Bulletin of Mathematical Sciences
Launched by King Abdulaziz University, Jeddah, Saudi Arabia

Aims and Scope
The Bulletin of Mathematical Sciences, a peer reviewed open access journal, will publish original
research work of highest quality and of broad interest in all branches of mathematical sciences.
The Bulletin will publish well-written expository articles (40–50 pages) of exceptional value giving
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**Scientific Overview**

The summer school will involve leaders in computer vision and experts from mathematics, statistics, engineering and computer science who are interested in vision. Computer Vision is a rapidly developing interdisciplinary field with an increasing number of practical applications such as automated cars, visual surveillance, and aids for the visually impaired. Its main goal is the automatic understanding and interpreting of images and image sequences. The school will present the core techniques in Computer Vision, illustrate the large range of visual tasks they can be applied to, and describe the conceptual and theoretical foundations that underlie them. These techniques include filtering, geometry, differential equations, harmonic analysis, probabilistic methods, machine learning, and many more. The school will describe real world applications and discuss interactions with related disciplines such as image processing, machine learning, and biological vision.
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MATHEMATICAL MOMENTS

See 100 Mathematical Moments, hear people talk about how they use math on the job in the modern world, and read translations in 13 languages at
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This month we celebrate the 125th anniversary of the remarkable Srinivasa Ramanujan. To commemorate the event, there is a four-part article about different aspects of his life and ideas. We also have features about Leibniz’s ideas in calculus, and about tetrahedral packing. The Opinion Column on the math gene should strike a familiar chord with many readers. As usual, we round things out with the Doceamus and Scripta Manent columns.

—Steven G. Krantz, Editor

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The American Mathematical Society announces

Mathematics Research Communities

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

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The summer conferences of the Mathematics Research Communities will be held in the breathtaking mountain setting of the Snowbird Resort, Utah, where participants can enjoy the natural beauty and a collegial atmosphere. The application deadline for summer 2013 is March 1, 2013.

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

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Complex Dynamics
Organizers:
Laura DeMarco (University of Illinois at Chicago)
Adam Epstein (University of Warwick)
Sarah Koch (Harvard University)

Week 1b (June 9-15, 2013)
Tropical and Nonarchimedean Analytic Geometry
Organizers:
Matt Baker (Georgia Institute of Technology)
Sam Payne (Yale University)

Week 2 (June 16-22, 2013)
Geometric Group Theory
Organizers:
Ruth Charney (Brandeis University)
Tullia Dymarz (University of Wisconsin, Madison)
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Kevin Wortman (University of Utah)

Week 3 (June 25-July 1, 2013)
Regularity Problems for Nonlinear Partial Differential Equations Modeling Fluids and Complex Fluids
Organizers:
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www.ams.org/programs/research-communities/mrc
Opinion

The Math Gene: A Ticket to Wealth or Nerdiness?

To say that a person has the Math Gene\(^1\) is to attribute to him an unusual propensity to handle numbers and the advanced algorithmic processes by which experts manipulate them. Among the people who possess these special talents, there is no biological or neurological evidence for any of it. And yet, those of us who exhibit these traits are easily identified among the general population.

My gene became evident at a young age and has remained conspicuous during all of my professional life. Throughout my journey, I have naturally and consciously surrounded myself with others like me. This is not surprising. Human beings always seek companions and colleagues who not only think and behave like they do, but inhabit a world of ideas, attitudes, and habits similar to their own.

In fact we mathematicians stand out. We don’t think and behave like the vast majority of our fellow citizens. John Q. Public knows us when he sees us, and—at the risk of overgeneralization—here are some of the more striking of our singular characteristics:

- We’re often socially awkward. We generally don’t pay much attention to clothes, fashion, or what’s in or hot or cool. Our homes, cars, and bodies are often unkempt, and we do poorly at small talk. We tend to be introverted, soft-spoken, and not terribly athletic.
- We excel at abstract thinking, but are notoriously weak at practical affairs.
- We are amazing problem solvers, especially those of the abstract or theoretical variety; but please don’t ask us to change a tire or balance a checkbook.
- We sometimes find it hard to look you straight in the eye, and we are easily embarrassed when we find ourselves the center of attention.

I cannot tell you how many times in my life when, in casual conversation with someone I’ve just met, after I reveal that I am a mathematician, the reaction is: “Oh my god, math was my worst subject in school; it was soooo hard. You must be a genius.” But at the same time, the one who has just uttered the confession/paean gives a furtive look at a fellow conversant which screams: “What a nerd! I wouldn’t have been like this guy for my weight in gold.”

However, in recent years, I detect another partially hidden reaction—both in stolen glances as well as in meekly asked follow-up questions, such as “So do you have a software or consulting company? I bet that you do OK?”

This is a result of society’s increasing fascination with technology and the seeming nerds who have pioneered its development. The names Bill Gates, Steve Jobs, Sergey Brin, and Mark Zuckerberg come to mind. Which leads to the question posed in the title: Is the Math Gene a ticket to wealth or nerdiness?

Alas, if there is a definitive answer, it is far closer to the latter than the former. Of the four names cited, only Brin can lay any claim to being a mathematician, and indeed his academic pedigree is more computer science than mathematics. Indeed, I know of only one academic mathematician—a former professor at Stony Brook University—who parlayed his math talent into a fortune. There might be others, but I doubt very many. For, generally speaking, the qualities that I have identified, which characterize mathematicians, are not those that equip a person with the skills needed to acquire great wealth.

Although the depiction of Mark Zuckerberg in the opening scene of “The Social Network” suggests some of the math nerd characteristics that I’ve specified, it would be a mistake to suppose that those traits helped Zuckerberg attain the phenomenal wealth that he enjoys today. No, the traits that enabled him and the other great modern technological entrepreneurs to do the things that garnered massive wealth for them were otherwise. They certainly include: extraordinary creativity and originality—as opposed to mere problem-solving skills; a willingness, indeed eagerness, to take great risks; an aggressive, self-confident, and strong-willed personality; persistence and single-mindedness; an ability to read people and gauge their desires; and an inclination to defy convention and a lack of concern about what others think of them.

Not exactly the characteristics of your typical mathematician. But, if I might address a wider audience than just the normal Notices’ readership: Not to despair, all ye parents and grandparents of a budding mathematician. Your progeny will not be cool, not trendy, probably not a leader of men, and almost certainly not rich. But a life of mathematics will yield: the satisfaction of cracking numerous mathematical puzzles; a professional life of honesty, fulfillment, a sense of doing something worthy, and occasional serenity; a camaraderie with others who are similarly endowed; and the respect, if not admiration, from the people one serves.

So, if your kid can swing a golf club as well as he can juggle numbers, and if you think that he would prefer riches to the contentment of a life filled with numbers, then take away his calculator and jam a putter in his hand. But, if he does have the Math Gene and you encourage it to flourish, then I promise you that he will lead a life in which he enjoys what he does for a living, often feels the joy of solving problems—even if they are theoretical and not practical—and finally, through teaching and research, he will take pride and pleasure in his role in the advancement of human knowledge.

—Ronald Lipsman
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\(^{1}\)The title of this essay “The Math Gene” is the same as the title of Keith Devlin’s fascinating 2001 book. But the essay takes a different point of view. Whereas Devlin’s book deals with the nature of mathematical thought, the workings of the human mind, and an intricate comparison of innate mathematical ability with innate language ability, this essay deals solely with the nature and behavior of mathematicians themselves—in particular, their social manifestations and economic motivations.

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Letters to the Editor

Mathematics and Home Schooling
I read the article “Mathematics and home schooling” (Notices, April 2012) and would like to make some comments. I and my wife are home-schooling parents, we are evangelical Christians, and we have home-schooled five children to varying grades. The oldest (a girl) is about to graduate in mechanical engineering.

1) The Constitution starts with the words “We the People”. The people delegate tasks to the government, but it was never the intention of the framers that the state would be the repository of authority and would delegate responsibility to parents. I take my responsibility as a parent very seriously, from God who gave me the children to begin with, and I do not recognize the state as delegating authority to me. The responsibility and authority are mine unless I screw up. What I do recognize is the right of the other “people” around me to take action if they see me not performing my responsibility to educate my children. Those “people” can form a government if they like, to enforce their view of what should be done as a minimum standard (and they have done so). The authors quote the Tenth Amendment, where powers not delegated to the United States by the Constitution, nor prohibited to it by the States, are reserved to the States respectively, or to the people.

2) Much is made in the article about girls and certain publications. I’ve never heard of them (and I’ve seen and heard a lot, being on home-schooling mailing lists), and I note the absence of data. What principal or school board member was ever seen going to a girls basketball game? There is ample data on gender discrimination in society, and the schools must be held accountable.

3) I do avoid the public school system out of a desire to maintain a Godly curriculum. It makes a major difference to a young person to know that God created them. Therefore others around them are special, and should be treated tenderly. The kids come home from high school talking about Maslow’s “hierarchy of needs”, which is accepted without any evidence. One gets only what one gives, and the giving has to come first. The focus is on giving, not on trying to fulfill one’s needs first (which is selfish and is hurtful to teach).

4) Much of “teacher certification” training is in handling groups of youngsters, preparing and executing group instruction, and is not germane to a home-schooling situation.

—Thomas A. Ryan
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(Received July 23, 2012)

A Collision with Salam
Regarding The Infinity Puzzle, reviewed by Brian E. Blank, in the Notices, September 2012. May I share a personal experience from my undergraduate days in Imperial College London in 1966? I was rushing to a class and collided with someone who almost fell over. In my haste I did not stop to apologize. Later I was told that I had almost killed a potential Nobelist. My victim was Salam, the same Nobelist discussed on p. 1107 of Mr. Blank’s review.

—Frank Okoh
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(Received September 6, 2012)

Severi’s Last Political Creed
There is one more piece of information that could complement the interesting article “A fresh look at Francesco Severi”, by Judith Goodstein and Donald Babbitt (Notices, September 2012). In the last years of his life Severi was the president of the “Associazione Italia-URSS”, a cultural association which was financed by the Soviet Union and was very close to the Italian Communist Party. Perhaps this association could deserve the epithet of “Communist Front Organization”.

—Alessandro Figà Talamanca
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(Received September 10, 2012)

Correction
The “Mathematics Opportunities” section of the August 2012 issue of Notices, carried a Call for Nominations for the Otto Neugebauer Prize, giving a deadline of December 31, 2012. In fact, the prize was awarded in July 2012, and the call for nominations is not open at present.

—Sandy Frost

Correction
The photographer for the photo in Figure 7 in “Glimpses of Benoît B. Mandelbrot (1924–2010), Notices, September 2012, was incorrectly identified as Richard Bernt. The photographer was actually Bernt Wahl.

—Sandy Frost
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Srinivasa Ramanujan: Going Strong at 125, Part I

Krishnaswami Alladi, Editor

The 125th anniversary of the birth of the Indian mathematical genius Srinivasa Ramanujan falls on December 22, 2012. To mark this occasion, the Notices offers the following feature article, which appears in two installments. The article contains an introductory piece describing various major developments in the world of Ramanujan since his centennial in 1987, followed by seven pieces describing important research advances in several areas of mathematics influenced by him. The first installment in the present issue of the Notices contains the introductory piece by Krishnaswami Alladi, plus pieces by George Andrews, Bruce Berndt, and Jonathan Borwein. Pieces by Ken Ono, K. Soundararajan, R. C. Vaughan, and S. Ole Warnaar will appear in the second installment in the January 2013 issue of the Notices.

Krishnaswami Alladi

Ramanujan’s Thriving Legacy

Srinivasa Ramanujan is one of the greatest mathematicians in history and one of the most romantic figures in the mathematical world as well. Born on December 22, 1887, to a poor Hindu brahmin family in Erode in the state of Tamil Nadu in South India, Ramanujan was a self-taught genius who discovered a variety of bewildering identities starting from his school days. There is a legend that the Hindu goddess Namagiri in the neighboring town of Namakkal used to come in his dreams and give him these formulae. Unable to find individuals in India to understand and evaluate his findings, Ramanujan wrote two letters in 1913 to G. H. Hardy of Cambridge University, England, listing several of his most appealing formulae. The depth and startling beauty of these identities convinced Hardy that Ramanujan was on a par with Euler and Jacobi in sheer manipulative ability. At Hardy’s invitation, Ramanujan went to Cambridge in 1914. The rest is history. In the five years he was in England, Ramanujan published several important papers, some of which stemmed from his discoveries in India; he collaborated with G. H. Hardy and wrote two very influential papers with him. For his pathbreaking contributions, Ramanujan was honored by being elected Fellow of Trinity College, Cambridge, and Fellow of the Royal Society (FRS) even though he did not have a college degree! The rigors of life in England during the First World War, combined with his own peculiar habits, led to a rapid decline in his health. Ramanujan returned to Madras, India, in 1919 a very sick man and died shortly after on April 20, 1920. Even during his last days, his mathematical creativity remained undiminished. He wrote one last letter to Hardy in January 1920 outlining his discovery of the mock theta functions, considered to be among his deepest contributions. In the decades after Ramanujan’s death, we have come to realize the depth, breadth, and significance of his many discoveries. Ramanujan’s work has had a major influence on several branches of mathematics, most notably in number theory and classical analysis, and even in some areas of physics.

During the Ramanujan Centennial in 1987, eminent mathematicians from around the world gathered in India to pay homage to this singular genius. It was an appropriate time to reflect on his legacy and consider the directions in which his work would have influence in the future. In this quarter century since the centennial, many significant developments have taken place in the world of Ramanujan: (i) there have been major research advances in recent years that have widened the arena of impact of Ramanujan’s work; (ii) books on Ramanujan’s work, of interest to students

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and researchers alike, and books on Ramanujan’s life with appeal to the general public have been published; (iii) journals bearing Ramanujan’s name have been established, one of which is devoted to all areas of research influenced by him; (iv) annual conferences devoted to various aspects of Ramanujan’s work are being held in his hometown in India; (v) international prizes bearing his name and encouraging young mathematicians have been created; and (vi) movies and plays about Ramanujan inspired by his remarkable life have also appeared or are in production.

This feature in the Notices of the AMS is devoted to describing some of the significant developments in the world of Ramanujan since the centennial. My opening article will broadly address the developments listed under (i)–(vi). This will be followed by articles by leading mathematicians on various aspects of research related to Ramanujan’s work.

Some Major Research Advances
I focus here on certain aspects of the theory of partitions and \( q \)-hypergeometric series with which I am most familiar and provide just a sample of some very important recent results. Research relating to Ramanujan’s work in many other areas has been very significant, and some of these ideas will be described by others in the following articles.

Ramanujan’s mock theta functions are mysterious, and the identities he communicated to Hardy about them are deep. Since George Andrews unearthed the Lost Notebook of Ramanujan at Trinity College Library in Cambridge University in 1976, he has been analyzing the identities contained therein, especially those on the mock theta functions. We owe much to Andrews for explaining the mock theta function identities in the context of the theory partitions (see for instance [12]). In Andrews-Garvan [21] the mock theta conjectures are formulated. These relate the \( q \)-hypergeometric mock theta function identities to partition identities; the mock theta conjectures were proved by others in the following articles.

In spite of their resemblance to the classical theta functions, the exact relationship between the mock theta functions and theta functions remained unclear. In the last decade, dramatic progress on this matter has been achieved by Ken Ono and his coworkers, most notably Kathrin Bringmann, in establishing the links between mock theta functions and Maass forms, thereby providing the key to unlock this mystery [32], [33], [34].

Ramanujan’s congruences for the partition function modulo the primes 5, 7, and 11 and their powers are among his most significant discoveries. More specifically, Ramanujan discovered that \( p(5n+4) \) is a multiple of 5, \( p(7n+5) \) is a multiple of 7, and \( p(11n+6) \) is a multiple of 11, where \( p(n) \) is the number of partitions of \( n \). In the ensuing decades, this led to a fruitful study of congruences satisfied by coefficients of modular forms. Yet it was unclear whether the partition function itself satisfied congruences with respect to other primes. Oliver Atkin [22] was the first to discover congruences for the partition function of the type \( p(An+b) \equiv C(mod p) \) with a prime modulus \( p > 11 \), but unlike the Ramanujan congruences, we have \( A \) not equal to \( p \). In recent years Scott Ahlgren [1] and Ken Ono [44] have discovered partition congruences to larger prime moduli and have shown that there are indeed infinitely many such congruences.

