/63

Classified Advertisements

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

MARYLAND

JOHNS HOPKINS UNIVERSITY
Department of Mathematics
J. J. Sylvester Assistant Professor

The Department of Mathematics invites applications for 2-year and 3-year non-tenure-track Assistant Professor positions beginning Fall 2014. The J.J. Sylvester Assistant Professorship is offered to Ph.D. recipients who are beginning their research career and have outstanding research potential. Candidates in all areas of pure mathematics are encouraged to apply. The teaching load is three courses per academic year. To submit your application, go to `http://www.mathjobs.org/jobs/jhu`. Submit the AMS cover sheet, your curriculum vitae, and research and teaching statements, and ensure that at least four letters of recommendation, one of which addresses teaching, are submitted by the reference writers. If you are unable to apply online, you may send application materials to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218. If you have questions concerning this position, please write to `cpoole@jhu.edu`. Preference will be given to applications received by December 1, 2013. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

000022

JOHNS HOPKINS UNIVERSITY
Department of Mathematics
Tenure-Track Assistant Professor

The Department of Mathematics invites applications for two positions at the tenure-track Assistant Professor level beginning July 1, 2014. A Ph.D. degree or its equivalent and demonstrated promise in research and commitment to teaching are required. Candidates in all areas of pure mathematics are encouraged to apply. To submit your application, go to `http://www.mathjobs.org/jobs/jhu`. Submit the AMS cover sheet, your curriculum vitae, list of publications, and research and teaching statements, and ensure that at least four letters of recommendation, one of which addresses teaching, are submitted by the reference writers. If you are unable to apply online, you may send application materials to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218. If you have questions concerning this position, please write to `cpoole@jhu.edu`. Preference will be given to applications received by October 15, 2013. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

000023

JOHNS HOPKINS UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for tenured positions at the Associate and Full Professor level beginning fall 2014 or later. The department is seeking candidates in areas of pure mathematics that fit in with the existing areas of the department, with an emphasis on analysis and geometry. Applications may be submitted online at `http://www.mathjobs.org/jobs/jhu` or mailed to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218. Submit the AMS cover sheet, a curriculum vitae, a list of publications, and the names and addresses of suggested references. The department will assume the responsibility of soliciting letters of evaluation and will provide evaluators with a summary of policies on confidentiality of letters of evaluation. If you have questions concerning this position, please write to `cpoole@jhu.edu`. Applications received by October 15, 2013, will be given priority. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

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Suggested uses for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The 2013 rate is \$3.50 per word with a minimum two-line headline. No discounts for multiple ads or the same ad in consecutive issues. For an additional \$10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified ads.

Upcoming deadlines for classified advertising are as follows: October 2013 issue–July 26, 2013; November 2013 issue–August 29, 2013; December 2013 issue–September 30, 2013; January 2014 issue–October 29, 2013; February 2014 issue–December 2, 2013; March 2014 issue–January 2, 2014.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

TENNESSEE

VANDERBILT UNIVERSITY
Tenure-Track and Tenured Faculty Positions

The Department of Mathematics at Vanderbilt University invites applications for a tenured, rank-open position and a tenure-track position (Assistant Professor) beginning fall 2014. Exceptional candidates from any area of pure or applied mathematics are encouraged to apply, but for the junior position priority will be given to applicants in applied analysis or one of the research areas of the department. The department especially encourages applications from women and minorities.

We are looking for individuals with an outstanding record in research and demonstrated excellence in teaching. A Ph.D. degree is required. Qualified candidates should submit their application materials electronically through the AMS website Mathjobs.org via the link `http://www.mathjobs.org/jobs`. Alternatively, application materials may be sent to: Faculty Hiring Committee, Vanderbilt University, Department of Mathematics, 1326 Stevenson Center, Nashville, TN 37240. These materials should include a letter of application, a curriculum vitae, a publication list, a description of current and planned research, a teaching statement, at least four letters of recommendation, and the AMS Cover Sheet. One of the letters must discuss the applicant's teaching qualifications. Senior applicants should also include three names of suggested reviewers. Reference letter writers should be asked to submit their letters online through `MathJobs.Org`. Evaluation of the applications will commence on November 1, 2013, and continue until the position is filled. For information about the Department of Mathematics at Vanderbilt University, please consult the Web at `http://www.vanderbilt.edu/math/`.

Vanderbilt is an Equal Employment Opportunity/Affirmative Action Employer.

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VANDERBILT UNIVERSITY
Non-Tenure-Track Assistant Professor Positions

We invite applications for several visiting and non tenure-track assistant professor positions in the research areas of the Mathematics Department beginning fall 2014. These positions will have variable terms and teaching loads but most will be three-year appointments with a 2-2 teaching load. We anticipate that some of these appointments will carry a 1-1 teaching load and provide a stipend to support research.

We are looking for individuals with outstanding research potential and a strong commitment to excellence in teaching. Preference will be given to recent doctorates. Submit your application and supporting materials electronically through the AMS website `Mathjobs.org` via the link `http://www.mathjobs.org/jobs`. Alternatively, application materials may be sent to: NTT Appointments Committee, Vanderbilt University, Department of Mathematics, 1326 Stevenson Center, Nashville, TN 37240. These materials should include a letter of application, a curriculum vitae, a publication list, a research statement, a teaching statement, at least four letters of recommendation and the AMS Cover Sheet. One of the letters must discuss the applicant's teaching qualifications. Reference letter writers should be asked to submit their letters online through `Mathjobs.org`. Evaluation of the applications will commence on December 1, 2013, and continue until the positions are filled. For information about the Department of Mathematics at Vanderbilt University, please consult the Web at `http://www.vanderbilt.edu/math/`.

Vanderbilt is an Equal Employment Opportunity/Affirmative Action Employer. Women and minorities are especially invited to apply.

000026

AMERICAN MATHEMATICAL SOCIETY

AMS to Launch New

Open Access Research Journals

Beginning in 2014, the AMS is pleased to offer two new gold open access research journals. This advancement is motivated by encouragement from research libraries, prompting from the mathematical community, directives from research sponsors, and the need for a transition of scholarly publishing to open access. The two new journals, *Proceedings of the American Mathematical Society, Series B*, and *Transactions of the American Mathematical Society, Series B*, will serve as companions to the subscription journals *Proceedings* and *Transactions of the AMS*. Each of the new journals will be electronic-only and freely available online, supported by Article Processing Charges designed to cover the Society's publication costs (these charges are typically paid by a funding agency or by the author's institution, and are not expected to be paid by the author personally). In order to assure the high editorial standard of each new journal, *Proceedings B* and *Transactions B* will share common editorial boards, and thus submission procedures, with their companion journals. In addition, editorial decisions will be completely independent of whether a paper is intended for the open access journal or its subscription counterpart.

This entry into open access publishing is a significant first for the AMS, which prior to this point has not had a method for accommodating authors who wish to publish under a "gold" open access model. The two new journals will provide immediate unrestricted access to the publisher's final version of the paper and allows immediate deposit of the version of record in other repositories. Research and library communities in particular will benefit from this movement toward open access, as it provides the AMS with an opportunity to publish more high-quality literature in freely accessible research journals.