Ramanujan (see [46]) wrote down two spectacular identities for the generating functions of \( p(5n+4) \) and \( p(7n+5) \), from which his congruences modulo 5 and 7 follow. Proofs of Ramanujan’s partition congruences were given by Atkin using the theory of modular forms. In 1944, Freeman Dyson [35] gave a combinatorial explanation of Ramanujan’s partition congruences mod 5 and 7 using the now famous statistic he called the rank. He then conjectured the existence of a statistic...
he dubbed the **crank** that would explain the mod 11 congruence. A combinatorial explanation of Ramanujan's partition congruence modulo 11 was first given in the Ph.D. thesis of Frank Garvan [36] using vector partitions and a vector crank. This was then converted to ordinary partitions by Andrews and Garvan [20] when they got together at the Ramanujan Centennial Conference at the University of Illinois, Urbana, in the summer of 1987, and so finally the crank conjectured by Dyson was found. Perhaps the Goddess of Namakkal made sure that the solution to this problem should actually happen during the Ramanujan Centennial! Since 1987 there has been an enormous amount of work on the rank and on cranks for various partition statistics by several mathematicians: Garvan, Kim, and Stanton [37] found cranks for $t$-cores; Mahlburg [43] found cranks for the partition congruences to moduli larger than 11; and Andrews [16] has noticed new connections with Durfee symbols of partitions. In the last decade, Richard Stanley [49] introduced a refinement of Dyson's rank, and this has led to important refinements and extensions of Ramanujan's partition congruences (see for instance Andrews [15] and Berkovich-Garvan [24]).

In the entire theory of partitions and $q$-hypergeometric series, the Rogers-Ramanujan identities are unmatched in simplicity of form, elegance, and depth. This pair of identities connects partitions into parts that differ by at least two with partitions into parts congruent to $\pm i$ (mod 5), for $i = 1, 2$. Nowadays, by a Rogers-Ramanujan (R-R) type identity, we mean an identity which in its analytic form equates a $q$-hypergeometric series to a product, where the series represents the generating function of partitions whose parts satisfy gap conditions and the product is the generating function of partitions whose parts satisfy congruence conditions. This subject has blossomed into an active area of research thanks to systematic analysis of R-R type identities, primarily by Andrews ([11], Chapter 7). In the 1980s the Australian physicist Rodney Baxter showed how certain R-R type identities arise as solutions of some models in statistical mechanics (see Andrews [13], Chapter 8). Soon after, Andrews, Baxter, and Forrester [18] determined the class of R-R type identities that arise in such models in statistical mechanics. For this work Baxter was recognized with the Boltzmann Medal of the American Statistical Society.

Subsequently there has been significant work on $q$-hypergeometric identities and integrable models in conformal field theory in physics. The leader in this effort is Barry McCoy, who in the 1990s, with his collaborators Alexander Berkovich, Anne Schilling, and Ole Warnaar [25], [26], [27], [28], discovered new R-R type identities from the study of integrable models in conformal field theory. For this work McCoy was recognized with the Heineman Prize in Mathematical Physics and an invited talk at the ICM in Berlin in 1998. My own work in the theory of partitions and $q$-hypergeometric series has been in the study of R-R type identities and their refinements [4], especially on a partition theorem of Göllnitz, one of the deepest R-R type identities. In collaboration with Basil Gordon, George Andrews, and Alexander Berkovich, I was able to obtain generalizations and refinements of Göllnitz's partition theorem in 1995 [9] and later, in 2003, a much deeper four-parameter extension of the Göllnitz theorem [10].

### Books on Ramanujan's Life and Work

Hardy's twelve lectures on Ramanujan [39] are a classic in exposition. For several decades after Ramanujan's death, this book and the *Collected Papers* [46] of Ramanujan were the primary sources for students and young researchers aspiring to enter the Ramanujan mathematical garden. In 1987, *The Lost Notebook of Ramanujan* was published [48]. Students today are very fortunate, because Bruce Berndt has edited the original three note-books of Ramanujan and published this material in five volumes [29]. In these volumes one can find proofs of Ramanujan's theorems and how they are related to past and contemporary research. For this monumental contribution, Berndt was recognized with the AMS Steele Prize. In the past five years, Bruce Berndt and George Andrews have joined forces to edit Ramanujan's *Lost Notebook*. This is expected to also require five volumes, of which three have already appeared [19].

Ramanujan is now making an impact beyond mathematics into society in general around the world. Throughout India, Ramanujan's life story is well known, and Ramanujan is a hero to every Indian student. But with the publication of Robert Kanigel's book *The Man Who Knew Infinity* [41], Ramanujan's life story has reached the world over. The impact of this book cannot be underestimated (see [2]). Subsequently, Bruce Berndt and Robert Rankin have published two wonderful books. The first one, called *Ramanujan—Letters and Commentary* [30], collects various letters written to, from, and about Ramanujan and makes detailed commentaries on each letter. For instance, if a letter contains a mathematical statement, there is an explanation of the mathematics with appropriate references. If there is a statement about Ramanujan being elected Fellow of the Royal Society, there is a description about the procedures and practices for such an election (see review [3]). The second book, *Ramanujan—Essays and Surveys* [31], is a collection of excellent articles by various
experts on Ramanujan’s life and work and about various individuals who played a major role in Ramanujan’s life (see review [5]). This book also contains an article by the great mathematician Atle Selberg, who describes how he was inspired by Ramanujan’s mathematical discoveries. Most recently, David Leavitt has published a book [42] entitled The Indian Clerk which focuses on the close relationship between Ramanujan and Hardy (see review [38]). All of these books will not only appeal to mathematicians but to students and lay persons as well.

Since the Ramanujan Centennial, I have written articles annually comparing Ramanujan’s life and mathematics with those of several great mathematicians in history, such as Euler, Jacobi, Galois, Abel, and others. These articles, which were written to appeal to the general public, appeared in The Hindu, India’s national newspaper, each year around Ramanujan’s birthday in December. The collection of all these articles, along with my book reviews and other Ramanujan-related articles, has just appeared as a book [8] for Ramanujan’s 125th anniversary.

There are many other books on Ramanujan that have been published, and my list above is certainly not exhaustive. However, I must add to this list the comprehensive CD on Ramanujan that Srinivasa Rao brought out in India a few years ago. In this CD we have scanned images of Ramanujan’s notebooks, his papers, several articles about Ramanujan, many important letters, etc.

Journals Bearing Ramanujan’s Name

Inspired by what I saw and heard during the Ramanujan Centennial, I wanted to create something that would be a permanent and continuing memorial to Ramanujan, namely, The Ramanujan Journal, devoted to all areas of mathematics influenced by Ramanujan. This idea received enthusiastic support from mathematicians worldwide, many of whom have served, or are serving, on the editorial board. The journal was launched in 1997 by Kluwer Academic Publishers, which published four issues of one hundred pages per year in one volume. Now the journal is published by Springer, which publishes nine issues per year of one hundred fifty pages each in three volumes. The rapid growth of this journal is a further testimony to the fact that Ramanujan’s work is continuing to have major influence on various branches of mathematics.

There is another journal bearing Ramanujan’s name: The Journal of the Ramanujan Mathematical Society, which is distributed by the AMS and is devoted to all areas of mathematics. It bears Ramanujan’s name since he is India’s most illustrious mathematician.

Prior to these two journals, in the 1970s Professor K. Ramachandra (now deceased) founded The Hardy-Ramanujan Journal, devoted to elementary and classical analytic number theory, and published it privately in India.

Annual Conferences in Ramanujan’s Hometown

A recent major event in the world of Ramanujan is the acquisition in 2003 of Ramanujan’s home in Kumbakonam, South India, by SAstra University. This private university, founded about twenty years ago, has grown by leaps and bounds. Since the university has purchased Ramanujan’s home, we have the active involvement of administrators, academicians, and students in the preservation of Ramanujan’s legacy. To mark the occasion of the purchase of Ramanujan’s home, SAstra University conducted an international conference at its Kumbakonam campus December 20–22, 2003, and had it inaugurated by Dr. Abdul Kalam, president of India. I was invited to bring a team of mathematicians to this conference. George Andrews gave the opening lecture of this conference as well as the concluding Ramanujan Commemoration Lecture on December 22, Ramanujan’s birthday. At the conclusion of the conference, the participants suggested that SAstra should conduct conferences annually in Kumbakonam on various areas of mathematics influenced by Ramanujan. I have helped SAstra organize these annual conferences. Each year several leading researchers visit SAstra in December to speak at these conferences, and by participating in them, I have had the pleasure of spending Ramanujan’s birthday, December 22, every year in Ramanujan’s hometown (see [6]).
Prizes Bearing Ramanujan’s Name
At the inauguration of the second Ramanujan conference at SAstra University in December 2004, Vice Chancellor Professor R. Sethuraman graciously offered to set apart US$10,000 annually to recognize pathbreaking research by young mathematicians.

In response to his offer of such support, I suggested that an annual prize be launched the next year to be given to mathematicians not exceeding the age of thirty-two for outstanding contributions to areas influenced by Ramanujan. The age limit was set at thirty-two because Ramanujan achieved so much in his brief life of thirty-two years. Thus the SAstra Ramanujan Prize was born. In 2005, the year the prize was launched, the prize committee felt that two brilliant mathematicians, Manjul Bhargava (Princeton) and Kannan Soundararajan (then at Michigan, now at Stanford), both deserved the prize for spectacular contributions to algebraic and analytic number theory respectively. The vice chancellor generously informed the prize committee that there would be two full prizes that year, and it would not be split. The prestige of any prize is determined by the caliber of the winners. The SAstra Ramanujan Prize could not have had a better start (see [7], [45]). The prize is now one of the most prestigious and coveted. The subsequent winners are: Terence Tao (UCLA) in 2006, Ben Green (Cambridge University) in 2007, Akshay Venkatesh (Stanford) in 2008, Kathrin Bringmann (Cologne) in 2009, Wei Zhang (Harvard) in 2010, Roman Holowinsky (Ohio State) in 2011, and Zhiwei Yun (MIT and Stanford) in 2012. This prize has been given in December each year in Ramanujan’s hometown, Kumbakonam, during the SAstra Ramanujan Conference.

There is another very prestigious prize with Ramanujan’s name attached, namely, the ICTP Ramanujan Prize. The International Centre for Theoretical Physics (ICTP) in Trieste, Italy, was created in the sixties by the great physicist Abdus Salam with a particular commitment to encourage scientists from developing countries. Keeping this vision of Salam, the ICTP Ramanujan Prize launched in 2003 is a US$10,000 annual prize for mathematicians under the age of forty-five from developing countries for outstanding research in any branch of mathematics. Whereas the SAstra Ramanujan Prize is open to mathematicians the world over but focuses on areas influenced by Ramanujan, the ICTP Ramanujan Prize is open to all areas of mathematics but focuses on candidates from developing countries. The ICTP Prize has Ramanujan’s name because Ramanujan is the greatest mathematician to emerge from a developing country. The ICTP Ramanujan Prize is given in cooperation with the Abel Foundation.

Finally, there is the Srinivasa Ramanujan Medal given by the Indian National Science Academy for outstanding contributions to mathematical sciences. There is no age limit for this medal. Since its launch in 1962, the medal has been given fourteen times.

Movies and Plays about Ramanujan
Ramanujan’s life story is so awe inspiring that movies and plays about him have been and are being produced. The first was a superb documentary about Ramanujan in the famous Nova series of the Public Broadcasting System (PBS) on television, which described some of his most appealing mathematical contributions in lay terms and some of the most startling aspects of his life, such as the episode of the taxi cab number 1729. This documentary was produced before the Ramanujan Centennial but after Andrews’s discovery of the Lost Notebook.

Since the Ramanujan Centennial, there have been many stage productions, including the Opera Ramanujan, which was performed in Munich in 1998. In 2005 I had the pleasure of seeing the play Partition at the Aurora Theater in Berkeley along with George Andrews. In this and other stage productions, there is usually a “playwright’s fancy”, namely, a modification of the true life story of Ramanujan for a special effect. The producer of Partition, Ira Hauptman, focuses on Ramanujan’s monumental work with Hardy on the asymptotic formula for the partition function, but for a special effect describes Ramanujan’s attempts to solve Fermat’s Last Theorem and Ramanujan’s conversation with the Goddess of Namakkal regarding this matter. As far as we know, Ramanujan never worked on Fermat’s Last Theorem, but this digression for a special effect is acceptable artist’s fancy (see [8], article 23).

In 2006 Andrews and I served on a panel to critique a script entitled A First Class Man which had received support from the Sloan Foundation. The reading of the script was done at the Tribeca Film Institute in New York when the distinguished writer David Freeman was present. Andrews and I helped in clearing up certain mathematical misconceptions in the script and also noted that the script had changed the Ramanujan life story in certain ways that were not appropriate. Regardless of how the life of Ramanujan is portrayed in these stage productions, they have had the positive effect of drawing the attention of the public around the world to the life of this unique figure in history.

In 2007 a play entitled A Disappearing Number was conceived and directed by the English playwright Simon McBurney for the Theatre Company. It first played at the Theater Royal in Plymouth, England, and won three very
prestigious awards in England in 2007. This play was performed at the International Congress of Mathematicians in Hyderabad, India, in August 2010.

The latest theatrical production is a movie that is now being produced in India based on Kanigel’s book The Man Who Knew Infinity and featuring one of the most popular actors in the Tamil cinema world as Ramanujan.

Events in 2011–12
Since December 2012 is the 125th anniversary of Ramanujan’s birth, the entire year starting from December 22, 2011, was declared as the Year of Mathematics by the prime minister of India at a public function in Madras on December 26, 2011. On that day, a stamp of Ramanujan was released and Robert Kanigel was given a special award for his biography of Ramanujan. Also, the Tata Institute released a reprinting of the Notebooks of Ramanujan in the form of a collector’s edition [47]. The mathematics year has featured several conferences and public lectures on Ramanujan throughout India.

The Ramanujan Journal is bringing out a special volume for the 125th birth anniversary in December 2012. The 125th anniversary celebrations will conclude in 2012 with an International Conference on the Works of Ramanujan at the University of Mysore, India, December 12–13; an International Conference on the Legacy of Ramanujan at SASTRA University in Kumbakonam during December 14–16; and an International Conference on Ramanujan’s Legacy in India’s capital New Delhi during December 17–22. In 2012 only, the SASTRA Ramanujan Prize will be given outside of Kumbakonam, namely, at the New Delhi conference.

Just as there was a Ramanujan Centennial Conference at the University of Illinois, Urbana, in the summer of 1987 before the centennial celebrations in India that December, there was a Ramanujan 125 Conference at the University of Florida, Gainesville, in November 2012, one month before the 125th anniversary celebrations in India. Finally, at the Joint Annual Meetings of the AMS and MAA in January 2013 in San Diego, there will be a Special Session on Ramanujan’s mathematics to mark his 125th birth anniversary.

We have much to be proud of regarding what has happened in the quarter century after the Ramanujan Centennial. The articles in this Notices feature convince us that the world of Ramanujan’s mathematics is continuing to grow, and so we have much to look forward to in the next quarter century.

References
[6], A pilgrimage to Ramanujan’s hometown, MAA Focus 26 (2006), 4–6.
[7], The first SASTRA Ramanujan prizes, MAA Focus 26 (2006), 7.
George E. Andrews

Partitions and the Rogers-Ramanujan Identities

In his first letter to G. H. Hardy [19, p. xxvii], Ramanujan asserts:

"The coefficient of $x^n$ in

$$\frac{1}{1 - 2x + 2x^4 - 2x^9 + 2x^{16} - \ldots}$$

(1)

is the nearest integer to

$$\frac{1}{4n} \left( \cosh(\pi \sqrt{n}) - \frac{\sinh(\pi \sqrt{n})}{\pi \sqrt{n}} \right).$$

and, in a footnote, Hardy states, “This is quite untrue. But the formula is extremely interesting for a variety of reasons.” Perhaps one of the most important justifications for calling it “extremely interesting” is that it eventually led to the Hardy-Ramanujan formula for $p(n)$.

Each positive integer can be partitioned into unordered sums of positive integers. For example, there are seven partitions of the number 5: $1+1+1+1+1$, $1+1+1+2$, $1+2+2$, $1+1+3$, $2+3$, $1+4$, 5.

We denote by $p(n)$ the number of partitions on $n$, so $p(5) = 7$.

Inspired by (1), Hardy and Ramanujan eventually proved [13] the following:

**Theorem 1.** Suppose that

$$\phi_q(n) = \frac{\sqrt{q}}{2\pi \sqrt{3}} \frac{d}{dn} \left( e^{Cn/q} / \lambda_n \right),$$

where $C$ and $\lambda_n$ are defined by $C = \frac{2\pi}{\sqrt{3}}$ and $\lambda_n = \sqrt{n - \frac{1}{24}}$, and for all positive integral values of $q$;

that $p$ is a positive integer less than and prime to $q$; that $\omega_{p,q}$ is a $24$-th root of unity, defined when $p$ is odd by the formula

$$\omega_{p,q} = \left( \frac{-d}{p} \right) \exp \left[ -\frac{1}{4} \left( 2 - pq - p \right) + \frac{1}{12} \left( q - \frac{1}{q} \right) \right] \left( 2p - p' + p'^2 \right) \pi i$$

and when $q$ is odd by the formula

$$\omega_{p,q} = \left( \frac{-p}{q} \right) \exp \left[ -\frac{1}{4} \left( q - 1 \right) + \frac{1}{12} \left( q - \frac{1}{q} \right) \right] \left( 2p - p' + p'^2 \right) \pi i,$$

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where \((a/b)\) is the symbol of Legendre and Jacobi and \(p'\) is any positive integer such that \(1 + pp'\) is divisible by \(q\); that

\[
A_q(n) = \sum_{p} \omega_{p,q} e^{-2\pi i p l / q};
\]

and that \(\alpha\) is any positive constant; and \(\nu\), the integer part of \(\alpha \sqrt{n}\).

Then

\[
p(n) = \nu \sum_{q=1}^{\nu} A_q \phi_q + O(n^{-\frac{1}{4}}),
\]

so that \(p(n)\) is, for all sufficiently large values of \(n\), the integer nearest to \(\nu \sum_{q=1}^{\nu} A_q \phi_q\).

In 1937 Rademacher was preparing lecture notes on this amazing theorem. To simplify things a bit, he replaced \(\frac{1}{2} e^{\lambda_n q / q}\) by \(\sinh(C\lambda_n / q)\) in the definition of \(\phi_q(n)\) [17, p. 699]. To his amazement, he was now able to prove that, in fact,

\[
p(n) = \sum_{q=1}^{\infty} A_q \phi_q.
\]

In the celebrations surrounding the one hundredth anniversary of Ramanujan's birth, Atle Selberg [22] notes a further major surprise:

If one looks at Ramanujan's first letter to Hardy, there is a statement there [ed: i.e., (1) above] which has some relation to his later work on the partition function, namely about the coefficient of the reciprocal of a certain theta series (a power series with square exponents and alternating signs as coefficients). It gives the leading term in what he claims as an approximate expression for the coefficient. If one looks at that expression, one sees that this is the exact analogue of

the leading term in the Rademacher formula for \(p(n)\) which shows that Ramanujan, in whatever way he had obtained this, had been led to the correct term of that expression.

In the work on the partition function, studying the paper, it seems clear to me that it must have been, in a way, Hardy who did not fully trust Ramanujan's insight and intuition, when he chose the other form of the terms in their expression, for a purely technical reason, which one analyses as not very relevant. I think that if Hardy had trusted Ramanujan more, they should have inevitably ended with the Rademacher series. There is little doubt about that.

The subsequent impact of the "circle method" introduced by Hardy and Ramanujan (cf. [25]) is discussed by Vaughan. Further amazing formulas for \(p(n)\) have been found by Folsom, Kent, and Ono [10], along with spectacular results on the divisibility of \(p(n)\); these aspects will be discussed by Ono.

The Rogers-Ramanujan identities also form an intriguing and surprising component of Ramanujan's career. In 1916 P. A. MacMahon began Chapter III, Section VII, of his monumental *Combinatory Analysis* [16, p. 33] as follows:

**RAMANUJAN IDENTITIES**

Mr Ramanujan of Trinity College, Cambridge, has suggested a large number of formulae which have applications to the partition of numbers. Two of the most interesting of these concern partitions whose parts have a definite relation to the modulus five. Theorem I gives the relation

\[
1 + \frac{x}{1-x} + \frac{x^4}{(1-x)(1-x^2)} + \frac{x^9}{(1-x)(1-x^2)(1-x^3)} + \cdots
\]

\[
+ \frac{x^{16}}{(1-x)(1-x^2)(1-x^3) + \cdots} + \frac{x^{25}}{(1-x)(1-x^2)\cdots(1-x^2)} + \cdots
\]

\[
= \frac{1}{(1-x)(1-x^6)(1-x^{11})\cdots(1-x^{5m+1})\cdots}
\]

\[
\times \frac{1}{(1-x^4)(1-x^9)(1-x^{14})\cdots(1-x^{5m+4})\cdots},
\]

where on the right-hand side the exponents of \(x\) are the numbers given by the congruences

\(\equiv 1 \mod 5, \equiv 4 \mod 5\).

This most remarkable theorem has been verified as far as the coefficient of \(x^{89}\) by actual expansion so that there is practically no reason to doubt its truth; but it has not yet been established.

MacMahon then notes that this identity implies the following assertion about partitions:
The theorem asserts that the partitions, whose parts are limited to be of the forms $5m + 1, 5m + 4$, are equi-numerous with those which involve neither repetitions nor sequences.

Subsequently, MacMahon notes that, in the second identity,

$$
1 + \frac{x^2}{1-x} + \frac{x^6}{1-x^2(1-x^2)} + \frac{x^{12}}{1-x(1-x^2)(1-x^3)} + \cdots \\
+ \frac{x^{2i}}{(1-x)(1-x^2)\cdots(1-x^i)} + \cdots \\
= \frac{1}{(1-x^2)(1-x^4)\cdots(1-x^{2i})} + \cdots \\
\times \frac{1}{1-x^3}(1-x^8)\cdots(1-x^{3i}) + \cdots \\
$$

the exponents of $x$ on the right-hand side are of the form $5m + 2$ and $5m + 3$.

This relation has also been verified by actual expansion to a high power of $x$, but it has not been established. As with the first identity, MacMahon notes the implications for partitions:

states that of any given number such partitions are equi-numerous with those whose parts are all of the forms $5m + 2, 5m + 3$.

So here in 1916 was an immensely appealing unsolved problem. As Hardy remarks [14, p. 91]:

Ramanujan rediscovered the formulae sometime before 1913. He had then no proof (and knew that he had none), and none of the mathematicians to whom I communicated the formulae could find one. They are therefore stated without proof in the second volume of MacMahon’s Combinatory Analysis.

The mystery was solved, trebly, in 1917. In that year Ramanujan, looking through old volumes of the Proceedings of the London Mathematical Society, came accidentally across Rogers’ paper. I can remember very well his surprise, and the admiration which he expressed for Rogers’ work. A correspondence followed in the course of which Rogers was led to a considerable simplification of his original proof. About the same time I. Schur, who was then cut off from England by the war, rediscovered the identities again.

In his account of Ramanujan’s notebooks, Berndt [9, pp. 77–79] gives a detailed history of subsequent work on the Rogers-Ramanujan identities.

Surprisingly, this aspect of the theory of partitions languished for the next forty years. W. N. Bailey [8], [7] and his student Lucy Slater [24], [23] did generalize the series-product identities, but D. H. Lehmer [15] and H. L. Alder [1] published papers suggesting that there were no generalizations of an obvious sort. Even Hans Rademacher [18, p. 73] asserted that “It can be shown there can be no corresponding identities for moduli higher than 5.”

It turned out that Lehmer and Alder had shown only that the wrong generalization is the wrong generalization. The subject truly opened up with B. Gordon’s magnificent partition-theoretic generalization [12] in 1961.

**Theorem 2.** Let $B_{k,i}(n)$ denote the number of partitions of $n$ of the form $b_1 + b_2 + \cdots + b_s$, where $b_j \geq b_{j+1}, b_j - b_{j+k-1} \geq 2$ and at most $i - 1$ of the $b_j = 1$. Let $A_{k,i}(n)$ denote the number of partitions of $n$ into parts $\neq 0, \pm 1 \text{ (mod 2k + 1)}$. Then $A_{k,i}(n) = B_{k,i}(n)$, for $1 \leq i \leq k$.

The cases $k = 2, i = 1, 2$ are the partition theoretic consequences of the original identities as stated by MacMahon.

The question of analogous identities remained open until 1974, when the following result appeared [15].

**Theorem 3.** For $1 \leq i \leq k$,

$$
\sum_{n_1, \ldots, n_k \geq 0} q^{N_1^k + \cdots + N_{k-1}^k + N_i + N_{i+1} + \cdots + N_{k-1}} (q)_{n_1} (q)_n \cdots (q)_{n_{k-1}} \\
= \prod_{n \equiv 0, \pm 1 \text{ (mod 2k + 1)}} \frac{1}{1-q^n}.
$$

where $N_j = n_j + n_{j+1} + \cdots + n_{k-1}, and (q)_n = (1-q)(1-q^2)\cdots(1-q^n)$.

Since the 1970s there has been a cornucopia of Rogers–Ramanujan-type results pouring forth. As mentioned earlier, Berndt [9, p. 77] gives many references to recent work.

It should be added that Schur (mentioned in Hardy’s brief history given above) had a strong influence on the combinatorial/arithmetical aspects of Rogers-Ramanujan theory. Both his independent discovery of the Rogers-Ramanujan identities [20] and his modulus 6 theorem of 1926 [21] greatly impacted subsequent developments. These include the Ph.D. thesis of H. Göllnitz [11] and the “weighted words” method of Alladi and Gordon [2], the latter culminating in a generalization of Göllnitz’s deep modulus 12 theorem by Alladi, Andrews, and Berkovich [3].

The analytic side of the study was greatly assisted by the discovery of “Bailey chains” in 1984 [6]. Further accounts of this part of the Rogers-Ramanujan identities are provided in S. O. Warnaar’s survey [26] “50 Years of Bailey’s lemma” and in Chapter 3 of the Selected Works of George E. Andrews [4].

The Rogers-Ramanujan identities also lead directly to a study of a related continued fraction, a topic dealt with at length in [9].
In particular, in 1987 only one book had been used to sit on the windowsill and do his “sums”, watching the passersby on the street.

**References**


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**The only cot at the humble home of Ramanujan in Kumbakonam. As a young boy, Ramanujan used to sit on the windowsill and do his “sums”, watching the passersby on the street.**

**Bruce C. Berndt**

**Ramanujan’s Earlier Notebooks and His Lost Notebook**

Since the centenary of Ramanujan’s birth, a large amount of Ramanujan’s mathematics that had been ensconced in his earlier notebooks and in his lost notebook has been brought to light. In particular, in 1987 only one book had been written on Ramanujan’s notebooks [2], but now several have appeared [2], [1]. We now have a larger portion of Ramanujan’s mathematics to appreciate, evaluate, analyze, and challenge. The challenge is to ascertain Ramanujan’s thinking and motivation and to properly place his work within contemporary mathematics. Since other writers in this series of articles are focusing on Ramanujan’s...
lost notebook, we give more concentration in this paper on his earlier notebooks.

For most of his life, both in Kumbakonam and later in Madras, Ramanujan worked on a slate. Paper was expensive for him, and so he recorded only his final results in notebooks. Writing down his proofs in notebooks would have taken precious time; Ramanujan was clearly anxious to get on with his next ideas. Moreover, if someone had asked him how to prove a certain claim in his notebooks, he undoubtedly was confident that he could reproduce his argument. We do not know precisely when Ramanujan began to record his mathematical discoveries in notebooks, but it was likely around the time that he entered the Government College in Kumbakonam in 1904. Except for possibly a few entries, he evidently stopped recording his theorems in notebooks after he boarded a passenger ship for England on March 17, 1914. That Ramanujan no longer concentrated on logging entries in his notebooks is evident from two letters that he wrote to friends in Madras during his first year in England [5, pp. 112–113; 123–125]. In a letter of November 13, 1914, to his friend R. Krishna Rao, Ramanujan confided, “I have changed my plan of publishing my results. I am not going to publish any of the old results in my notebooks till the war is over.” And in a letter of January 7, 1915, to S. M. Subramanian, Ramanujan admitted, “I am doing my work very slowly. My notebook is sleeping in a corner for these four or five months. I am publishing only my present researches as I have not yet proved the results in my notebooks rigorously.”

Prior to his journey to England in 1914, Ramanujan prepared an enlarged edition of his first notebook; this augmented edition is the second notebook. A third notebook contains only thirty-three pages. G. N. Watson, in his delightful account of the notebooks [16], relates that Sir Gilbert Walker, head of the Indian Meteorological Observatory and a strong supporter of Ramanujan, told him that in April 1912 he observed that Ramanujan possessed four or five notebooks, each with a black cover and each about an inch thick. We surmise that these notebooks were either a forerunner of the first notebook or that the first notebook is an amalgam of these earlier black-covered notebooks.

When Ramanujan returned to India on March 13, 1919, he took with him only his second and third notebooks. The first notebook was left with G. H. Hardy, who used it to write a paper [9] on a chapter in the notebook devoted to hypergeometric series. Hardy’s paper [9] was read on February 5, 1923, and published later during that year. He begins by writing, “I have in my possession a manuscript note-book which Ramanujan left with me when he returned to India in 1919.” It was not until March 1925 that Hardy returned the first notebook to the University of Madras through its librarian, S. R. Rangathanan [15, pp. 56, 57]. A handwritten copy was subsequently made and sent to Hardy in August 1925.

Meanwhile, Hardy had originally wanted to bring Ramanujan’s published papers, his notebooks, and any other unpublished manuscripts together for publication. To that end, in a letter to Hardy dated August 30, 1923, Francis Dewsbury, registrar at the University of Madras, wrote, “I have the honour to advise despatch to-day to your address per registered and insured parcel post of the four manuscript note-books referred to in my letter No. 6796 of the 2nd idem. I also forward a packet of miscellaneous papers which have not been copied. It is left to you to decide whether any or all of them should find a place in the proposed memorial volume. Kindly preserve them for ultimate return to this office.” The “four manuscript notebooks” were handwritten copies of the second and third notebooks, and the packet of miscellaneous papers evidently included the “lost notebook”, which Hardy passed on to Watson and which was later rediscovered by George Andrews in the Trinity College Library in March 1976. Note that, in contradistinction to Dewsbury’s request, Hardy never returned the miscellaneous papers.

As it transpired, only Ramanujan’s published papers were collected for publication. However, published with the Collected Papers [12] were the first two letters that Ramanujan had written to Hardy, which contained approximately one hundred twenty mathematical claims. Upon their publication, these letters generated considerable interest, with the further publication of several papers establishing proofs of these claims. Consequently, either in 1928 or 1929, at the strong suggestion of Hardy, Watson and B. M. Wilson, one of the three editors of [12], agreed to edit the notebooks. The word “edit” should be interpreted in a broader sense than usual. If a proof of a claim can be found in the literature, then it is sufficient to simply cite sources where proofs can be found; if a proof cannot be found in the literature, then the task of the editors is to provide one. In an address [16] to the London Mathematical Society on February 5, 1931, Watson cautioned (in retrospect, far too optimistically), “We anticipate that it, together with the kindred task of investigating the work of other writers to ascertain which of his results had been discovered previously, may take us five years.” Wilson died prematurely in 1935, and although Watson wrote approximately thirty papers on Ramanujan’s work, his interest evidently flagged in the late 1930s, and so the editing was not completed.
Altogether, the notebooks contain over three thousand claims, almost all without proof. Hardy surmised that over two-thirds of these results were rediscoveries. This estimate is much too high; on the contrary, at least two-thirds of Ramanujan’s claims were new at the time that he wrote them, and two-thirds more likely should be replaced by a larger fraction. Almost all of the results are correct; perhaps no more than five to ten claims are incorrect. The topics examined by Ramanujan in his notebooks fall primarily under the purview of analysis, number theory, and elliptic functions, with much of his work in analysis being associated with number theory and with some of his discoveries also having connections with enumerative combinatorics and modular forms. Chapter 16 in the second notebook represents a turning point, since in this chapter he begins to examine \( q \)-series for the first time and also to begin an enormous devotion to theta functions. Chapters 16–21 and considerable material in the unorganized pages that follow focus on Ramanujan’s distinctive theory of elliptic functions, in particular, on theta functions. Especially in the years 1912–1914 and 1917–1920, Ramanujan’s concentration on number theory was through \( q \)-series and elliptic functions.