The open access publication option will be available starting September 1, 2013 for all articles accepted by the *Proceedings* and *Transactions of the AMS* editorial boards. New articles should be submitted via www.ams.org/procsubmit or www.ams.org/transubmit, and the open access publication decision may be determined by the author upon notification of acceptance.

The Article Processing Charges are:

- *Proceedings of the AMS, Series B*: List Price $1,500 (2014 discount price $750)
- *Transactions of the AMS, Series B*: List Price $2,750 (2014 discount price $1,400)

Further information will become available on **www.ams.org** as the journals approach their 2014 release date.

125th Anniversary

AMS

AMERICAN MATHEMATICAL SOCIETY

Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Louisville, Kentucky

University of Louisville

October 5–6, 2013

Saturday – Sunday

Meeting #1092

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: June/July 2013
Program first available on AMS website: August 22, 2013
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 34, Issue 3

Deadlines

For organizers: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael Hill, University of Virginia, *Framed manifolds and equivariant homotopy: A solution to the Kervaire Invariant One problem.*

Suzanne Lenhart, University of Tennessee and NIMBioS, *Using optimal control of PDEs to investigate population questions.*

Ralph McKenzie, Vanderbilt University, *A perspective on fifty years of work, delight and discovery in general algebra.*

Victor Moll, Tulane University, *2-adic valuations of classical sequences: A collection of examples.*

Special Sessions

Algebraic Coding Theory, **Steve Szabo**, Eastern Kentucky University, and **Heide Gluesing-Luerssen**, University of Kentucky.

Algebraic Cryptography, **Daniel Smith**, University of Louisville.

Applied Analysis and Inverse Problems, **Peijun Li**, Purdue University, **Jiguang Sun**, Michigan Technological University, and **Yongzhi Steve Xu**, University of Louisville.

Combinatorial Commutative Algebra, **Juan Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

Commutative Rings, Ideals, and Modules, **Ela Celikbas** and **Olgur Celikbas**, University of Missouri-Columbia.

Extremal Graph Theory, **Jozsef Balogh**, University of Illinois at Urbana-Champaign, and **Louis DeBiasio** and **Tao Jiang**, Miami University, Oxford, OH.

Finite Universal Algebra, **Ralph McKenzie**, Vanderbilt University, and **Matthew Valeriote**, McMaster University.

Fixed Point Theorems and Applications to Integral, Difference, and Differential Equations, **Jeffrey W. Lyons**, Nova Southeastern University, and **Jeffrey T. Neugebauer**, Eastern Kentucky University.

Harmonic Analysis and Partial Differential Equations, **Russell Brown** and **Katharine Ott**, University of Kentucky.

History of Mathematics and Its Use in Teaching, **Daniel J. Curtin**, Northern Kentucky University, and **Daniel E. Otero**, Xavier University.

Homogenization of Partial Differential Equations, **Zhongwei Shen**, University of Kentucky, and **Yifeng Yu**, University of California, Irvine.

Mathematical Analysis of Complex Fluids and Flows, **Xiang Xu**, Carnegie Mellon University, and **Changyou Wang**, University of Kentucky.

Mathematical Issues in Ecological and Epidemiological Modeling, **K. Renee Fister**, Murray State University, and **Suzanne Lenhart**, University of Tennessee.

Mathematical Models in Biology and Physiology, **Yun Kang**, Arizona State University, and **Jiaxu Li**, University of Louisville.

Partial Differential Equations from Fluid Mechanics, **Changbing Hu**, University of Louisville, and **Florentina Tone**, University of West Florida.

Partially Ordered Sets, **Csaba Biro** and **Stephen J. Young**, University of Louisville.

Recent Advances on Commutative Algebra and Its Applications, **Hamid Kulosman** and **Jinjia Li**, University of Louisville, and **Hamid Rahmati**, Miami University.

Set Theory and Its Applications, **Paul Larson**, Miami University, **Justin Moore**, Cornell University, and **Grigor Sargsyan**, Rutgers University.

Spreading Speeds and Traveling Waves in Spatial-Temporal Evolution Systems, **Bingtuan Li**, University of Louisville, and **Roger Lui**, Worcester Polytechnic Institute.

The Work of Mathematicians and Mathematics Departments in Mathematics Education, **Benjamin Braun**, **Carl Lee**, and **David Royster**, University of Kentucky.

Topological Dynamics and Ergodic Theory, **Alica Miller**, University of Louisville, and **Joe Rosenblatt**, University of Illinois at Urbana-Champaign.

Weak Convergence in Probability and Statistics, **Cristina Tone**, **Ryan Gill**, and **Kiseop Lee**, University of Louisville.

Philadelphia, Pennsylvania

Temple University

October 12–13, 2013

Saturday – Sunday

Meeting #1093

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June/July 2013
Program first available on AMS website: August 29, 2013
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 34, Issue 3

Deadlines

For organizers: Expired
For abstracts: August 20, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Patrick Gerald Brosnan, University of Maryland, *Normal functions*.

Xiaojun Huang, Rutgers University at New Brunswick, *Equivalence problems in several complex variables*.

Barry Mazur, Harvard University, *Arithmetic statistics: Elliptic curves and other mathematical objects* (Erdős Memorial Lecture).

Robert Strain, University of Pennsylvania, *On the Boltzmann equation without angular cut-off*.

Special Sessions

Analysis and Computing for Electromagnetic Waves (Code: SS 10A), **David Ambrose** and **Shari Moskow**, Drexel University.

Combinatorial Commutative Algebra (Code: SS 12A), **Tái Huy Há**, Tulane University, and **Fabrizio Zanello**, Massachusetts Institute of Technology and Michigan Technological University.

Contact and Symplectic Topology (Code: SS 5A), **Joshua M. Sabloff**, Haverford College, and **Lisa Traynor**, Bryn Mawr College.

Difference Equations and Applications (Code: SS 9A), **Michael Radin**, Rochester Polytechnic Institute, and **Faina Berezovskaya**, Howard University.

Geometric Aspects of Topology and Group Theory (Code: SS 17A), **David Futer**, Temple University, and **Ben McReynolds**, Purdue University.

Geometric Topology of Knots and 3-manifolds (Code: SS 16A), **Abhijit Champanerkar**, **Ilya Kofman**, and **Joseph Maher**, College of Staten Island and The Graduate Center, City University of New York.

Geometric and Spectral Analysis (Code: SS 3A), **Thomas Krainer**, Pennsylvania State Altoona, and **Gerardo A. Mendoza**, Temple University.

Higher Structures in Algebra, Geometry and Physics (Code: SS 2A), **Jonathan Block**, University of Pennsylvania, **Vasily Dolgushev**, Temple University, and **Tony Pantev**, University of Pennsylvania.

History of Mathematics in America (Code: SS 4A), **Thomas L. Bartlow**, Villanova University, **Paul R. Wolfson**, West Chester University, and **David E. Zitarelli**, Temple University.

Mathematical Biology (Code: SS 8A), **Isaac Klapper**, Temple University, and **Kathleen Hoffman**, University of Maryland, Baltimore County.

Meshfree, Particle, and Characteristic Methods for Partial Differential Equations (Code: SS 21A), **Toby Driscoll** and **Louis Rossi**, University of Delaware, and **Benjamin Seibold**, Temple University.

Modular Forms and Modular Integrals in Memory of Marvin Knopp (Code: SS 20A), **Helen Grundman**, Bryn Mawr College, and **Wladimir Pribitkin**, College of Staten Island and the Graduate Center, City University of New York.

Multiple Analogues of Combinatorial Special Numbers and Associated Identities (Code: SS 11A), **Hasan Coskun**, Texas A&M University Commerce.

Nonlinear Elliptic and Wave Equations and Applications (Code: SS 15A), **Nsoki Mavinga**, Swarthmore College, and **Doug Wright**, Drexel University.

Parabolic Evolution Equations of Geometric Type (Code: SS 18A), **Xiaodong Cao**, Cornell University, **Longzhi Lin**, Rutgers University, and **Peng Wu**, Cornell University.

Partial Differential Equations, Stochastic Analysis, and Applications to Mathematical Finance (Code: SS 14A), **Paul Feehan** and **Ruoting Gong**, Rutgers University, and **Camelia Pop**, University of Pennsylvania.

Recent Advances in Harmonic Analysis and Partial Differential Equations (Code: SS 1A), **Cristian Gutiérrez** and **Irina Mitrea**, Temple University.

Recent Developments in Noncommutative Algebra (Code: SS 6A), **Edward Letzter** and **Martin Lorenz**, Temple University.

Representation Theory, Combinatorics and Categorification (Code: SS 19A), **Corina Calinescu**, New York City College of Technology, City University of New York, **Andrew Douglas**, New York City College of Technology and Graduate Center, City University of New York, and **Joshua Sussan** and **Bart Van Steirteghem**, Medgar Evers College, City University of New York.

Several Complex Variables and CR Geometry (Code: SS 7A), **Andrew Raich**, University of Arkansas, and **Yuan Zhang**, Indiana University-Purdue University Fort Wayne.

The Geometry of Algebraic Varieties (Code: SS 13A), **Karl Schwede**, Pennsylvania State University, and **Zsolt Patakfalvi**, Princeton University.

St. Louis, Missouri

Washington University

October 18–20, 2013

Friday – Sunday

Meeting #1094

Central Section
Associate secretary: Georgia M. Benkart
Announcement issue of *Notices*: August 2013
Program first available on AMS website: September 5, 2013
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 34, Issue 4

Deadlines

For organizers: Expired
For abstracts: August 27, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Ronny Hadani, University of Texas at Austin, *Title to be announced*.

Effie Kalfagianni, Michigan State University, *Title to be announced*.

Jon Kleinberg, Cornell University, *Title to be announced*.

Vladimir Sverak, University of Minnesota, *Title to be announced*.

Special Sessions

Advances in Difference, Differential, and Dynamic Equations with Applications (Code: SS 12A), **Elvan Akin**, Missouri S&T University, **Youssef Raffoul**, University of Dayton, and **Agacik Zafer**, American University of the Middle East.

Advances in Mathematical Methods for Disease Modeling (Code: SS 21A), **Jimin Ding**, Washington University in St. Louis, **Necibe Tuncer**, University of Tulsa, and **Naveen K. Vaidya**, University of Missouri-Kansas City.

Algebraic Cycles and Coherent Sheaves (Code: SS 19A), **Roya Beheshti**, **Matt Kerr**, and **N. Mohan Kumar**, Washington University, St. Louis.

Algebraic and Combinatorial Invariants of Knots (Code: SS 1A), **Heather Dye**, McKendree University, **Allison Henrich**, Seattle University, **Aaron Kaestner**, North Park University, and **Louis Kauffman**, University of Illinois.

Automorphic Forms and Representation Theory (Code: SS 7A), **Dubravka Ban** and **Joe Hundley**, Southern Illinois University, and **Shuichiro Takeda**, University of Missouri, Columbia.

Commutative Algebra (Code: SS 11A), **Lianna Sega**, University of Missouri, Kansas City, and **Hema Srinivasan**, University of Missouri, Columbia.

Computability Across Mathematics (Code: SS 2A), **Wesley Calvert**, Southern Illinois University, and **Johanna Franklin**, University of Connecticut.

Convex Geometry and its Applications (Code: SS 16A), **Susanna Dann**, **Alexander Koldobsky**, and **Peter Pivovarov**, University of Missouri.

Geometric Aspects of 3-Manifold Invariants (Code: SS 10A), **Oliver Dasbach**, Louisiana State University, and **Effie Kalfagianni**, Michigan State University.

Geometric Topology in Low Dimensions (Code: SS 4A), **William H. Kazez**, University of Georgia, and **Rachel Roberts**, Washington University in St. Louis.

Groupoids in Analysis and Geometry (Code: SS 6A), **Alex Kumjian**, University of Nevada at Reno, **Markus Pflaum**, University of Colorado, and **Xiang Tang**, Washington University in St. Louis.

Interactions between Geometric and Harmonic Analysis (Code: SS 3A), **Leonid Kovalev**, Syracuse University, and **Jeremy Tyson**, University of Illinois, Urbana-Champaign.

Linear and Non-linear Geometry of Banach Spaces (Code: SS 13A), **Daniel Freeman** and **Nirina Lovasoa Randrianarivony**, St. Louis University.

Noncommutative Rings and Modules (Code: SS 5A), **Greg Marks** and **Ashish Srivastava**, St. Louis University.

Operator Theory (Code: SS 9A), **John McCarthy**, Washington University in St. Louis.

PDEs of Fluid Mechanics (Code: SS 17A), **Roman Shvydkoy**, University of Illinois Chicago, and **Vladimir Sverak**, University of Minnesota.

Spectral, Index, and Symplectic Geometry (Code: SS 15A), **Alvaro Pelayo** and **Xiang Tang**, Washington University, St. Louis.

Statistical Properties of Dynamical Systems (Code: SS 14A), **Timothy Chumley** and **Renato Feres**, Washington University in St. Louis, and **Hongkun Zhang**, University of Massachusetts, Amherst.

Topological Combinatorics (Code: SS 20A), **John Shareshian**, Washington University, St. Louis, and **Russ Woodroofe**, Mississippi State University.

Wavelets, Frames, and Related Expansions (Code: SS 8A), **Marcin Bownik**, University of Oregon, **Darrin Speegle**, Saint Louis University, and **Guido Weiss**, Washington University, St. Louis.

p-local Group Theory, Fusion Systems, and Representation Theory (Code: SS 18A), **Justin Lynd**, Rutgers University, and **Julianne Rainbolt**, Saint Louis University.