Finally, in 1957, the notebooks were made available to the public when the Tata Institute of Fundamental Research in Bombay published a photocopy edition [13], but no editing was undertaken. The notebooks were set in two volumes, with the first containing the first notebook and with the second comprising the second and third notebooks. The reproduction is quite faithful, with even Ramanujan’s scratch work photographed. Buttressed by vastly improved technology, a new, much clearer, edition was published in 2011 to commemorate the 125th anniversary of Ramanujan’s birth.

In February 1974, while reading two papers by Emil Grosswald [7], [8] in which some formulas from the notebooks were proved, we observed that we could prove these formulas by using a transformation formula for a general class of Eisenstein series that we had proved two years earlier. We found a few more formulas in the notebooks that could be proved using our methods, but a few thousand further assertions that we could not prove. In May 1977 the author began to devote all of his attention to proving all of Ramanujan’s claims in the notebooks. With the help of a copy of the notes from Watson and Wilson’s earlier attempt at editing the notebooks and with the help of several other mathematicians, the task was completed in five volumes [2] in slightly over twenty years.

In this series of articles for the Notices, George Andrews, Ken Ono, and Ole Warnaar, in particular, write about Ramanujan’s discoveries in his lost notebook, which is dominated by \( q \)-series. However, published with the lost notebook [14] are several partial manuscripts and fragments of manuscripts on other topics that provide valuable insight into Ramanujan’s interests and ideas. We first mention two topics that we have examined with Sun Kim and Alexandru Zaharescu in two series of papers, with [3] and [4] being examples of the two series. First, Ramanujan had a strong interest in the circle problem and Dirichlet divisor problem, with two deep formulas in the lost notebook clearly aimed at attacking these problems. Second, [14] contains three very rough, partial manuscripts on diophantine approximation. In one of these, Ramanujan derives the best diophantine approximation to \( e^{2/\alpha} \), where \( \alpha \) is a nonzero integer, a result not established in the literature until 1978 [6]. Also appearing in [14] are fragments of material that were originally intended for portions of published papers, for example, [10] and [11]. It is then natural to ask why Ramanujan chose not to include these results in his papers. In at least two instances, the discarded material depends on the use of complex analysis, a subject that Ramanujan occasionally employed but not always correctly. In particular, in the cases at hand, Ramanujan did not have a firm knowledge of the Mittag-Leffler Theorem for developing partial fraction decompositions. The fragments and incomplete manuscripts will be examined in the fourth book.
that the author is writing with Andrews on the lost notebook [1].

We conclude with a few remarks about Ramanujan’s methods. It has been suggested that he discovered his results by “intuition” or by making deductions from numerical calculations or by inspiration from Goddess Namagiri. Indeed, like most mathematicians, Ramanujan evidently made extensive calculations that provided guidance. However, Hardy and this writer firmly believe that Ramanujan created mathematics as any other mathematician would and that his thinking can be explained like that of other mathematicians. However, because Ramanujan did not leave us any proofs for the vast number of results found in his earlier notebooks and in his lost notebook, we often do not know Ramanujan’s reasoning. As Ramanujan himself was aware, some of his arguments were not rigorous by then-contemporary standards. Nonetheless, despite his lack of rigor at times, Ramanujan doubtless thought and devised proofs as would any other mathematician.

References


Jonathan M. Borwein

Ramanujan and Pi

Since Ramanujan’s 1987 centennial, much new mathematics has been stimulated by uncanny formulas in Ramanujan’s Notebooks (lost and found). In illustration, I mention the exposition by Moll and his colleagues [1] which illustrates various neat applications of Ramanujan’s Master Theorem, which extrapolates the Taylor coefficients of a function, and relates them to methods of integration used in particle physics. I also note lovely work on the modular functions behind Apéry and Domb numbers by Chan and others [6], and finally I mention my own work with Crandall on Ramanujan’s arithmetic-geometric continued fraction [12].

For reasons of space, I now discuss only work related directly to $\pi$, and so continue a story started in [9], [11]. Truly novel series for $1/\pi$, based on elliptic integrals, were found by Ramanujan around 1910 [19], [5], [7], [21]. One is

$$\frac{1}{\pi} = \frac{2\sqrt{2}}{9801} \sum_{k=0}^{\infty} \frac{(4k)! (1103 + 26390k)}{(k!)^4 99^{4k}}. $$

Each term of (1) adds eight correct digits. Though then unknown, Gosper used (1) for the computation of a then-record 17 million digits of $\pi$ in 1985, thereby completing the first proof of (1) [7, Ch. 3]. Soon after, David and Gregory Chudnovsky found the following variant, which relies on the quadratic number field $Q(\sqrt{-163})$ rather than $Q(\sqrt{58})$, as is implicit in (1):

$$\frac{1}{\pi} = 12 \sum_{k=0}^{\infty} \frac{(-1)^k (6k)! (13591409 + 5451403k)}{(3k)! (k!)^3 640320^{3k+3/2}}. $$

Each term of (2) adds fourteen correct digits. (Were a larger imaginary quadratic field to exist with class number one, there would be an even more extravagant rational series for some surd divided by $\pi$ [10].) The brothers used this formula several times, culminating in a 1994 calculation of $\pi$ to over four billion decimal digits. Their remarkable story was told in a prize-winning New Yorker article [18]. Remarkably, (2) was used again in 2010 and 2011 for the current record computations of $\pi$ to five and ten trillion decimal digits respectively.

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Quartic Algorithm for \( \pi \)

The record for computation of \( \pi \) has gone from 29.37 million decimal digits in 1986 to ten trillion digits in 2011. Since the algorithm below, which found its inspiration in Ramanujan’s 1914 paper, was used as part of computations both then and as late as 2009, it is interesting to compare the performance in each case: Set \( a_0 := 6 - 4\sqrt{2} \) and \( \gamma_0 := \sqrt{2} - 1 \); then iterate

\[
y_{k+1} = \frac{1 - (1 - y_k^4)^{1/4}}{1 + (1 - y_k^4)^{1/4}},
\]

(3)

\[
a_{k+1} = a_k(1 + y_{k+1})^4 - 2^{k+3} y_{k+1}(1 + y_{k+1} + y_{k+1}^2).
\]

Then \( a_k \) converges quartically to \( 1/\pi \); each iteration quadruples the number of correct digits. Twenty-one iterations produce an algebraic number that coincides with \( \pi \) to well over six trillion places.

This scheme and the 1976 Salamin–Brent scheme [7, Ch. 3] have been employed frequently over the past quarter century. Here is a highly abbreviated chronology (based on http://en.wikipedia.org/wiki/Chronology_of_computation_of_\pi):

- 1986: David Bailey used (3) to compute 29.4 million digits of \( \pi \). This required 28 hours on one CPU of the new Cray-2 at NASA Ames Research Center. Confirmation using the Salamin-Brent scheme took another 40 hours. This computation uncovered hardware and software errors on the Cray-2.
- January 2009: Takahashi used (3) to compute 1.649 trillion digits (nearly 60,000 times the 1986 computation), requiring 73.5 hours on 1,024 cores (and 6.348 Tbyte memory) of the Appro Xtreme-X3 system. Confirmation via the Salamin-Brent scheme took another 29.4 million digits of \( \pi \).
- April 2009: Takahashi computed 2.576 trillion digits.
- December 2009: Bellard computed nearly 2.7 trillion decimal digits (first in binary) using (2). This took 131 days, but he used only a single four-core workstation with lots of disk storage and even more human intelligence!
- August 2010: Kondo and Yee computed 5 trillion decimal digits, again using equation (2). This was done in binary, then converted to decimal. The binary digits were confirmed by computing 32 hexadecimal digits of \( \pi \) ending with position 4,152,410,118,610 using BBP-type formulas for \( \pi \) due to Bellard and Plouffe [7, Chapter 3]. Additional details are given at http://www.numberworld.org/misc_runs/pi-5t/announce_en.html. See also [4], in which analysis showing these digits appear to be “very normal” is made.

Daniel Shanks, who in 1961 computed \( \pi \) to over 100,000 digits, once told Phil Davis that a billion-digit computation would be “forever impossible”. But both Kanada and the Chudnovskys achieved that in 1989. Similarly, the intuitionists Brouwer and Heyting asserted the “impossibility” of ever knowing whether the sequence 0123456789 appears in the decimal expansion of \( \pi \); yet it was found in 1997 by Kanada, beginning at position 17387594880. As late as 1989, Roger Penrose ventured, in the first edition of his book The Emperor’s New Mind, that we likely will never know if a string of ten consecutive 7s occurs in the decimal expansion of \( \pi \). This string was found in 1997 by Kanada, beginning at position 22869046249.

Figure 6 shows the progress of \( \pi \) calculations since 1970, superimposed with a line that charts the long-term trend of Moore’s Law. It is worth noting that whereas progress in computing \( \pi \) exceeded Moore’s Law in the 1990s, it has lagged a bit in the past decade. Most of this progress is still in mathematical debt to Ramanujan.

As noted, one billion decimal digits were first computed in 1989, and the ten (actually fifty) billion digit mark was first passed in 1997. Fifteen years later one can explore, in real time, multibillion step walks on the hex digits of \( \pi \) at http://carmaweb.newcastle.edu.au/piwalk.shtml, as drawn by Fran Aragon.

Formulas for \( 1/\pi^2 \) and More

About ten years ago Jésus Guillera found various Ramanujan-like identities for \( 1/\pi^N \) using integer...
relation methods. The three most basic—and entirely rational—identities are

\[
\frac{4}{\pi^2} = \sum_{n=0}^{\infty} (-1)^n r(n) \left(13 + 180n + 820n^2\right) \left(\frac{1}{32}\right)^{2n+1},
\]

(4)

\[
\frac{2}{\pi^2} = \sum_{n=0}^{\infty} (-1)^n r(n) \left(1 + 8n + 20n^2\right) \left(\frac{1}{2}\right)^{2n+1},
\]

(5)

\[
\frac{4}{\pi^2} = \sum_{n=0}^{\infty} r(n) \left(1 + 14n + 76n^2 + 168n^3\right) \left(\frac{1}{2}\right)^{2n+1},
\]

(6)

where \(r(n) := (1/2 \cdot 3/2 \cdot \ldots \cdot (2n - 1)/2)/n!\).

Guillera proved (4) and (5) in tandem by very ingeniously using the Wilf-Zeilberger algorithm [20], [17] for formally proving hypergeometric-like identities [7], [15], [21]. No other proof is known. The third, (6), is almost certainly true. Guillera ascribes (6) to Gourevich, who found it using integer relation methods in 2001.

There are other sporadic and unexplained examples based on other symbols, most impressively a 2010 discovery by Cullen:

\[
\frac{2^{11}}{\pi^2} = \sum_{n=0}^{\infty} \frac{(1/2)_n \left(\frac{1}{2}\right)_n}{(1)_n} \times (21 + 466n + 4340n^2 + 20632n^3 + 43680n^4) \left(\frac{1}{2}\right)^{12n}.
\]

We shall revisit this formula below.

**Formulae for \(\pi^2\)**

In 2008 Guillera [15] produced another lovely, if numerically inefficient, pair of third-millennium identities—discovered with integer relation methods and proved with creative telescoping—this time for \(\pi^2\) rather than its reciprocal. They are based on:

\[
\sum_{n=0}^{\infty} \frac{1}{2^{2m}} \frac{(x + 1)_n^3}{(x + 1)_n^m} (6(n + x) + 1) = 8x \sum_{n=0}^{\infty} \frac{(1/2)_n^2}{(x + 1)_n^m},
\]

(8)

and

\[
\sum_{n=0}^{\infty} \frac{1}{2^{2m}} \frac{(x + 1)_n^3}{(x + 1)_n^m} (42(n + x) + 5) = 32x \sum_{n=0}^{\infty} \frac{(x + 1)_n^2}{(2x + 1)_n^m}.
\]

Here \((a)_n = a(a + 1) \cdots (a + n - 1)\) is the rising factorial. Substituting \(x = 1/2\) in (8) and (9), he obtained respectively the formulae

\[
\sum_{n=0}^{\infty} \frac{1}{2^{2m}} \frac{(1/2)_n^3}{(1/2)_n^m} (3n + 2) = \pi^2 / 4,
\]

(10)

\[
\sum_{n=0}^{\infty} \frac{1}{2^{2m}} \frac{(1/2)_n^3}{(1/2)_n^m} (21n + 13) = 4 \pi^2 / 3.
\]

**Calabi-Yau Equations and Supercongruences**

Motivated by the theory of Calabi-Yau differential equations [2], Almkvist and Guillera have discovered many new identities. One of the most pleasing is

\[
\frac{1}{\pi^2} = \frac{32}{3} \sum_{n=0}^{\infty} \frac{(6n)! (32n^2 + 126n + 9)}{10^{6n+3}}.
\]

This is yet one more case where mysterious connections have been found between disparate parts of mathematics and Ramanujan’s work [21], [13], [14].

As a final example, we mention the existence of supercongruences of the type described in [3], [16], [23]. These are based on the empirical observation that a Ramanujan series for \(1/\pi^N\), if truncated after \(p - 1\) terms for a prime \(p\), seems always to produce congruences to a higher power of \(p\). The formulas below are taken from [22]:

\[
\sum_{n=0}^{p-1} \frac{(1/2)_n (3/2)_n}{2^{4n} (1)_n} (3 + 34n + 120n^2) = 3p^2 (mod p^3),
\]

(12)

\[
\sum_{n=0}^{p-1} \frac{(1/2)_n (3/2)_n}{2^{10n} (1)_n} (21 + 466n + 4340n^2 + 20632n^3 + 43680n^4) \equiv 21p^4 (mod p^5).
\]

(13)

We note that (13) is the supercongruence corresponding to (6), while for (12) the corresponding infinite series sums to \(32/\pi^4\). We conclude by reminding the reader that all identities marked with ‘\(\approx\)’ are assuredly true but remain to be proved. Ramanujan might well be pleased.

**References**


The second installment of this article—with pieces by Ken Ono, K. Soundararajan, R. C. Vaughan, and S. Ole Warnaar—will appear in the January 2013 issue of the Notices.
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Mysteries in Packing Regular Tetrahedra

Jeffrey C. Lagarias and Chuanming Zong

The regular tetrahedron is the simplest Platonic solid. Nevertheless, in studying its packing properties, several renowned scholars have made mistakes, and many questions about it remain unsolved. Currently no one knows the density of its densest packings, the density of its densest translatively packings, or the exact value of its congruent kissing number. In this paper we recount historical developments on packing regular tetrahedra, report new results on its translatively packing density and congruent kissing number, and formulate several unsolved problems.

Aristotle’s Error
In the history of mathematics, one of the earliest recorded mistakes was made by Aristotle. More than 2,300 years ago, Aristotle (384–322 BCE) taught that the regular tetrahedra fill space. In De Caelo (On the Heavens) Book III.8 he says (in translation): “Among surfaces it is agreed that there are three figures which fill the place that contain them—the triangle, the square and the hexagon; among solids only two, the pyramid and the cube” [3, 306b, p. 319]. Here “pyramid” refers to the regular tetrahedron, a Platonic solid. Thus Aristotle’s assertion can be taken to mean: space can be tiled by congruent regular tetrahedra.

Such a tiling is impossible. Let $T$ denote a regular tetrahedron with unit edges and let $\alpha$ denote one of its dihedral angles. By a routine computation one can deduce that

$$\alpha = \arccos(1/3) \approx 70^\circ 32'. $$

If five tetrahedra are fitted around an edge (see Figure 1), then there is a small gap whose angular measure $\theta$ satisfies

$$0 < \theta = 2\pi - 5\alpha \approx 7^\circ 21' < \alpha,$$

and we conclude that regular tetrahedra cannot fill the space when arranged face-to-face. In any other tiling arrangement, along an edge a dihedral angle of $\pi - \alpha$ is created, which also cannot be filled by regular tetrahedra.

Of course, at the time of Aristotle, methods of geometric measurement and computation were more limited and computers were not available!
Eighteen Hundred Years to a Corrigendum

It took 1,800 years for Aristotle’s error to be resolved. Much of the following history was uncovered by Struik [51].

Simplicius and Averroës

Aristotle’s early commentators considered regular tetrahedral packing around a point and in so doing introduced a new mistake.

In the sixth century, to clarify Aristotle’s assertion, the commentator Simplicius stated that twelve regular tetrahedra (locally) fill space about a point [33, p. 650, lines 27–28], [51]. Such an arrangement of regular tetrahedra, if it existed, would have twelve tetrahedra touch at a point and fill the solid angle. (But twelve tetrahedra do not fill the solid angle.)