Riverside, California

University of California Riverside

November 2–3, 2013

Saturday – Sunday

Meeting #1095

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2013
Program first available on AMS website: September 19, 2013
Program issue of electronic *Notices*: November 2013
Issue of *Abstracts*: Volume 34, Issue 4

Deadlines

For organizers: Expired
For abstracts: September 10, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Michael Christ, University of California, Berkeley, *Title to be announced*.

Mark Gross, University of California, San Diego, *Title to be announced*.

Matilde Marcolli, California Institute of Technology, *Title to be announced*.

Paul Vojta, University of California, Berkeley, *Title to be announced*.

Special Sessions

Algebraic Structures in Knot Theory (Code: SS 19A), **Allison Henrich**, Seattle University, and **Sam Nelson**, Claremont McKenna College.

Analysis and Geometry of Metric Spaces (Code: SS 12A), **Asuman G. Aksoy**, Claremont McKenna College, and **Zair Ibragimov**, California State University, Fullerton.

Categorification in Representation Theory (Code: SS 15A), **Aaron Lauda** and **David Rose**, University of Southern California.

Commutative Algebra and its Interaction with Algebraic Geometry and Combinatorics (Code: SS 10A), **Kuei-Nuan Lin** and **Paolo Mantero**, University of California, Riverside.

Computational Problems on Large Graphs and Applications (Code: SS 16A), **Kevin Costello** and **Laurent Thomas**, University of California, Riverside.

Computer, Mathematics, Imaging, Technology, Network, Health, Big Data, and Statistics (Code: SS 3A), **Subir Ghosh**, University of California, Riverside.

Developments in Markov Chain Theory and Methodology (Code: SS 2A), **Jason Fulman**, University of California, Riverside, and **Mark Huber**, Claremont McKenna College.

Diophantine Geometry and Nevanlinna Theory (Code: SS 14A), **Aaron Levin**, Michigan State University, **David McKinnon**, University of Waterloo, and **Paul Vojta**, University of California, Berkeley.

Dynamical Systems (Code: SS 13A), **Nicolai Haydn**, University of Southern California, and **Huyi Hu**, Michigan State University.

Fluids and Boundaries (Code: SS 5A), **James P. Kelliher**, **Juhi Jang**, and **Gung-Min Gie**, University of California, Riverside.

Fractal Geometry, Dynamical Systems, and Mathematical Physics (Code: SS 9A), **Michel L. Lapidus**, University of California, Riverside, **Erin P. J. Pearse**, California State Polytechnic University, San Luis Obispo, and **John A. Rock**, California State Polytechnic University, Pomona.

From Harmonic Analysis to Partial Differential Equations: In Memory of Victor Shapiro (Code: SS 11A), **Alfonso Castro**, Harvey Mudd College, **Michel L. Lapidus**, University of California, Riverside, and **Adolfo J. Rumbos**, Pomona College.

Geometric Analysis (Code: SS 4A), **Zhiqin Lu**, University of California, Irvine, **Bogdan D. Suceava**, California State University, Fullerton, and **Fred Wilhelm**, University of California, Riverside.

Geometric and Combinatorial Aspects of Representation Theory (Code: SS 8A), **Wee Liang Gan** and **Jacob Greenstein**, University of California, Riverside.

Geometry of Algebraic Varieties (Code: SS 6A), **Karl Fredrickson**, University of California, Riverside, **Mark Gross**, University of California, San Diego, and **Ziv Ran**, University of California, Riverside.

Heights, Diophantine Problems, and Lattices (Code: SS 17A), **Lenny Fukshansky**, Claremont McKenna College, and **David Krumm**, University of Georgia and Claremont McKenna College.

Homotopy Theory and K-Theory (Code: SS 7A), **Julie Bergner**, University of California, Riverside, and **Christian Haesemeyer**, University of California, Los Angeles.

Teaching ODEs: Best Practices from CODEE (Community of Ordinary Differential Equations Educators) (Code: SS 18A), **Nishu Lal**, Pomona College and Pitzer College, and **Ami Radunskaya**, Pomona College.

The Mathematics of Planet Earth (Code: SS 1A), **John Baez**, University of California, Riverside.

Baltimore, Maryland

Baltimore Convention Center, Hilton Baltimore, and Baltimore Marriott Inner Harbor Hotel

January 15–18, 2014

Wednesday – Saturday

Meeting #1096

Joint Mathematics Meetings, including the 120th Annual Meeting of the AMS, 97th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia M. Benkart
Announcement issue of *Notices*: October 2013
Program first available on AMS website: November 1, 2013
Program issue of electronic *Notices*: January 2013
Issue of *Abstracts*: Volume 35, Issue 1

Deadlines

For organizers: Expired
For abstracts: September 17, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/national.html`.

Joint Invited Addresses

Benson Farb, University of Chicago, *Title to be announced* (AMS-MAA Invited Address).

Eitan Grinspun, Columbia University, *Title to be announced* (MAA-AMS-SIAM Gerald and Judith Porter Public Lecture).

Carl Pomerance, Dartmouth College, *Title to be announced* (AMS-MAA Invited Address).

AMS Invited Addresses

Andrew Blake, Microsoft Research Cambridge, *Title to be announced* (AMS Josiah Willard Gibbs Lecture).

Emmanuel Candès, Stanford University, *Title to be announced.*

Christopher Hacon, University of Utah, *Title to be announced.*

Dusa McDuff, Columbia University, *Title to be announced* (AMS Colloquium Lectures).

Paul Seidel, Massachusetts Institute of Technology, *Title to be announced.*

H.-T. Yau, Harvard University, *Title to be announced.*

AMS Special Sessions

Some sessions are cosponsored with other organizations. These are noted within the parenthesis at the end of each listing, where applicable.

Accelerated Advances in Higher Order Invexities/Univexities with Applications to Optimization and Mathematical Programming (Code: SS 8A), **Ram U. Verma**, International Publications USA, and **Alexander J. Zaslavski**, Technion-Israel Institute of Technology.

Advances in Analysis and PDEs (Code: SS 49A), **Tepper L. Gill** and **Daniel A. Williams**, Howard University.

Algebraic Geometry (Code: SS 50A), **Christopher Hacon**, University of Utah, and **Zsolt Patakfalvi**, Princeton University.

Algebraic Structures Motivated by Knot Theory (Code: SS 17A), **Mieczyslaw K. Dabkowski**, University of Texas at Dallas, **Jozef Przytycki**, George Washington University, and **Radmila Sazdanovic**, University of Pennsylvania.

Algebraic and Analytic Aspects of Integrable Systems and Painleve Equations (Code: SS 32A), **Anton Dzhamay**, University of Northern Colorado, **Kenichi Maruno**, University of Texas-Pan America, and **Christopher Ormerod**, California Institute of Technology.

Analytic Number Theory (Code: SS 23A), **Angel Kumchev**, Towson University, **Scott Parsell**, West Chester University, and **Gang Yu**, Kent State University.

Applied Harmonic Analysis: Large Data Sets, Signal Processing, and Inverse Problems (Code: SS 12A), **Mauro Maggioni**, Duke University, and **Naoki Saito** and **Thomas Strohmer**, University of California, Davis.

Banach Spaces, Metric Embeddings, and Applications (Code: SS 16A), **Mikhail Ostrovskii**, St. John's University, and **Beata Randrianantoanina**, Miami University.

Big Data: Mathematical and Statistical Modeling, Tools, Services, and Training (Code: SS 18A), **Ivo Dinov**, University of California Los Angeles.

Categorical Topology (Code: SS 42A), **Frédéric Mynard**, Georgia Southern University, and **Gavin Seal**, École Polytechnique Fédérale de Lausanne.

Classification Problems in Operator Algebras (Code: SS 38A), **Ionut Chifan**, University of Iowa, and **David Penneys**, University of Toronto.

Communication of Mathematics via Interactive Activities (Code: SS 47A), **Benjamin Levitt** and **Glen Whitney**, National Museum of Mathematics.

Computability in Geometry and Topology (Code: SS 39A), **Mieczyslaw Dabkowski**, University of Texas at Dallas, and **Rumen D. Dimitrov**, Western Illinois University.

De Bruijn Sequences and Their Generalizations (Code: SS 53A), **Abbas Alhakim**, American University of Beirut, and **Steven Butler**, Iowa State University.

Deformations Spaces of Geometric Structures on Low-dimensional Manifolds (Code: SS 40A), **Caleb Ashley**, Howard University, **Michelle Lee** and **Melissa Macasieb**, University of Maryland, and **Andy Sanders**, University of Illinois at Chicago.

Difference Equations and Applications (Code: SS 9A), **Michael A. Radin**, Rochester Institute of Technology.

Dispersive and Geometric Partial Differential Equations (Code: SS 1A), **Shuanglin Shao**, University of Kansas, **Chongchun Zeng**, Georgia Institute of Technology, and **Shijun Zheng**, Georgia Southern University.

Ergodic Theory and Symbolic Dynamics (Code: SS 31A), **Aimee Johnson**, Swarthmore College, and **Cesar Silva**, Williams College.

Fractal Geometry: Mathematics of Fractals and Related Topics (Code: SS 11A), **Michel Lapidus**, University of California Riverside, **Erin Pearse**, California State Polytechnic University, San Luis Obispo, **Robert Strichartz**, Cornell University, and **Machiel Van Frankenhuijsen**, Utah Valley University.

Fractional, Stochastic, and Hybrid Dynamic Systems with Applications (Code: SS 7A), **John Graef**, University of Tennessee at Chattanooga, **Gangaram S. Ladde**, University of South Florida, and **Aghalaya S. Vatsala**, University of Louisiana at Lafayette.

Geometric Applications of Algebraic Combinatorics (Code: SS 48A), **Elizabeth Beazley**, Haverford College, and **Kristina Garrett**, St. Olaf College (AMS-AWM).

Geometric Group Theory, I (a Mathematics Research Communities Session) (Code: SS 54A), **Tariq Aougab**, Yale University, **Curtis Kent**, University of Toronto, **Sang Rae Lee**, Texas A&M University, and **Emily Stark**, Tufts University.

Global Dynamics and Bifurcations of Difference Equations (Code: SS 37A), **Mustafa Kulenovic** and **Orlando Merino**, University of Rhode Island.

Heavy Tailed Probability Distributions and Their Applications (Code: SS 22A), **Tuncay Alparslan** and **John P. Nolan**, American University.

Highlighting Achievements and Contributions of Mathematicians of the African Diaspora (Code: SS 34A), **Asamoah Nkwanta**, Morgan State University, and **Talitha M. Washington**, Howard University.

History of Mathematics (Code: SS 29A), **Sloan Despeaux**, Western Carolina University, **Della Dumbaugh**, University of Richmond, and **Glen van Brummelen**, Quest University.

Homological and Characteristic p Methods in Commutative Algebra (Code: SS 4A), **Neil Epstein**, George Mason University, **Sean Sather-Wagstaff**, North Dakota State University, and **Karl Schwede**, Penn State University.

Homotopy Theory (Code: SS 20A), **Niles Johnson**, Ohio State University at Newark, **Mark W. Johnson**, Penn State University, Altoona, **Nitu Kitchloo**, Johns Hopkins University, **James Turner**, Calvin College, and **Donald Yau**, Ohio State University at Newark.

Hyperplane Arrangements and Applications (Code: SS 41A), **Takuro Abe**, Kyoto University, **Max Wakefield**, United States Naval Academy, and **Masahiko Yoshinaga**, Hokkiado University.

Logic and Probability (Code: SS 2A), **Wesley Calvert**, Southern Illinois University, **Doug Cenzer**, University of Florida, **Johanna Franklin**, University of Connecticut, and **Valentina Harizanov**, George Washington University (AMS-ASL).

Mathematics and Mathematics Education in Fiber Arts (Code: SS 14A), **Sarah-Marie Belcastro**, Smith College, and **Carolyn Yackel**, Mercer University.

Mathematics in Natural Resource Modeling (Code: SS 43A), **Shandelle Henson**, Andrews University, and **Catherine Roberts**, College of the Holy Cross.

Mathematics of Computation: Differential Equations, Linear Algebra, and Applications (Code: SS 30A), **Susanne C. Brenner**, Louisiana State University, and **Chi-Wang Shu**, Brown University (AMS-SIAM).

My Favorite Graph Theory Conjectures (Code: SS 35A), **Craig Larson**, Virginia Commonwealth University, and **Ralucca Gera**, Naval Postgraduate School.

Nineteenth Century Algebra and Analysis (Code: SS 10A), **Frank D. Grosshans**, West Chester University, **Karen H. Parshall**, University of Virginia, and **Paul R. Wolfson**, West Chester University.

Nonlinear Systems: Polynomial Equations, Nonlinear PDEs, and Applications (Code: SS 27A), **Wenrui Hao**, University of Notre Dame.

Outreach for Mathematically Talented Youth (Code: SS 45A), **Christina Eubanks-Turner**, University of Louisiana at Lafayette, **Virginia Watson**, Kennesaw State University, and **Daniel Zaharopol**, Art of Problem Solving Foundation.

Progress in Free Probability (Code: SS 26A), **Dmitry Kaliuzhnyi-Verbovetskyi**, Drexel University, and **Todd Kemp**, University of California San Diego.

Quantum Walks, Quantum Computation, and Related Topics (Code: SS 6A), **Chaobin Liu**, Bowie State University, **Takuya Machida**, University of Tokyo, **Nelson Petulante**, Bowie State University, and **Salvador E. Venegas-Andraca**, Tecnológico de Monterrey, Campus Estado de México.

Random Matrices: Theory and Applications (Code: SS 13A), **Paul Bourgade** and **Horng-Tzer Yau**, Harvard University.

Reaction Diffusion Equations and Applications (Code: SS 44A), **Jerome Goddard II**, Auburn University Montgomery, and **Ratnasingham Shivaji**, University of North Carolina Greensboro.