In the twelfth century Averroës (Abu al-Walid Mohammad ibn Ahmad al Rushd (1126–1198)), in Cordoba, wrote thousands of pages of commentary on Aristotle, basing his work on Arabic translations of the Greek. Concerning Aristotle’s assertion in De Caelo, he formulated a (mistaken) analysis of trihedral angles as sums of three dihedral angles and, based on this, inferred that twelve tetrahedra fill the same solid angle as eight cubes (they don’t). He then concluded that twelve regular tetrahedra (locally) fill space around a point [4, Comm. 66, pp. 628–631].

Michael Scot

The Arabic commentaries of Averroës reached Christian Europe through Latin translations, many done by the Toledo school of translators. Ger- ard of Cremona (c. 1114–1187) translated many books, including Ptolemy’s Almagest and Euclid’s Elements. The translation of the commentaries of Averroës on De Caelo is attributed to Michael Scotus (Michael Scot (1175–c. 1234)) [19, p. 27], [54, pp. 23–25]. In 1217, in Toledo, Scot translated from Arabic the astronomical treatise of Alpetragius (al-Bitrūji (died c. 1204)), a non-Ptolemaic astronomical system for describing planetary motion [7]. He also translated works of Aristotle and Avicenna on animals. He later joined the service of the Holy Roman Emperor Frederick II as astrologer and wrote several works covering topics on astrology, meteorology, and other subjects [32]. His request to Leonardo of Pisa (Fibonacci) for a copy of Liber Abaci led Fibonacci to prepare his 1228 revised edition, which he dedicated to Scot [50, pp. 15–16]. Scot’s knowledge of alchemy and other esoteric subjects (e.g., using the astrolabe to invoke evil spirits but recommending against it) led to his acquiring a reputation as a magician [54, Chap 12]. He appears in Dante’s Inferno, condemned to the second lowest circle of Hell [1, Canto XX, v. 115–116]. He is also mentioned in Boccaccio’s Decameron, as a necromancer [8, Eighth Day, Story 9].

Scholastic Philosophers: Roger Bacon, Peter of Auvergne, and Thomas Bradwardine

In 1266–1267 Roger Bacon (c. 1214–1294) wrote a series of essays on natural science at the request of Pope Clement II. According to Struik [51], Bacon writes in “Opus Tertium” [5, Chap. XL, pp. 135–140] that there is a fool in Paris who says that Averroës was incorrect and that twenty pyramids fill space (around a point). Bacon defends the assertion of Averroës that twelve pyramids fill space around a point but concludes that one cannot have complete certainty on these things without constructing the bodies as in Euclid’s Book 13.1

Thomas Aquinas (c. 1225–1274), best known for his lectures on theology, commented on Aristotle using new, more literal, translations of Aristotle made by William of Moerbeke2 (1215–c. 1286). In Naples in 1272–1273 he wrote lectures on Aristotle’s De Caelo. These remained incomplete at his death, and the lectures of De Caelo, covering Books III and IV, were completed by Peter of Auvergne (d. 1304) [2, p. 222, bottom]. Peter criticizes Averroës’s commentary, saying the assertion of Averroës that twelve tetrahedra fill space (at a point) is contrary to both sense perception and reason and that his assertion on solid angles is not intelligible [2, Book III, Lectio XII, pp. 234–238]. Concerning sense perception, Peter says he saw it for himself.3

A perceptive observation was made by Bradwardinus (Thomas Bradwardine (c. 1290–1349)), a scholastic philosopher who late in life became Archbishop of Canterbury. In Geometria Speculativa he stated that there are differing opinions whether the assertion of Averroës that twelve tetrahedra fill space is correct, that others assert that twenty regular tetrahedra (locally) fill space. He observed that a regular icosahedron can be subdivided around its centroid into twenty congruent tetrahedra. But he could not decide if the tetrahedra in this subdivision were regular tetrahedra [44, 51, pp. 25–27].

1 The culminating Book 13 of The Elements proves existence and uniqueness of the five regular solids and constructs them, in each case inscribed in a sphere.

2 William of Moerbeke translated part of De Caelo by 1260, the full text by 1265, and later the Greek commentary of Simplicius, finishing on June 15, 1271 [19, pp. 29 and 48]. He also translated mathematical works of Hero of Alexandria and Archimedes.

3 “Sensui quidem; quoniam si accipiantur duodecim pyramides aequilaterae, et applicentur secundum duodecim angulos circa punctum unum, ad sensum apparebit eas non replere locum corporaliter, et hoc ad sensum expertus sum” [2, p. 237].
In fact, they are not regular; the solid angle at the central vertex is about ten percent larger than that of a regular tetrahedron.

Regiomontanus and Paul of Middelburg

Aristotle’s error was detected by the fifteenth century. According to Struik [51], the incorrectness of Averroës’s assertion, and of Aristotle’s, was likely known to Regiomontanus (Johannes Müller von Königsberg (1436–1476)). The work of Regiomontanus covers symbolic algebra, spherical trigonometry, astronomy, and calendar reform. He apparently obtained a correct measure of solid angles, but the results of his investigations were not published. Only a title is known from a catalogue of his posthumous works: “On the five like-sided bodies, that are usually called regular, and which of them fill their natural place, and which do not, in contradiction to the commentator on Aristotle, Averroës.” No manuscript copy is known.

In any event, a definite observation of incorrectness was made by Paul of Middelburg (Paulus van Middelburg (1445–1534)), professor of astrology in Padua circa 1478–1481, in astrological prognostics made for the years 1480 and 1481.4 He asserts the impossibility of a (local) filling of space using any number of regular tetrahedra, since any such filling would produce a regular polyhedron having the same number of triangular faces, but the only possibilities allowed by Euclid’s Book 13, the octahedron and icosahedron, cannot work.

Francesco Maurolico

A modification that corrects Aristotle’s assertion by changing the tiling was found by Francesco Maurolico (1494–1575). He was of Greek descent, became a Benedictine monk in 1521 and later abbot in Messina, Sicily, and eventually was in charge of the Messina mint. He was a mathematician and astronomer and wrote many books, including observations of the supernova in 1572. His Arithmeticon libri duo [42], published posthumously, contains an early proof by mathematical induction (see Libri [40, pp. 102–118]). His writings include a manuscript with a title nearly identical to the one of Regiomontanus [41]. This manuscript is now lost, but it was catalogued in Rome in 1883, listing a table of contents and a colophon stating that it was completed on December 9, 1529. According to Libri [40, pp. 242–243], a catalogue of Maurolico’s works lists this one as:5 “Our booklet on plane and spatial regular figures, which fill their place; although it is certain that Johannes Regiomontanus has written in great detail on this, this work has never been published as far as I know. We show now in this booklet that, of the regular bodies, the cube itself, and pyramids together with octahedra, fill the place whereby it will be clear that Averroës erred in a childish way.”

That is, Maurolico knew: there exists a tiling of space using regular polyhedra other than the cube: this tiling is a periodic face-to-face tiling using a mixture of regular tetrahedra and regular octahedra having the same side length (cf. [51]).

To describe it, make a polyhedron by gluing two regular tetrahedra to diagonally opposite faces of a regular octahedron; it has six congruent faces, each a 60°–120° rhombus (see Figure 2). This polyhedron then lattice tiles space using the face-centered cubic (fcc) lattice. The tiling has eight tetrahedra and six octahedra meeting at each vertex, and this tiling is vertex-transitive.

Hilbert’s 18th Problem

In the extended version of his talk presented at the ICM 1900 in Paris, Hilbert [34] proposed twenty-three unsolved mathematical problems. At the end of his eighteenth problem, he wrote, “I point out the following question, related to the preceding one, and important to number theory and perhaps sometimes useful to physics and chemistry: How can one arrange most densely in space an infinite number of equal solids of given form, e.g., spheres with given radii or regular tetrahedra with given edges (or in prescribed position); that is, how can

4The 1481 prognostic reads: “Correlarium de errore aristotelis et commentatoris eius averroys patum ex 15 propositione 13 euclidis: quia pyra- mides ex quibus lcoedron conficit non sunt regularis: ergo pyramides regulares non possunt replere locum sedum si 20 sumant: immo nec in quocunque allo numero facerent corpus regulare quod est impossible” ([51, p. 136]).

5“De figuris planis, solidisque regularibus locum implen-tibus libellus noster; quamquam de hoc negocio Ioannem a Regiomonte accurativisse scripissse certum sit: verum opus nondum, quod sciam, editum. Demonstramus autem in libello e solidis regularibus cubos per se; pyramides vero cum octahedris compactas duntaxat implere locum, qua in re Averroem pueriliter errasse, manifestum erit.”
one so fit them together that the ratio of the filled to the unfilled space may be as great as possible?"

The sphere case has a long and complicated history (see Hales [30], [31] and Lagarias [39]). Kepler’s conjecture, made in 1611 [37], asserts that the fcc lattice packing is a densest (general) sphere packing. The fcc packing was determined to be the densest lattice sphere packing by Gauss and Seeber in 1831 by studying the arithmetic of positive definite ternary quadratic forms (see [21], [61, Chap. 2]). Perhaps this was one of the reasons for Hilbert to ask this question.

Let $K$ denote a convex body in the Euclidean space $\mathbb{E}^3$, with boundary $\partial(K)$, nonempty interior $\text{int}(K)$, and volume $\text{vol}(K)$. We define three notions of packing density as follows. Let $W = [-\frac{1}{2}, \frac{1}{2}]^3$ denote a unit cube centered at the origin so that $sW = [-\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}]^3$. A general packing $\mathcal{P}$ consists of a (possibly infinite) collection of nonoverlapping congruent copies of $K$, where nonoverlapping means disjoint interiors. For such $\mathcal{P}$ we define an (upper) density

$$\delta^\mathcal{P}(K) := \limsup_{s \to \infty} \frac{\text{vol}(\mathcal{P} \cap sW)}{\text{vol}(sW)}.$$

Then we define the congruent packing density, the translatively packing density, and the lattice packing density of $K$ respectively as

$$\delta^c(K) := \sup_{\mathcal{P}} \delta^\mathcal{P}(K) : \mathcal{P} \text{ a general packing},$$

$$\delta^l(K) := \sup_{\mathcal{P}} \delta^\mathcal{P}(K) : \mathcal{P} \text{ uses translates of } K,$$

and

$$\delta^L(K) := \sup_{\mathcal{P}} \delta^\mathcal{P}(K) : \mathcal{P} \text{ is a lattice packing}.$$

One can show that each of these suprema is attained: e.g., there exists a general packing $\mathcal{P}$ having

$$\delta^\mathcal{P}(K) = \delta^c(K),$$

and similarly there exist a translatively packing and lattice packing attaining their respective suprema. Moreover, such $\mathcal{P}$ can also be chosen to have a limiting density, i.e., having the corresponding lower density equal to their upper density. In fact, for $\delta^c(K)$, $\delta^l(K)$ and $\delta^L(K)$, the unit cube $W$ in the definition of $\delta^\mathcal{P}(K)$ can be replaced by any other fixed convex body. For basic results and problems about these densities we refer to [10], [17], [18], [24], [46], and [61].

It follows from these definitions that

$$\delta^L(K) \leq \delta^l(K) \leq \delta^c(K) \leq 1$$

hold for every convex body $K$. Let $\sigma(x)$ denote a nonsingular affine linear transformation from $\mathbb{E}^3$ to $\mathbb{E}^3$. It is known (easy to verify) that both

$$\delta^L(\sigma(K)) = \delta^l(K)$$

and

$$\delta^c(\sigma(K)) = \delta^l(K)$$

hold for all $K$ and $\sigma$. However, for some objects $K$ and suitable $\sigma$, we may have

$$\delta^c(\sigma(K)) \neq \delta^l(K).$$

For example, let $u_1$, $u_2$, $v_1$, $v_2$, ..., $v_6$ be the eight vertices of a unit cube, as shown in Figure 3, and let $T_i$ denote the tetrahedron with vertices $u_1$, $u_2$, $v_i$, and $v_{i+1}$ (we take $v_7 = v_1$ in $T_6$). It is easy to see that the six tetrahedra $T_1$, $T_2$, ..., $T_6$ are congruent to each other. Thus, since unit cubes tile the space nicely, we have

$$\delta^l(T_1) = 1.$$

In fact, we obtain a periodic tetrahedron tiling of space by copies of $T_1$ having six tetrahedra in its unit cell. On the other hand, for the regular tetrahedron $T$ we have (see [9], p. 208)

$$\delta^l(T) < 1,$$

and therefore

$$\delta^c(T_1) \neq \delta^l(T),$$

although $T_1 = \sigma(T)$ holds for some suitable affine linear transformation $\sigma$. This illustrates the subtle dependence of the maximal density of a (congruent) tetrahedron packing on the shape of the tetrahedron. It remains an open problem to determine those shapes of tetrahedra whose congruent copies tile space; see Senechal [49].

**Minkowski’s Genius and Mistake**

Assume that $a_1$, $a_2$, $a_3$ are three linearly independent vectors in $\mathbb{E}^3$. We call

$$\Lambda = \left\{ \sum z_i a_i : z_i \in \mathbb{Z} \right\}$$

a lattice. Lattices are very regular discrete sets in the space, which are additive groups with three generators.

The first work on lattice packing of general convex bodies in $\mathbb{E}^3$ was done by Minkowski [43] in 1904. Let $S$ be a centrally symmetric convex body...
centered at the origin \( o \). Minkowski proved the following criterion for densest lattice packings:

**Theorem 1.** If \( S \) has a lattice packing of \( S + \Lambda \) of maximal density, then \( \Lambda \) has a basis \( \mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3 \) such that either

\[
\{ \mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3, \mathbf{a}_1 - \mathbf{a}_2, \mathbf{a}_2 - \mathbf{a}_3, \mathbf{a}_3 - \mathbf{a}_1 \} \subset \partial(2S)
\]
or

\[
\{ \mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3, \mathbf{a}_1 + \mathbf{a}_2, \mathbf{a}_2 + \mathbf{a}_3, \mathbf{a}_3 + \mathbf{a}_1 \} \subset \partial(2S).
\]

As an application, he determined the density of the densest lattice packings of an octahedron \( O \). In other words, he proved

\[
\delta^l(O) = \frac{18}{19}.
\]

Let \( K \) be a convex set and define

\[
D(K) = \{ x - y : x, y \in K \}.
\]

Usually, we call \( D(K) \) the difference set of \( K \). Clearly \( D(K) \) is a centrally symmetric convex set centered at the origin \( o \). It can be shown (see [43]) that

\[
(K + x) \cap (K + y) \neq \emptyset
\]

if and only if

\[
\left( \frac{1}{2} D(K) + x \right) \cap \left( \frac{1}{2} D(K) + y \right) \neq \emptyset.
\]

Therefore, for a discrete set \( X \) in \( \mathbb{E}^3 \), \( K + X \) is a packing if and only if \( \frac{1}{2} D(K) + X \) is a packing. Consequently, we get

\[
\delta^l(K) = \frac{2^3 \text{vol}(K)}{\text{vol}(D(K))} \cdot \delta^l(D(K))
\]

and

\[
\delta^l(K) = \frac{2^3 \text{vol}(K)}{\text{vol}(D(K))} \cdot \delta^l(D(K)).
\]

In [43, p. 312], Minkowski wrote⁶ "If \( K \) is a tetrahedron, then \( \frac{1}{2} D(K) \) is an octahedron with faces parallel to the faces of the tetrahedron." Let \( O \) denote the regular octahedron of edge length one. By routine computations, one can get

\[
\text{vol}(T) = \sqrt{2}/12
\]

and

\[
\text{vol}(O) = \sqrt{2}/3.
\]

Then, by (2) and (4) Minkowski [43] concluded that

\[
\delta^l(T) = \frac{9}{38}.
\]

Minkowski’s idea was brilliant. Unfortunately, he made a mistake. The difference set of a regular tetrahedron is not an octahedron but a cuboctahedron. As shown in Figure 4, a cuboctahedron is very different from an octahedron.

\[\text{Octahedron Cuboctahedron}\]

**Figure 4. A cuboctahedron is very different from an octahedron.**

**Groemer’s and Hoylman’s Work**

Minkowski’s mistake was discovered by Groemer [23] in 1962.

Let \( T^r \) denote the tetrahedron with vertices \((-1,1,1), (1,-1,1), (1,1,-1), (-1,-1,-1)\), and let \( \Lambda \) be the lattice generated by \( \mathbf{a}_1 = (2, -\frac{1}{2}, -\frac{1}{2}), \mathbf{a}_2 = (-\frac{1}{2}, 2, -\frac{1}{2}) \) and \( \mathbf{a}_3 = (-\frac{1}{2}, -\frac{1}{2}, 2) \).

It can be shown that

\[
D(T') = \{ (x_1,x_2,x_3) : \sum |x_i| \leq 4, |x_i| \leq 2 \}
\]

and

\[
\Lambda \cap \text{int}(D(T')) = o.
\]

Therefore both \( \frac{1}{2} D(T') + \Lambda \) and \( T' + \Lambda \) are lattice packings.⁷ By routine computation it follows that the packing density of \( \frac{1}{2} D(T') + \Lambda \) and \( T' + \Lambda \) are \( \frac{45}{59} \) and \( \frac{18}{49} \), respectively. Thus, Groemer [23] obtained

\[
\delta^l(D(T')) \geq \frac{45}{49}
\]

and

\[
\delta^l(T') \geq \frac{18}{49}.
\]

Clearly Minkowski’s conclusion (5) is wrong.

In addition, Groemer also observed that each tetrahedron in \( T' + \Lambda \) touches fourteen others. However, he was not able to prove that the equalities in (6) and (7) hold.

In 1970 Hoylman [35] applied Minkowski’s criterion to a cuboctahedron \( C \). By considering thirty-eight cases with respect to the possible positions of the three vectors of the bases, he proved

\[
\delta^l(C) = \frac{45}{49},
\]

\[
\delta^l(T) = \frac{18}{49},
\]

and the optimal lattice is unique up to certain equivalence. In fact, Groemer’s example is the only optimal lattice tetrahedron packing.

⁶"Ist z.B. K ein Tetraeder, so wird \( \frac{1}{2} D(K) \) ein Oktaeder mit Flächen parallel den Flächen des Tetraeders."

⁷Minkowski’s paper also provided a criterion to check whether \( K + \Lambda \) is a packing.
Based on Minkowski’s work, in 2000 Betke and Henk [6] developed an algorithm by which one can determine the density of the densest lattice packing of an arbitrary three-dimensional polytope. As an example of application, Hoylman’s result was verified.

**Tetrahedra Touching a Point**

How many nonoverlapping regular tetrahedra can touch a point?

By considering the solid angle that a regular tetrahedron cuts out, which is

\[ 3 \arccos \left( \frac{1}{3} \right) - \pi \approx 0.55129 \text{ steradians}, \]

and comparing with the full solid angle \(4\pi\), it follows that at most twenty-two tetrahedra can occupy the solid angle without overlap.

One finds that twenty regular tetrahedra can touch without overlap. This fact can be deduced from the structure of an icosahedron, as shown in Figure 5, since the distance between its centroid and vertices is shorter than its edge length. One places the twenty tetrahedra so each has one vertex at its centroid of edge length so that their opposite face sits (concentrically) inside a corresponding face of the icosahedron. There are now small gaps between each of the twenty tetrahedra so arranged.

**Conjecture 1.** The maximal number of nonoverlapping regular tetrahedra that can meet at a point is twenty.

This problem has circulated in the mathematical community for some years and has been noted by more than one person. Paul Sally (University of Chicago) [47] said that he encountered the question at Lincoln Laboratories in 1958 and later circulated it.

Conjecture 1 can be reformulated as a two-dimensional packing problem. It is equivalent to the assertion: The maximum number of equilateral spherical triangles with angle \( \arccos \left( \frac{1}{3} \right) \) that can be placed without overlap on the surface of a sphere is twenty.

**Kissing Numbers of Tetrahedra**

The kissing number problem concerns finite packings. It was originally raised as the question: How many spheres, all of the same radius, can touch another sphere of the same radius? In the fourteenth century Thomas Bradwardine observed that twelve such spheres can touch a given sphere [44, Sect. 4.42]. The mathematician David Gregory discussed related problems with Isaac Newton in 1694, and in an unpublished notebook, Gregory recorded the assertion that thirteen spheres can touch one sphere [45, Vol. III, p. 317]. A rigorous mathematical proof that the kissing number of a sphere is twelve was published only in 1953 by Schütte and van der Waerden [48] (see also [9, Chap. 8], [14, Chap. 1], [61, Chap. 1]).

To generalize the thirteen sphere problem of Gregory and Newton, Hadwiger [26] introduced and studied the translative kissing number of a general convex body \( K \). Let \( \tau^c(K) \), \( \tau^t(K) \) and \( \tau^l(K) \) denote the congruent kissing number, the translative kissing number, and the lattice kissing number of \( K \), respectively. For example, \( \tau^t(K) \) is the maximal number of nonoverlapping translates of \( K \), all of which touch \( K \) at its boundary. Clearly, we have

\[
\tau^l(K) \leq \tau^t(K) \leq \tau^c(K).
\]

In addition, both \( \tau^t(K) \) and \( \tau^l(K) \) are invariant under nonsingular linear transformations. Of course, for \( \tau^c(K) \) this is not always true.

In 1961 Grünbaum [25] made the following conjecture: The translative kissing number of an \( n \)-dimensional simplex is \( n(n + 1) \).

This conjecture lasted only one year, as Groemer’s example from the last section disproves it. Groemer’s example shows that

\[
\tau^c(T) \geq \tau^t(T) \geq \tau^l(T) \geq 14.
\]

But what are the values of \( \tau^t(T) \), \( \tau^l(T) \), and \( \tau^c(T) \)?

For convenience, we assume that one of the four vertices of \( T \) is the origin \( o \) and the other three are \( v_1, v_2, \) and \( v_3 \).
When Grünbaum made his conjecture, perhaps he thought about the structure that at each vertex of $T$ there are three translates that touch it (as shown in Figure 6), and therefore altogether twelve translates surround $T$. In fact, this is the local structure of the lattice packing $T + \Lambda_1$, where
\[
\Lambda_1 = \left\{ \sum z_i v_i : z_i \in \mathbb{Z} \right\}.
\]

In 1996 Zong [59] observed that the holes in $T + \Lambda_1$ are big enough to hold additional translates of $T$. In fact, we can put a whole copy of $T + \Lambda_1$ into it. We write $a_1 = v_1$, $a_2 = v_2$, and $a_3 = \frac{1}{2}(v_1 + v_3 + v_3)$ and define
\[
\Lambda_2 = \left\{ \sum z_i a_i : z_i \in \mathbb{Z} \right\}.
\]

Then it can be verified that $T + \Lambda_2$ is a lattice packing of density $1/3$ in which each tetrahedron touches eighteen others. Together with Groemer and Hoylman’s result, we have (see [60])

**Theorem 2.** The density of the densest lattice tetrahedron packings is $18/49$, in which each tetrahedron touches fourteen others. There is a lattice tetrahedron packing of density $1/3$ in which each tetrahedron touches eighteen others.

Besides this discovery, Zong [59] proved that
\[
\tau^l(T) = 18
\]
and
\[
18 \leq \tau^l(T) \leq 19.
\]

Finally, there is still room at each vertex to insert four more tetrahedra touching it without overlap; these tetrahedra have some room to move and need not sit face-to-face. This adds sixteen more tetrahedra, giving the desired cluster $B_{57}$. One may check that this cluster has twenty tetrahedra touching each of the vertices of $T$ and furthermore that the final layer of sixteen tetrahedra may be chosen so that $B_{57}$ has the full $S_4$-symmetry group of isometries. This construction establishes that
\[
\tau^c(T) \geq 56.
\]

To obtain an upper bound, let $B$ denote the unit ball centered at the origin. If $T^*$ is congruent to $T$ and $T \cap T^* \neq \emptyset$, then we have
\[
T^* \subset T + B.
\]

Thus we get
\[
(\tau^c(T) + 1) \cdot \text{vol}(T) \leq \text{vol}(T + B).
\]

By routine computations we get
\[
\text{vol}(T) = \frac{\sqrt{2}}{12},
\]
\[
\text{vol}(T + B) = \frac{\sqrt{2}}{12} + \sqrt{3}
\]
\[
+ 3 \left( \pi - 2 \arctan \frac{\sqrt{2}}{2} \right) + \frac{4\pi}{3},
\]
and therefore
\[
\tau^c(T) \leq \left\lfloor \frac{\text{vol}(T + B)}{\text{vol}(T)} \right\rfloor - 1 = 98.
\]

In view of the conjecture that at most twenty regular tetrahedra can touch a point, it seems reasonable to guess that the construction above is optimal.

**Conjecture 2.** The congruent kissing number of the regular tetrahedron is
\[
\tau^c(T) = 56.
\]

The congruent kissing number is not invariant under linear transformations, so it can be considered for tetrahedra of any shape. As the shape of $T$ varies, $\tau^c(T)$ may become arbitrarily large. Consider a tetrahedron $T_\alpha$ having one face an equilateral triangle of side length 1 in the $(x, y)$ plane, with centroid located at the origin, and with a fourth vertex along the positive $z$-axis at $(0, 0, \alpha)$. As $\alpha$ decreases to 0, the tetrahedron flattens out. Now rotate the tetrahedron $T_\alpha$ so that its equilateral triangular face is parallel to the $(y, z)$ plane. For small $\alpha$ many such rotated tetrahedra can be moved by translations to be stacked in parallel touching the original tetrahedron from below without overlap. Thus the kissing number for $T_\alpha$ grows without bound as $\alpha$ approaches 0.

This leads to the following natural problem.

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8Chen gives explicit constructions with coordinates for all the clusters listed, but does not observe the kissing number property of $B_{57}$. 

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Problem 1. Determine the minimal congruent kissing number $\delta^c(T)$ among all possible tetrahedral shapes $T$.

In particular one may ask: Does the regular tetrahedron have the minimal congruent kissing number among all shapes of tetrahedra?

A Race for Densest Congruent Packing

In 2006 Conway and Torquato [15] made a breakthrough in constructing dense congruent tetrahedron packings. Their idea is simple but very efficient.

1. Pack twenty regular tetrahedra into an icosahedron (see Figure 5). The fraction of the icosahedral volume occupied by the tetrahedra can be approximately $0.8567627$.

2. Construct a lattice icosahedra packing with maximum density. According to Betke and Henk [6] it is $0.8363574$.

Thus we obtain a congruent tetrahedron packing of density approximately $0.8363574 \times 0.8567627 \approx 0.716559$.

In other words, we have

$$\delta^c(T) \leq 0.716559.$$ 

They further observed that, by deforming this packing, one can slightly increase the density, and in this way they found a packing with density approximately $0.717455$.

It was conjectured by Ulam (see p. 135 of [20]) that the maximal density (0.74048...) for packing congruent spheres is smaller than that for any other convex body. Of course, it makes sense to consider a regular tetrahedron as a possible candidate for a counterexample, as Conway and Torquato [15] did.

However, in 2008, by constructing a cluster of eighteen congruent regular tetrahedra and a suitable lattice packing of the cluster, the lower bound (9) of Conway and Torquato was improved by Chen [11] to

$$\delta^c(T) \geq 0.778615.$$ 

This shows that the regular tetrahedron does not supply a counterexample to Ulam’s conjecture.

Packings of tetrahedra have recently become relevant in materials science, in part because it is now possible to manufacture nanomaterials made of small tetrahedra, and these materials may have interesting physical properties. It has become a very active research topic, with materials scientists, physicists, and mathematicians all studying tetrahedral packings.

As one example, the Glotzer lab in chemical engineering at the University of Michigan studied such packings viewed as a fluid of hard tetrahedra, and Haji-Akbari, Engel, and Glotzer [27], [28] computed by simulation its thermodynamic phase diagram. It was observed that such a fluid appears to have a quasicrystalline solid phase at a wide range of pressures and densities [29], [28]. This is the first example of a quasicrystalline phase associated with identical nonspherical particles. Furthermore, this result appears robust against small changes in the shape of the tetrahedra.

Chen’s 2008 lower bound was rapidly improved by [55], [56], [29], [36], [57], [13], and [58], some packings being found by computer simulation and others by new constructions.

The current record packing is that of Chen, Engel, and Glotzer [13, Theorem 1]. It is a periodic packing of regular tetrahedra having four tetrahedra in the unit cell, consisting of a dimer of two tetrahedra sharing a face and a reflected copy of this dimer (see Figure 7), and it achieves a packing density $4000/4671 \approx 0.856347$. This packing has a set of isometries that act transitively on the individual dimers. It was found as a deformation of a packing of Kallus et al. [36], which itself used a three-dimensional extension of a double-lattice packing idea of Kuperberg and Kuperberg [38]. The paper [13] presents heuristic evidence based on simulation, suggesting that this packing could be the densest packing of regular tetrahedra. In any case, it establishes

$$\delta^c(T) \geq \frac{4000}{4671} \approx 0.856347.$$ 

While the race for better lower bounds may continue, the first nontrivial upper bound for $\delta^c(T)$ was achieved only in 2011. It was proved by Gravel, Elser, and Kallus [22] that

$$\delta^c(T) \leq 1 - 2.6 \times 10^{-25}. \quad (10)$$

Congruent tetrahedron packings are still far from being understood. We end this section with two basic problems.

Problem 2. What is the value of $\delta^c(T)$? Can the optimum be achieved by a periodic packing?
There is a chance that the packing of Chen, Engel, and Glotzer [13] may be extremal. If true, such a result will likely be very hard to prove. It seems harder than the sphere packing problem, because a proof must take into account the orientation of the tetrahedra in a packing.

Problem 3. Let $\mathcal{F}$ denote the family of all tetrahedral shapes. Is it true that among these the regular tetrahedra are the hardest to pack? That is, do we have
\[
\min_{K \in \mathcal{F}} \{\delta^c(K)\} = \delta^c(T)?
\]

The Translative Packing Density
Perhaps it is easier to determine the value of $\delta^t(T)$ than the value of $\delta^c(T)$. Moreover, since it is invariant under nonsingular affine linear transformations, $\delta^t(T)$ is important.

It was proved by Estermann [16] and Süss [52] in 1928 that
\[
\frac{\text{vol}(D(T))}{\text{vol}(T)} = \frac{\text{vol}(C)}{\text{vol}(T)} = 20.
\]
Together with (1), (3), and (7), we can deduce
\[
\frac{18}{49} \leq \delta^t(T) \leq \frac{2}{5},
\]
where the lower bound is 0.3673469 · · ·. Recently, by introducing a particular local method, Zong [62] has proved
\[
\delta^t(C) \leq \frac{90\sqrt{10}}{95\sqrt{10} - 4} = 0.9601527 \cdots
\]
and
\[
\delta^t(T) \leq \frac{36\sqrt{10}}{95\sqrt{10} - 4} = 0.384061 \cdots.
\]
These facts support the following conjecture.

Conjecture 3. The translative packing density of the regular tetrahedron is
\[
\delta^t(T) = \frac{18}{49}.
\]

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References


47. P. Sally, private communication.


60. _______, *Strange Phenomena in Convex and Discrete Geometry*, Springer-Verlag, New York, 1996.


Leibniz’s Laws of Continuity and Homogeneity

Mikhail G. Katz and David M. Sherry

From the *Characteristica Universalis* to Ideal Entities

Leibniz envisioned the creation of a universal language, *characteristica universalis*, ambitiously designed to serve as the vehicle for deduction and discovery in all fields of knowledge. Couturat [10] pointed out in 1901 that, in Leibniz’s vision, the infinitesimal calculus was but the first salvo, or sample, of his *characteristica universalis*.

Leibniz’s vision of the ideal nature of mathematical entities was remarkably modern. His description of infinitesimals as fictional entities shocked his disciples J. Bernoulli, l’Hôpital, and Varignon. And his infinitesimals certainly appeared as “Mysteries” to critics such as Berkeley, whose empiricist philosophy tolerated no conceptual innovations, such as infinitesimals, without an empirical counterpart or referent:

Yet some there are, who, though they shrink at all other Mysteries, make no difficulty of their own, who strain at a Gnat and swallow a Camel [1, section XXXIV].

While today we are puzzled by Berkeley’s rigid rejection of the idea of an infinitely divisible continuum, he also articulated a specifically logical criticism of the calculus (see [46]), alleging that the system suffered from logical flaws and even contradictions. Even today, many historians believe Berkeley’s criticism to have been on target. Not even Robinson escaped this trend, praising Berkeley’s criticism of the foundations of the calculus as “a brilliant exposure of their logical inconsistencies” [45, p. 280].