Recent Advances in Homogenization and Model Reduction Methods for Multiscale Phenomena (Code: SS 21A), **Silvia Jiménez Bolaños** and **Burt S. Tilley**, Worcester Polytechnic Institute.

Recent Progress in Geometric and Complex Analysis (Code: SS 3A), **Zheng Huang**, City University of New York, Graduate Center and College of Staten Island, **Longzhi Lin**, Rutgers University, and **Marcello Lucia**, City University of New York, Graduate Center & College of Staten Island.

Recent Progress in Multivariable Operator Theory (Code: SS 46A), **Ron Douglas**, Texas A&M University, and **Michael Jury**, University of Florida.

Recent Progress in the Langlands Program (Code: SS 15A), **Moshe Adrian**, University of Utah, and **Shuichiro Takeda**, University of Missouri.

Representation Theory of p-adic Groups and Automorphic Forms (Code: SS 28A), **Arsalan Chademan**, University of Kurdistan, and **Manouchehr Misaghian**, Prairie View A&M University.

Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs (Code: SS 25A), **Bernard Brooks** and **Jobby Jacobs**, Rochester Institute of Technology, **Jacqueline Jensen-Vallin**, Slippery Rock University, and **Carl Lutzer**, **Darran Narayan**, and **Tamas Wiandt**, Rochester Institute of Technology.

Set-Valued Optimization and Variational Problems with Applications (Code: SS 24A), **Akhtar Khan**, Rochester Institute of Technology, **Mau Nam Nguyen**, Portland State University, **Miguel Sama**, Universidad Nacional de Educacin e Distancia, and **Christiane Tammer**, Martin Luther University of Halle-Wittenberg.

Structural and Extremal Problems (Code: SS 19A), **Daniel Cranston**, Virginia Commonwealth University, and **Gexin Yu**, College of William & Mary.

Symplectic and Contact Structures on Manifolds with Special Holonomy (Code: SS 51A), **Sergey Grigorian**, University of Texas Pan American, **Sema Salur**, University of Rochester, and **Albert J. Todd**, University of California, Riverside.

The Changing Education of Pre-service Teachers in Light of the Common Core (Code: SS 52A), **William McCallum**, University of Arizona, **Kristin Umland**, University of New Mexico, and **Ellen Whitesides**, University of Arizona.

The Ubiquity of Dynamical Systems (Code: SS 33A), **Edray H. Goins**, Purdue University, and **Talitha M. Washington**, Howard University.

Topological Graph Theory: Structure and Symmetry (Code: SS 5A), **Jonathan L. Gross**, Columbia University, and **Thomas W. Tucker**, Colgate University.

Trends in Graph Theory (Code: SS 36A), **Ralucca Gera**, Naval Postgraduate School.

Knoxville, Tennessee

University of Tennessee, Knoxville

March 21–23, 2014

Friday – Sunday

Meeting #1097

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: January 2014
Program first available on AMS website: February 6, 2014
Program issue of electronic *Notices*: March 2014
Issue of *Abstracts*: Volume 35, Issue 2

Deadlines

For organizers: August 21, 2013
For abstracts: January 28, 2014

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Maria Chudnovsky, Columbia University, *Title to be announced* (Erdős Memorial Lecture).

Ilse Ipsen, North Carolina State University, *Title to be announced.*

Daniel Krashen, University of Georgia, *Title to be announced.*

Suresh Venapally, Emory University, *Title to be announced.*

Special Sessions

Commutative Ring Theory (in honor of the retirement of David E. Dobbs) (Code: SS 1A), **David Anderson**, University of Tennessee, Knoxville, and **Jay Shapiro**, George Mason University.

Diversity of Modeling and Optimal Control: A Celebration of Suzanne Lenhart's 60th Birthday (Code: SS 3A), **Wandi Ding**, Middle Tennessee State University, and **Renee Fister**, Murrray State University.

Fractal Geometry and Ergodic Theory (Code: SS 2A), **Mrinal Kanti Roychowdhury**, University of Texas Pan American.

Harmonic Analysis and Nonlinear Partial Differential Equations (Code: SS 5A), **J. Denzler**, **M. Frazier**, **Tuoc Phan**, and **T. Todorova**, University of Tennessee, Knoxville.

Randomized Numerical Linear Algebra (Code: SS 4A), **Ilse Ipsen**, North Carolina State University.

Baltimore, Maryland

University of Maryland, Baltimore County

March 29–30, 2014

Saturday – Sunday

Meeting #1098

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2014
Program first available on AMS website: February 26, 2014
Program issue of electronic *Notices*: March 2014
Issue of *Abstracts*: Volume 35, Issue 2

Deadlines

For organizers: August 29, 2013
For abstracts: January 28, 2014

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Maria Gordina, University of Connecticut, *Title to be announced.*

L. Mahadevan, Harvard University, *Title to be announced.*

Nimish Shah, Ohio State University, *Title to be announced.*

Dani Wise, McGill University, *Title to be announced.*

Special Sessions

Invariants in Low-Dimensional Topology (Code: SS 1A), **Jennifer Hom**, Columbia University, and **Tye Lidman**, University of Texas at Austin.

Albuquerque, New Mexico

University of New Mexico

April 5–6, 2014
Saturday – Sunday

Meeting #1099
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: January 2014
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: April 2014
Issue of *Abstracts*: To be announced

Deadlines
For organizers: September 5, 2013
For abstracts: February 11, 2014

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Anton Gorodetski, University of California, Irvine, *To be announced*.

Fan Chung Graham, University of California, San Diego, *To be announced*.

Adrian Ioana, University of California, San Diego, *To be announced*.

Karen Smith, University of Michigan, Ann Harbor, *To be announced*.

Special Sessions

Commutative Algebra (Code: SS 7A), **Daniel J. Hernandez**, University of Utah, **Karen E. Smith**, University of Michigan, and **Emily E. Witt**, University of Minnesota.

Descriptive Set Theory and its Applications (Code: SS 6A), **Alexander Kechris**, California Institute of Technology, and **Christian Rosendal**, University of Illinois, Chicago.

Interactions in Commutative Algebra (Code: SS 4A), **Louiza Fouli**, New Mexico State University, **Bruce Olberding**, New Mexico State University, and **Janet Vassilev**, University of New Mexico.

Progress in Noncommutative Analysis (Code: SS 2A), **Anna Skripka**, University of New Mexico, and **Tao Mei**, Wayne State University.

Stochastics and PDEs (Code: SS 5A), **Juraj Földes**, Institute for Mathematics and Its Applications, **Nathan Glatt-Holtz**, Institute for Mathematics and Its Applications and Virginia Tech, and **Geordie Richards**, Institute for Mathematics and Its Applications and University of Rochester.

The Inverse Problem and Other Mathematical Methods Applied in Physics and Related Sciences (Code: SS 1A), **Hanna Makaruk**, Los Alamos National Laboratory, and **Robert Owczarek**, University of New Mexico and Enfitek, Inc.