We argue that, contrary to Berkeley’s view, Leibniz’s system for the differential calculus was robust and free of contradiction. Leibniz articulated a set of coherent heuristic procedures for his calculus. Thus, Leibniz’s system incorporated versatile heuristic principles, such as his law of continuity and laws of homogeneity, which were amenable, in the ripeness of time, to implementation as general principles governing the manipulation of modern infinitesimal and infinitely large quantities, such as the transfer principle and the standard part principle. Kanovei [21] and others performed similar reconstructions of Euler’s work.

We will draw on Leibniz’s work, more specifically his *Cum Prodiisset*, to argue for the consistency of Leibniz’s system for the differential calculus. We will also draw on the work of Leibniz historians Bos, Ferraro, Horváth, Knobloch, and Laugwitz.

Berkeley’s attack on infinitesimal calculus focused specifically on the product rule as well as

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1 The text *Cum Prodiisset* sheds more light on foundational issues than the terser 1684 text *Nova methodus pro maximis et minimis...* [35], so named because the determination of maxima and minima was one of the central problems of analysis as practiced at the time, with leading scholars having composed works of similar titles (see, e.g., [12]).
on the derivation of polynomials. Once the logical contradiction, alleged by Berkeley, is resolved in the context of the product rule (see the section “Justification of the Product Rule” below), it can similarly be resolved (namely, by applying the transcendental law of homogeneity) in all other contexts.

In a seminal 1974 study of Leibnizian methodology, Bos described a pair of distinct approaches to justifying the calculus:

Leibniz considered two different approaches to the foundations of the calculus; one connected with the classical methods of proof by “exhaustion”, the other in connection with a law of continuity [5, item 4.2, p. 55].

The first approach relies on an Archimedean “exhaustion” methodology. We will therefore refer to it as the A-methodology. The other methodology exploits infinitesimals and the law of continuity. We will refer to it as the B-methodology, in an allusion to Johann Bernoulli, who, having learned an infinitesimal methodology from Leibniz, never wavered from it.

Knobloch explains the role of Leibniz’s law of continuity in the following terms:

In his treatise Leibniz used a dozen rules which constitute his arithmetic of the infinite. He just applied them without demonstrating them, only relying on the law of continuity: The rule of the finite remains valid in the domain of the infinite [30, p. 67].

Laugwitz pointed out that Leibniz’s law of continuity contains an a priori assumption: our mathematical universe of discourse contains both finite objects and infinite ones [32, p. 145].

What is the ontological status of such infinitary (infinitesimal or infinite) objects in Leibniz’s theory? Leibniz’s was a remarkably modern insight that mathematical entities need not have a referent, or empirical counterpart. The fictional nature of infinitesimals was stressed by Leibniz in 1706:

Philosophically speaking, I no more admit magnitudes infinitely small than infinitely great… I take both for mental fictions, as more convenient ways of speaking, and adapted to calculation, just like imaginary roots are in algebra (Leibniz to Des Bosses, 11 March 1706, in [16, II, p. 305]).

Infinitesimals, like imaginaries, were well-founded fictions to Leibniz. The nature of Leibniz’s infinitesimals is further clarified by Ferraro, who analyzes a lengthy quotation from Leibniz’s famous letter of 1702 [38] to Varignon (which we do not reproduce here to save space) in the following terms:

According to Leibniz, imaginary numbers, infinite numbers, infinitesimals, the powers whose exponents were not “ordinary” numbers and other mathematical notions are not mere inventions; they are auxiliary and ideal quantities that…serve to shorten the path of thought [13, p. 35].

In Ferraro’s view, Leibniz’s infinitesimals enjoy an ideal ontological status similar to that of the complex numbers, surd (irrational) exponents, and other ideal quantities.

In the next section we will examine Leibniz’s foundational stance as expressed in his seminal text Cum Prodiisset.

Cum Prodiisset

Leibniz’s text Cum Prodiisset [37] (translated by Child [9]) dates from around 1701 according to modern scholars. The text is of crucial importance in understanding Leibniz’s foundational stance. We will analyze it in detail in this section.

Law of Continuity, with Examples

Leibniz formulates his law of continuity in the following terms:

Proposito quocunque transitu continuo in aliquem terminum desinente, liceat raciocinationem communem instituere, qua ul timus terminus comprehendatur [37, p. 40].

The passage can be translated as follows:

In any supposed continuous transition, ending in any terminus, it is permissible to institute a general reasoning, in which the final terminus may also be included.

We have deliberately avoided using the term limit in our translation. In fact, translating terminus as limit would involve a methodological error, because the term limit misleadingly suggests its modern technical meaning of a real-valued operation applied to sequences or functions.

In a similar vein, Bos notes that the fundamental concepts of the Leibnizian infinitesimal calculus can best be understood as extrapolations to the actually infinite of concepts of the calculus of finite sequences. I use the term “extrapolation”
Here Leibniz provides an explanation in terms of a state of transition (status transitus in the original Latin [37, p. 42]):

A state of transition may be imagined, or one of evanescence, in which indeed there has not yet arisen exact equality…or parallelism, but in which it is passing into such a state, that the difference is less than any assignable quantity; also that in this state there will still remain some difference,…some angle, but in each case one that is infinitely small; and the distance of the point of intersection, or the variable focus, from the fixed focus will be infinitely great, and the parabola may be included under the heading of an ellipse [9, p. 149].

A state of transition in which “there has not yet arisen exact equality” refers to example (2) in the previous subsection; “parallelism” refers to example (1); including parabola under the heading of ellipse is example (3).

Thus, the term terminus encompasses the status transitus, involving a passage into an assignable entity while being as yet inassignable. Translating terminus as limit amounts to translating it as an assignable entity, the antonym of the meaning intended by Leibniz.

The observation that Leibniz’s status transitus is an inassignable quantity is confirmed by Leibniz’s conceding that its metaphysical status is “open to question”:

Whether such a state of instantaneous transition from inequality to equality,…from convergence [i.e., lines meeting—] to parallelism, or anything of the sort, can be sustained in a rigorous or metaphysical sense, or whether infinite extensions successively greater and greater, or infinitely small ones successively less and less, are legitimate considerations, is a matter that I own to be possibly open to question [9, p. 149].

Yet Leibniz asserts that infinitesimals may be utilized independently of metaphysical controversies:

But for him who would discuss these matters, it is not necessary to fall back upon metaphysical controversies, such as the composition of the continuum, or to make geometrical matters depend thereon [9, pp. 149–150].

To summarize, Leibniz holds that the inassignable status of status transitus is no obstacle to its effective use in geometry. The point is reiterated in the next paragraph:

If any one wishes to understand these [i.e., the infinitely great or the infinitely small—] as the ultimate things, or as truly infinite, it can be done, and that too without falling back upon a controversy about the reality of extensions, or of infinite continuums in general, or of the infinitely small, ay, even though he think that such things
are utterly impossible; it will be sufficient simply to make use of them as a tool that has advantages for the purpose of the calculation, just as the algebraists retain imaginary roots with great profit [9, p. 150]. Leibniz has just asserted the possibility of the mathematical infinite: “it can be done”, without philosophical commitments as to its ontological reality.

Mathematical Implementation of Status Transitus

We will illustrate Leibniz’s concept of status transitus by implementing it mathematically in the three examples mentioned by Leibniz.

In the subsection “Status Transitus”, we mentioned that Leibniz viewed infinitesimals as fictions, and so his methods avoided any metaphysical commitments. Ishiguro [20] and others viewed a Leibnizian infinitesimal as a logical fiction, involving a syncategorematic paraphrase with a hidden quantifier applied to ordinary real values. We have argued against the syncategorematic interpretation in [28]. Rather, Leibnizian infinitesimals are pure fictions akin to imaginaries. Thus, Leibniz exploited infinitely large and infinitely small quantities in the same sense in which Albert Girard (1595–1632) and others exploited imaginary roots in order to simplify algebra. In neither case is there a commitment to corresponding mathematical entities. Thus, Leibniz anticipates modern formalist positions such as Hilbert’s and Robinson’s.

Of course, the structural properties of Leibniz’s infinite and infinitely small quantities are different from those of modern day infinitesimals. Nonetheless, modern theories of infinitesimals are a way of implementing Leibniz’s heuristic procedures. Thus, example (2) can be illustrated as follows. Leibniz denotes a finite positive quantity by

\[(d)x\]

(Bos [5, p. 57] replaced this by \(dx\)). The assignable quantity \((d)x\) passes via infinitesimal \(dx\) on its way to absolute 0. Then the infinitesimal \(dx\) is the status transitus. Zero is merely the assignable shadow\(^6\) of the infinitesimal. Then a line (i.e., segment) of length \(2x + dx\) will be equal to one of length \(2x\), up to an infinitesimal. This particular status transitus is the foundation of the Leibnizian definition of the differential quotient.

Example (1) of parallel lines can be elaborated as follows. Let us follow Leibniz in building the line through \((0,1)\) parallel to the \(x\)-axis in the plane. Line \(L_H\) with \(y\)-intercept 1 and \(x\)-intercept \(H\) is given by \(y = 1 - \frac{x}{H}\). For infinite \(H\), the line \(L_H\) has negative infinitesimal slope, meets the \(x\)-axis at an infinite point, and forms an infinitesimal angle with the \(x\)-axis at the point where they meet. We will denote by \(st(x)\) the assignable (i.e., real) shadow\(^7\) of a finite \(x\). Then every finite point \((x, y) \in L_H\) satisfies

\[
st(x, y) = (st(x), st(y))
\]

\[
= (st(x), st\left(1 - \frac{x}{H}\right))
\]

\[
= (st(x), 1).
\]

Hence the finite portion of \(L_H\) is infinitely close to the line \(y = 1\) parallel to the \(x\)-axis, which is its shadow. Thus, the parallel line is constructed by varying the oblique line depending on a parameter. Such variation passes via the status transitus defined by an infinite value of \(H\).

To implement example (3), let’s follow Leibniz in deforming an ellipse, via a status transitus, into a parabola. The ellipse with vertex (apex) at \((0, -1)\) and with foci at the origin and at \((0; H)\) is given by

\[
\sqrt{x^2 + y^2} + \sqrt{x^2 + (y - H)^2} = H + 2.
\]

We square (1) to obtain

\[
x^2 + y^2 + x^2 + (H - y)^2 + 2\sqrt{(x^2 + y^2)(x^2 + (H - y)^2)} = H^2 + 4H + 4.
\]

We move the radical to one side:

\[
2\sqrt{(x^2 + y^2)(x^2 + (H - y)^2)} = H^2 + 4H + 4 - \left(x^2 + y^2 + x^2 + (H - y)^2\right)
\]

and square again. After cancellation we see that (1) is equivalent to

\[
\left(y + 2 + \frac{2}{H}\right)^2 - (x^2 + y^2)\left(1 + \frac{4}{H} + \frac{4}{H^2}\right) = 0.
\]

The calculation (1) through (4) depends on habits of general reasoning, such as:

- squaring undoes a radical,
- the binomial formula,
- terms in an equation can be transferred to the other side, etc.

General reasoning of this type is familiar in the realm of ordinary assignable (finite) numbers, but why does it remain valid when applied to the fictional “realm” of inassignable (infinite or infinitesimal) numbers? The validity of transferring such general reasoning, originally instituted in

\(^7\)Here “st” stands for the standard part function in the context of the hyperreals. Of course, Leibniz used neither the term “shadow” nor the “st” notation. Rather, these notations from modern infinitesimal analysis implement mathematically a heuristic principle of Leibniz’s called the transcendental law of homogeneity, discussed in the section “Assignable and Inassignable Quantities” below.
the finite realm, to the “realm” of the infinite is precisely the content of Leibniz’s law of continuity.\footnote{When the general reasoning being transferred to the infinite “realm” is generalized to encompass arbitrary elementary properties (i.e., first-order properties), one obtains the Łoś-Robinson transfer principle.}

We therefore apply Leibniz’s law of continuity to equation (4) for an infinite \( H \). The resulting entity is still an ellipse of sorts, to the extent that it satisfies all of the equations (1) through (4). However, this entity is no longer finite. It represents a Leibnizian \textit{status transitus} between ellipse and parabola. This \textit{status transitus} has foci at the origin and at an infinitely distant point \((0, H)\). Assuming \( x \) and \( y \) are finite, we set \( x_0 = \text{st}(x) \) and \( y_0 = \text{st}(y) \) to obtain an equation for a real shadow of this entity:

\[
\text{st} \left( \left( y + 2 + \frac{2}{H} \right)^2 - (x^2 + y^2) \left( 1 + \frac{4}{H^2} + \frac{4}{H^2} \right) \right) \\
= \left( y_0 + 2 + \text{st} \left( \frac{2}{H} \right) \right)^2 \\
- \left( x_0^2 + y_0^2 \right) \left( 1 + \text{st} \left( \frac{4}{H^2} + \frac{4}{H^2} \right) \right) \\
= (y_0 + 2)^2 - (x_0^2 + y_0^2) \\
= 0.
\]

Simplifying, we obtain

\begin{equation}
(y_0 = \frac{x_0^2}{2} - 1).
\end{equation}

Thus, the finite portion of the \textit{status transitus} (4) is infinitely close to its shadow (5), namely, the real parabola \( y = \frac{x^2}{2} - 1 \). This is the kind of payoff Leibniz is seeking with his law of continuity.

Some historians have been reluctant to interpret Leibniz’s mathematics in terms of modern mathematical theories. Thus, Dauben presents a list of authors, including Detlef Laugwitz, who “have used nonstandard analysis to rehabilitate or ‘vindicate’ earlier infinitesimalists,” and concludes:

Leibniz, Euler, and Cauchy...had, in the views of some commentators, “Robinsonian” nonstandard infinitesimals in mind from the beginning. The most detailed and methodically \textit{sic} sophisticated of such treatments to date is that provided by Imre Lakatos; in what follows, it is his analysis of Cauchy that is emphasized [11, p. 179].

However, Lakatos’s treatment was certainly not “the most detailed and methodically sophisticated” one by the time Dauben’s text appeared in 1988. Thus, in 1987, Laugwitz had published a detailed scholarly study of Cauchy in \textit{Historia Mathematica} [31]. Laugwitz’s text in \textit{Historia Mathematica} seems to be the published version of his 1985 preprint “Cauchy and infinitesimals”. Laugwitz’s 1985 preprint does appear in Dauben’s bibliography [11, p. 199], indicating that Dauben was familiar with it. It is odd to suggest, as Dauben seems to, that a scholarly study published in \textit{Historia Mathematica} would countenance a view that Leibniz and Cauchy could have had “‘Robinsonian’ nonstandard infinitesimals in mind from the beginning.” Surely Dauben has committed a strawman fallacy here.

To a historian, the claim that Leibniz’s differential calculus was free of logical fallacies may seem analogous to claiming that the circle can be squared,\footnote{Such was indeed the tenor of a recent referee report; see \url{http://u.cs.biu.ac.il/~katzmi/straw2.html}} but only if the historian embraces the triumviratist story of analysis as an ineluctable march from incoherent infinitesimalism toward the yawning heights of Weierstrassian epsilontics.

Rather, Lakatos, Laugwitz, Bråting [8], and others have argued that infinitesimals as employed by Leibniz, Euler, and Cauchy have found a set-theoretic implementation in the framework of modern theories of infinitesimals. The existence of such implementations indicates that the historical infinitesimals were less prone to contradiction than has been routinely maintained by triumvirate historians.\footnote{C. Boyer refers to Cantor, Dedekind, and Weierstrass as “the great triumvirate;” see [7, p. 298].} The issue is dealt with in more detail by Katz and Katz [22], [23], [24], [25]; Błaszczyk et al. [2]; Borovik et al. [3]; Katz and Leichtnam [26]; Katz, Schaps, and Shnider [27].

\section*{Assignable versus Unassignable}

In this section we will retain the term “unassignable” from Child’s translation [9] (\textit{inaassignabiles} in the original Latin; see [37, p. 46]). After introducing finite quantities \((d)x, (d)y, (d)z\), Leibniz notes that the unassignables \( dx \) and \( dy \) may be substituted for them by a method of supposition even in the case when they are evanescent [9, p. 153].