Topics in Spectral Geometry and Global Analysis (Code: SS 3A), **Ivan Avramidi**, New Mexico Institute of Mining and Technology, and **Klaus Kirsten**, Baylor University.

Lubbock, Texas

Texas Tech University

April 11–13, 2014
Friday – Sunday

Meeting #1100
Central Section
Associate secretary: Georgia M. Benkart
Announcement issue of *Notices*: February 2014
Program first available on AMS website: February 27, 2014
Program issue of electronic *Notices*: April 2014
Issue of *Abstracts*: Volume 35, Issue 2

Deadlines
For organizers: September 18, 2013
For abstracts: February 10, 2014

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Nir Avni, Northwestern University, *To be announced*.

Alessio Figalli, University of Texas, *To be announced*.

Jean-Luc Thiffeault, University of Wisconsin-Madison, *To be announced*.

Rachel Ward, University of Texas at Austin, *To be announced*.

Special Sessions

Algebraic Geometry (Code: SS 9A), **David Weinberg**, Texas Tech University.

Analysis and Applications of Dynamic Equations on Time Scales (Code: SS 2A), **Heidi Berger**, Simpson College, and **Raegan Higgins**, Texas Tech University.

Complex Function Theory and Special Functions (Code: SS 7A), **Roger W. Barnard** and **Kent Pearce**, Texas Tech University, **Kendall Richards**, Southwestern University, and **Alex Solynin** and **Brock Williams**, Texas Tech University.

Fractal Geometry and Dynamical Systems (Code: SS 3A), **Mrinal Kanti Roychowdhury**, The University of Texas-Pan American.

Homological Methods in Algebra (Code: SS 8A), **Lars W. Christensen**, Texas Tech University, **Hamid Rahmati**, Miami University, and **Janet Striuli**, Fairfield University.

Issues Regarding the Recruitment and Retention of Women and Minorities in Mathematics (Code: SS 5A), **James Valles Jr.** and **Doug Scheib**, Saint Mary-of-the-Woods College.

Qualitative Theory for Non-linear Parabolic and Elliptic Equations (Code: SS 6A), **Akif Ibragimov**, Texas Tech University, and **Peter Polacik**, University of Minnesota.

Recent Advancements in Differential Geometry and Integrable PDEs, and Their Applications to Cell Biology and Mechanical Systems (Code: SS 4A), **Giorgio Bornia**, **Akif Ibragimov**, and **Magdalena Toda**, Texas Tech University.

Topology and Physics (Code: SS 1A), **Razvan Gelca** and **Alastair Hamilton**, Texas Tech University.

Tel Aviv, Israel

Bar-Ilan University, Ramat-Gan and Tel-Aviv University, Ramat-Aviv

June 16–19, 2014

Monday – Thursday

Meeting #1101

The Second Joint International Meeting between the AMS and the Israel Mathematical Union.
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: January 2014
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/internmtgs.html.

Special Sessions

Mirror Symmetry and Representation Theory, **David Kazhdan**, Hebrew University, and **Roman Bezrukavnikov**, Massachusetts Institute of Technology.

Nonlinear Analysis and Optimization, **Boris Mordukhovich**, Wayne State University, and **Simeon Reich** and **Alexander Zaslavski**, The Technion-Israel Institute of Technology.

Qualitative and Analytic Theory of ODE's, **Yosef Yomdin**, Weizmann Institute.

Eau Claire, Wisconsin

University of Wisconsin-Eau Claire

September 20–21, 2014

Saturday – Sunday

Meeting #1102

Central Section
Associate secretary: Georgia M. Benkart
Announcement issue of *Notices*: June 2014
Program first available on AMS website: August 7, 2014
Program issue of electronic *Notices*: September 2014
Issue of *Abstracts*: Volume 35, Issue 3

Deadlines

For organizers: March 20, 2014
For abstracts: July 29, 2014

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Matthew Kahle, Ohio State University, *To be announced*.

Markus Keel, University of Minnesota, *To be announced*.

Svitlana Mayboroda, University of Minnesota, *To be announced*.

Dylan Thurston, Indiana University, *To be announced*.

Halifax, Canada

Dalhousie University

October 18–19, 2014

Saturday – Sunday

Meeting #1103

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: August 2014
Program first available on AMS website: September 5, 2014
Program issue of electronic *Notices*: October 2014
Issue of *Abstracts*: Volume 35, Issue 3

Deadlines

For organizers: March 18, 2014
For abstracts: August 19, 2014

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

François Bergeron, Université du Québec à Montréal, *Title to be announced*.

Sourav Chatterjee, New York University, *Title to be announced*.

William M. Goldman, University of Maryland, *Title to be announced*.

Sujatha Ramdorai, University of British Columbia, *Title to be announced*.

San Francisco, California

San Francisco State University

October 25–26, 2014

Saturday – Sunday

Meeting #1104

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2014
Program first available on AMS website: September 11, 2014
Program issue of electronic *Notices*: October 2014
Issue of *Abstracts*: Volume 35, Issue 4

Deadlines

For organizers: March 25, 2014
For abstracts: September 3, 2014

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Kai Behrend, University of British Columbia, Vancouver, Canada, *To be announced*.

Kiran S. Kedlaya, University of California, San Diego, *To be announced*.

Julia Pevtsova, University of Washington, Seattle, *To be announced*.

Burt Totaro, University of California, Los Angeles, *To be announced*.

Special Sessions

Algebraic Geometry (Code: SS 1A), **Renzo Cavalieri**, Colorado State University, **Noah Giansiracusa**, University of California, Berkeley, and **Burt Totaro**, University of California, Los Angeles.

Geometry of Submanifolds (Code: SS 3A), **Yun Myung Oh**, Andrews University, **Bogdan D. Suceava**, California State University, Fullerton, and **Mihaela B. Vajiac**, Chapman University.

Polyhedral Number Theory (Code: SS 2A), **Matthias Beck**, San Francisco State University, and **Martin Henk**, Universität Magdeburg.

Greensboro, North Carolina

University of North Carolina, Greensboro

November 8–9, 2014

Saturday – Sunday

Meeting #1105

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: August 2014
Program first available on AMS website: September 25, 2014
Program issue of electronic *Notices*: November 2014
Issue of *Abstracts*: Volume 35, Issue 4

Deadlines

For organizers: April 8, 2014
For abstracts: September 16, 2014

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Susanne Brenner, Louisiana State Unviersity, *Title to be announced*.

Skip Garibaldi, Emory Unviersity, *Title to be announced*.

Stavros Garoufaldis, Georgia Institute of Technology, *Title to be announced*.

James Sneyd, Unviersity of Auckland, *Title to be announced* (AMS-NZMS Maclaurin Lecture).

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015

Saturday – Tuesday

Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th Annual Meeting of the Mathematical Association of America (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: April 1, 2014
For abstracts: To be announced

Washington, District of Columbia

Georgetown University

March 7–8, 2015
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 7, 2014
For abstracts: To be announced

Huntsville, Alabama

University of Alabama in Huntsville

March 20–22, 2015
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: August 20, 2014
For abstracts: To be announced

Las Vegas, Nevada

University of Nevada, Las Vegas

April 18–19, 2015
Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines
For organizers: September 18, 2014
For abstracts: To be announced

Porto, Portugal

University of Porto

June 11–14, 2015
Thursday – Sunday
First Joint International Meeting involving the American Mathematical Socierty (AMS), the European Mathematical Society (EMS), and the Sociedade de Portuguesa Matematica (SPM).
Associate secretary: Georgia M. 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*: Not applicable

Deadlines
For organizers: To be announced
For abstracts: To be announced

Chicago, Illinois

Loyola University Chicago

October 3–4, 2015
Saturday – Sunday
Central Section
Associate secretary: Georgia M. Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2015
Issue of *Abstracts*: To be announced

Deadlines
For organizers: March 10, 2015
For abstracts: To be announced

Fullerton, California

California State University, Fullerton

October 24–25, 2015
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*: October 2015
Issue of *Abstracts*: To be announced

Deadlines
For organizers: March 27, 2015
For abstracts: To be announced

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

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

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 M. 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 274 in the the February 2013 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences in Cooperation with the AMS:

(see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

November 1–3, 2013: Sixth International Conference on Science and Mathematics Education in Developing Countries, Mandalay, Myanmar.

AMERICAN MATHEMATICS SOCIETY

For the Knowledge Enthusiast

As a new school year begins and the bustle of autumn returns, find a moment to treat yourself to one of these colorful and informative reads.

What's Happening in the Mathematical Sciences, Volume 9

Dana Mackenzie

What's Happening in the Mathematical Sciences looks at some highlights of the most recent developments in pure and applied mathematics. These include the mathematics behind stories that made headlines, as well as fascinating mathematical vignettes that never made it into the newspapers. Topics covered in this volume include the mathematics surrounding natural and manmade disasters, such as the 2009 H1N1 outbreak and the 2011 tsunami in Japan, as well as developments in the pure mathematical realm, including the 2012 solutions to the Willmore and Lawson Conjectures. The stories in this book invite the reader into the exciting world of modern mathematics, which teems with the thrill of discovery and the anticipation of what is still to come.

What's Happening in the Mathematical Sciences, Volume 9; 2013; 127 pages; Softcover; ISBN: 978-0-8218-8739-4; List US$25; AMS members US$20; Order code HAPPENING/9

Axiomatic Geometry

John M. Lee, *University of Washington, Seattle, WA*

Designed for advanced undergraduates who plan to teach secondary school geometry, this book tells the story of how the axiomatic method has progressed from Euclid's time to ours as a way of understanding what mathematics is, how we read and evaluate mathematical arguments, and why mathematics has achieved the level of certainty it has.

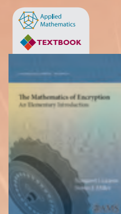
Pure and Applied Undergraduate Texts, Volume 21; 2013; 469 pages; Hardcover; ISBN: 978-0-8218-8478-2; List US$75; AMS members US$60; Order code AMSTEXT/21

Complex Proofs of Real Theorems

Peter D. Lax, *Courant Institute, New York, NY*, and **Lawrence Zalcman**, *Bar-Ilan University, Ramat Gan, Israel*

This graduate text illustrates how complex variables can be used to provide efficient proofs of a wide variety of important results in such areas as approximation theory, operator theory, harmonic analysis, and complex dynamics.

University Lecture Series, Volume 58; 2012; 90 pages; Softcover; ISBN: 978-0-8218-7559-9; List US$29; AMS members US$23.20; Order code ULECT/58



The Mathematics of Encryption

An Elementary Introduction

Margaret Cozzens, *DIMACS, Rutgers University, Piscataway, NJ*, and **Steven J. Miller**, *Williams College, Williamstown, MA*

This book provides a historical and mathematical tour of cryptography, from classical ciphers to quantum cryptography. The authors introduce just enough mathematics to explore modern encryption methods, with nothing more than basic algebra and some elementary number theory being necessary.

Mathematical World, Volume 29; 2013; approximately 348 pages; Softcover; ISBN: 978-0-8218-8321-1; List US$49; AMS members US$39.20; Order code MAWRLD/29

Theory of Algebraic Functions of One Variable

Richard Dedekind and **Heinrich Weber**

Translated and introduced by John Stillwell

The inaugural English translation of Dedekind and Weber's classic long paper provides easy access to the work for a wide mathematical audience.

Co-published with the London Mathematical Society beginning with Volume 4. Members of the LMS may order directly from the AMS at the AMS member price. The LMS is registered with the Charity Commissioners.

History of Mathematics, Volume 39; 2012; 152 pages; Softcover; ISBN: 978-0-8218-8330-3; List US$49; AMS members US$39.20; Order code HMATH/39

Invitation to a Mathematical Festival

Ivan Yashchenko, *Moscow Center for Continuous Mathematical Education, Russia*

This collection of problems, hints, and solutions, drawn from the Moscow Mathematical Festival during the years 1990–2011, skillfully assists middle school students in developing key skills such as intuitive reasoning and quick thinking.

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

MSRI Mathematical Circles Library, Volume 12; 2013; 172 pages; Softcover; ISBN: 978-0-8218-6905-5; List US$25; All individuals US$18.75; Order code MCL/12

Those Fascinating Numbers

Jean-Marie De Koninck, *Université Laval, Quebec, QC, Canada*

Translated by Jean-Marie De Koninck

This is a first rate resource for teachers and should certainly interest researchers. ... I loved this book and am glad I have it to play with.

—LMS Newsletter

This book provides a listing of positive integers along with their most remarkable properties, serving as a vehicle to explore elementary and advanced topics in classical number theory. Each of the open problems included in the book represents an enigma that will stimulate the reader's curiosity. The book offers a variety of features, including short proofs of key results and various algorithms.

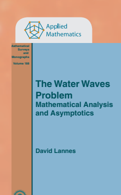
2009; 426 pages; Softcover; ISBN: 978-0-8218-4807-4; List US$49; AMS members US$39.20; Order code MBK/64

Compactness and Contradiction

Terence Tao, *University of California, Los Angeles, CA*

The articles, essays, and notes in this book are derived from the author's mathematical blog in 2010. It contains a broad selection of mathematical expositions, commentary, and self-contained technical notes in many areas of mathematics, such as logic, group theory, analysis, and partial differential equations. The topics range from the foundations of mathematics to discussions of recent mathematical breakthroughs.

2013; 256 pages; Softcover; ISBN: 978-0-8218-9492-7; List US$44; AMS members US$35.20; Order code MBK/81



The Water Waves Problem

Mathematical Analysis and Asymptotics

David Lannes, *Ecole Normale Supérieure et CNRS, Paris, France*

This is the first self-contained presentation of the water waves theory, which proposes a simple and robust framework that allows readers to address important issues raised by the water waves equations.

Mathematical Surveys and Monographs, Volume 188; 2013; 321 pages; Hardcover; ISBN: 978-0-8218-9470-5; List US$98; AMS members US$78.40; Order code SURV/188

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