Leibniz proceeds to derive his multiplicative law in the case \( ay = xv \). Simplifying the differential quotient, Leibniz obtains

\begin{equation}
\frac{ady}{dx} = \frac{xdv}{dx} + v + dv.
\end{equation}

At this point Leibniz proposes to transfer “the matter, as we may, to straight lines that never become evanescent,” obtaining\footnote{Child incorrectly transcribes formula (7) over (6) that the expressions \( \frac{(d)y}{(d)x} \) and \( \frac{(d)z}{(d)x} \) are assignable (real). At this stage, Leibniz points out that \( dv \) is superfluous.” The reason given is that “it alone can become evanescent.”}

\begin{equation}
\frac{a(d)y}{(d)x} = \frac{x(d)v}{(d)x} + v + dv.
\end{equation}

The advantage of (7) over (6) is that the expressions \( \frac{(d)y}{(d)x} \) and \( \frac{(d)z}{(d)x} \) are assignable (real). At this stage, Leibniz points out that “\( dv \) is superfluous.” The reason given is that “it alone can become evanescent.”
The transcendental law of homogeneity (see the section “Assign-able and Inassignable Quantities”) is not mentioned explicitly in Cum Prodisset; there-fore the discussion of this step necessarily remains a bit vague. Discarding the $dv$ term, one obtains the expected product formula $a(d)v = x(d)v + v$ in this case. Note that thinking of the left-hand side of (7) as the assignable shadow of the right-hand side is consistent with Leibniz’s example (2) (see the subsection “Law of Continuity, with Examples”).

**Souverain Principe**

In a February 2, 1702, letter to Varignon, Leibniz formulated the law of continuity as follows:

...et il se trouve que les règles du fini réussissent dans l’infini comme s’il y avait des atomes (c’est à dire des éléments assignables de la nature) quoiqu’il n’y en ait point la matière étant actuellement sousdivisée sans fin; et que vice versa les règles de l’infini réussissent dans le fini, comme s’il y avait des infiniments petits métaphysiques, quoiqu’on n’en ait point besoin; et que la division de la matière ne parvienne jamais à des parcelles infiniment petites: c’est parce que tout se gouverne par raison, et qu’autrement il n’aurait point de science ni règle, ce qui ne serait point conforme avec la nature du souverain principe [38, p. 350].

This formulation was cited by Robinson in 1966, [45, p. 262]. To summarize: the rules of the finite succeed in the infinite, and conversely.

**Assignable and Inassignable Quantities**

How did Leibniz view the relation of assignable and inassignable quantities?

**Relation of Being Infinitely Close**

The rule governing infinitesimal calculation that Knobloch represents as Leibniz’s rule 2.2 states:

2.2. $x, y$ finite, $x = (y +$ infinitely small) $\iff$ $x - y \approx 0$ (not assignable difference) [30, p. 67].

Here the pair of parallel wavy lines represents the relation of being infinitely close. Leibnizian assignable quantities mark locations in what would be called today an Archimedean continuum, or A-continuum for short. Such a continuum stems from the sixteenth-century work of Simon Stevin (1548–1620) [47], [48]. Stevin initiated a systematic approach to decimal representation of measuring numbers, marking a transition from a discrete arithmetic as practiced by the Greeks, to the arithmetic of the continuum taken for granted today (see [41], [44], and [2]).

Closely related to the distinction between the A- and B-methodologies is a distinction between two types of continua, which could be called an A-continuum and a B-continuum. The latter encompasses inassignable entities such as infinitesimals (in addition to assignable ones) and can be described as a “thick” continuum. On occasion, Leibniz describes such entities as “incomparable quantities” and defines them in terms of the violation of what today is called the Archimedean property. Thus, Leibniz writes in a letter to l’Hôpital:

I call incomparable quantities of which the one can not become larger than the other if multiplied by any finite number. This conception is in accordance with the fifth definition of the fifth book of Euclid ([36, p. 288], cited in [19, p. 63]).

**Transcendental Law of Homogeneity**

To mediate between assignable and inassignable quantities, Leibniz developed an additional principle called the transcendental law of homogeneity. Leibniz’s transcendental law of homogeneity governs equations involving differentials. Bos interprets it as follows:

A quantity which is infinitely small with respect to another quantity can be neglected if compared with that quantity. Thus all terms in an equation except those of the highest order of infinity, or the lowest order of infinite smallness, can be discarded. For instance,

\[ a + dx = a, \]
\[ dx + ddy = dx, \]

etc. The resulting equations satisfy this...requirement of homogeneity [5, p. 33], paraphrasing [39, pp. 381–382].

The title of Leibniz’s 1710 text is *Symbolismus memorabilis calculi algebraici et infinitesimalis in comparatione potentiarum et differentiarum, et de lege homogeneorum transcendentali*. The inclusion of the transcendental law of homogeneity (*lex homogeneorum transcendentalis*) in the title of the text attests to the importance Leibniz attached to this law.

How did Leibniz use the transcendental law of homogeneity in developing the calculus? In the next section we will illustrate an application of the transcendental law of homogeneity to the particular example of the derivation of the product rule.

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12The B-continuum can be thought of as “thicker” than the A-continuum, because the B-continuum is, as it were, packed chock-full of numbers, including infinitesimals.

13Horváth notes that Leibniz is actually referring to the fourth definition of the fifth book.
Justification of the Product Rule

The issue is the justification of the last step in the following calculation:

\[
\frac{d(uv)}{dx} = \frac{(u + du)(v + dv) - uv}{dx} = \frac{udv + vdu + du dv}{dx} = \frac{udv + vdu}{dx}.
\]

The last step in the calculation (9), namely,

\[
udv + vdu + du dv = udv + vdu,
\]

is an application of Leibniz’s law of homogeneity.\(^\text{14}\)

In his 1701 text *Cum Prodisset* [37, pp. 46–47], Leibniz presents an alternative justification of the product rule (see [5, p. 58]). Here he divides by \(dx\) and argues with differential quotients rather than differentials. We analyzed Leibniz’s calculation in the subsection “Assignable versus Unassignable”. Adjusting Leibniz’s notation to fit with (9), we obtain an equivalent calculation:

\[
\frac{d(uv)}{dx} = \frac{(u + du)(v + dv) - uv}{dx} = \frac{udv + vdu + du dv}{dx} = \frac{udv + vdu}{dx}.
\]

Under suitable conditions the term \(\frac{du dv}{dx}\) is infinitesimal, and therefore the last step

\[
\frac{udv + vdu}{dx} + \frac{du dv}{dx} = u \frac{dv}{dx} + v \frac{du}{dx}
\]

is legitimized as a special case of the transcendental law of homogeneity, which interprets the equality sign in (8) as the relation of being infinitely close, i.e., an equality up to infinitesimal error. Note that the use of the equality sign “=” to denote a nonsymmetric relation of discarding the “inhomogeneous” terms as in (8) and (9) should

\[^{15}\text{Leibniz had two laws of homogeneity, one for dimension and the other for the order of infinitesimality. Bos notes that they “disappeared from later developments” [5, p. 35], referring to Euler and Lagrange.}\]

\[^{14}\text{The special case treated by Leibniz is } u(x) = x. This limitation does not affect the conceptual structure of the argument.}\]

hardly shock the modern reader accustomed to the “big O” notation: we write \(\sin x = O(1)\), but we would certainly not write \(O(1) = \sin x\). Leibniz’s transcendental law of homogeneity involved such an “asymmetric” relation, since it replaced an assignable quantity such as \(2x + dx\) by the assignable quantity \(2x\).

Was Leibniz’s System for Differential Calculus Consistent?

Berkeley’s logical criticism of the calculus is that it treated the evanescent increment as first assumed to be nonzero to set up an algebraic expression and then treated as zero in discarding the terms that contained that increment when the increment is said to vanish. The criticism, however, involves a misunderstanding of Leibniz’s method. The rebuttal of Berkeley’s criticism is that the evanescent increment need not be “treated as zero” but, rather, merely discarded through an application of the transcendental law of homogeneity by Leibniz, as illustrated in the previous section in the case of the product rule.

While consistent, Leibniz’s system unquestionably relied on heuristic principles, such as the laws of continuity and homogeneity, and would thus fall short of a standard of rigor if measured by today’s criteria. On the other hand, the consistency and resilience of Leibniz’s system is confirmed through the development of modern implementations of Leibniz’s heuristic principles. Thus, in the 1940s, Hewitt [18] developed a modern implementation of a hyperreal B-continuum extending \(\mathbb{R}\) by means of a technique referred to today as the ultrapower construction. We will denote such a B-continuum by the new symbol \(\mathbb{R}_\infty\). Denoting by \(\mathbb{R}_\infty\) the subset of \(\mathbb{R}\) consisting of inverses of nonzero infinitesimals, we obtain a partition \(\mathbb{R} = \mathbb{R}_\infty \cup \mathbb{R}_\infty\), where \(\mathbb{R}_\infty\) is the complement of \(\mathbb{R}_\infty\). We then have the standard part function

\[\text{st}: \mathbb{R}_\infty \to \mathbb{R},\]

illustrated in Figure 1. Note that the hyperreals can be constructed out of integers (see [4]). The traditional quotient construction using Cauchy sequences, usually attributed to Cantor (and actually due to Méray [43], who published three years earlier than E. Heine), can be factored through the hyperreals (see [17]). In 1955, Loś [40] proved his celebrated theorem on ultraproducts, implying in particular that elementary (more generally, first-order) statements over \(\mathbb{R}\) are true if and only if they are true over \(\mathbb{R}_\infty\), yielding a modern implementation of the Leibnizian law of continuity. Such a result is equivalent to what is known in the literature as the transfer principle (see [29]). The map that associates to every finite element of \(\mathbb{R}\) the real number infinitesimally close to it is known in the literature as

---

\[^{15}\text{Leibniz had two laws of homogeneity, one for dimension and the other for the order of infinitesimality. Bos notes that they “disappeared from later developments” [5, p. 35], referring to Euler and Lagrange.}\]

\[^{14}\text{The special case treated by Leibniz is } u(x) = x. This limitation does not affect the conceptual structure of the argument.}\]
the standard part function (10) (alternatively, the shadow). Such a map is a mathematical implementation of the Leibnizian transcendental law of homogeneity.

Acknowledgments

The authors are grateful to S. Wenmackers for helpful comments. The influence of Hilton Kramer (1928–2012) is obvious.

References

About the Cover

Does it get any better?
The theme of this month’s cover is taken from the article by Jeff Lagarias and Chuanming Zong in this issue. As they mention, the highest known packing density of regular tetrahedra is 4000/4671 (about 0.856347...). The packing is reported in “Dense crystalline dimer packings of regular tetrahedra”, an article in Discrete and Computational Geometry by Elizabeth Chen, Michael Engel, and Sharon Glotzer. It is a lattice made up of a basic assembly of 4 regular tetrahedra, grouped in pairs. Each pair, called a dimer, is a pair of tetrahedra joining face-to-face. One of these dimers is the inversion of the other, so that the two dimers are complementary, and are tightly bound to each other, with faces intersecting as in the figure at left on the cover.

In the packing, a layer of dimers is laid out in a slightly rising plane. A layer of inverted dimers is then inserted tightly onto that one, and then more alternating layers are added. Some idea of how the layers fit can be seen in the top view on the cover, and in the figure below.

One thing notable about the packing is how similar it appears to the well-known packing of spheres proved not so long ago by Tom Hales to be optimal.

The packing was constructed so as to be optimal among lattice packings with faces intersecting tightly. Chen et al. include in their article some heuristic reasoning that they might in fact have discovered the densest possible packing of regular tetrahedra, although it is hard to imagine that this can ever be proved. The article includes in an appendix a remarkable set of pictures illustrating the construction, drawn by Chen.

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


[36] Leibniz to l’Hospital, 21 June 1695, in [15], II, pp. 287–289.


[38] Leibniz to Varignon, 2 February, 1702, in [15], IV, pp. 91–95.


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WHAT IS...  

a Shimura Variety?

James S. Milne

Most mathematicians have encountered modular functions. For example, when the group theorists discovered the monster group, they were surprised to find that the degrees of its irreducible representations were already encoded in the $q$-coefficients of the $j$-function. The theory of Shimura varieties grew out of the applications of modular functions and modular forms to number theory. Roughly speaking, Shimura varieties are the varieties on which modular functions live.

**Shimura Curves**

According to the uniformization theorem, every simply connected Riemann surface is isomorphic to the Riemann sphere, the complex plane, or the open unit disk (equivalently the complex upper half plane $D_1$). The Shimura curves are the quotients of $D_1$ by the actions of certain discrete groups, which I now describe.

The action $\left( \begin{array}{cc} a & b \\ c & d \end{array} \right) \cdot z = \frac{az+b}{cz+d} \mod \mathbb{Z}$ of $\text{SL}_2(\mathbb{R})$ on $D_1$ realizes $\text{SL}_2(\mathbb{R})/\{\pm I\}$ as the group of holomorphic automorphisms $\text{Hol}(D_1)$ of $D_1$. Let $B$ be a quaternion algebra over a totally real number field $F$ such that $\mathbb{R} \otimes_F B$ is isomorphic to $M_2(\mathbb{R})$ for exactly one embedding of $F$ into $\mathbb{R}$, and let $G$ be the algebraic group over $\mathbb{Q}$ whose $R$-points for any $\mathbb{Q}$-algebra $R$ are the elements of $B \otimes_\mathbb{Q} R$ of norm 1. Then $G(\mathbb{R})$ is a product of $\text{SL}_2(\mathbb{R})$ with a compact group, and so there is a surjective homomorphism $\varphi: G(\mathbb{R}) \to \text{Hol}(D_1)$ with compact kernel. A Shimura curve is the quotient of $D_1$ by the image in $\text{Hol}(D_1)$ of a congruence subgroup of $G(\mathbb{Q})$.

For example, when $B = M_2(\mathbb{Q})$, the group $G$ is $\text{SL}_2$, and we get the familiar elliptic modular curves, namely, the quotients of $D_1$ by a discrete subgroup $\Gamma$ of $\text{Hol}(D_1)$ containing the image of a principal congruence subgroup

$$\Gamma(N) \overset{\text{def}}{=} \{ A \in \text{SL}_2(\mathbb{Z}) \mid A \equiv I \mod N \}.$$  

In this case, the Riemann surface $\Gamma\backslash D_1$ can be compactified in a natural way by adding a finite number of points (called the cusps), and so $\Gamma\backslash D_1$ has a unique structure of an algebraic curve compatible with its analytic structure. In all other cases, $\Gamma\backslash D_1$ is compact and so is automatically an algebraic curve.

Each Shimura curve has a natural embedding in projective space. Consider, for example, the elliptic modular curve $Y(N) \overset{\text{def}}{=} \Gamma(N)\backslash D_1$. A cusp form of weight $2k$ for $\Gamma(N)$ is a holomorphic function $f$ on $D_1$ vanishing at the cusps and such that

$$(1) \quad f(Az) = (cz+d)^{2k} \cdot f(z) \quad \text{for all } A = \left( \begin{array}{cc} a & b \\ c & d \end{array} \right) \in \Gamma(N).$$

For some fixed $k$, a basis $f_0, \ldots, f_n$ for the cusp forms of weight $2k$ defines an embedding

$$P \to (f_0(P): \ldots : f_n(P)): Y(N) \to \mathbb{P}^n(\mathbb{C})$$

of $Y(N)$ as an algebraic subvariety of $\mathbb{P}^n(\mathbb{C})$. In fact, we can do better. Each of the cusps is fixed by a unipotent matrix $\left( \begin{array}{cc} 1 & h \\ 0 & 1 \end{array} \right)$ with $h$ a positive integer. For such a matrix, (1) becomes $f(z) = f(z + h)$, and so a cusp form $f$ has an expansion

$$(2) \quad f(z) = a_1 q + a_2 q^2 + a_3 q^3 + \cdots , \quad q = e^{2\pi i/h}.$$  

Let $\mathbb{Q}(\zeta_N)$ be the field generated over $\mathbb{Q}$ by a $N$th root of 1. It is possible to choose the basis $f_0, \ldots, f_n$ so that the coefficients in (2) lie in the field $\mathbb{Q}(\zeta_N)$ and, when this is done, the homogeneous polynomials defining $Y(N)$ have coefficients in $\mathbb{Q}[\zeta_N]$. Thus $Y(N)$ has a canonical model over $\mathbb{Q}(\zeta_N)$. This property of $Y(N)$ is very unusual. Typically, an algebraic variety over $\mathbb{C}$ will not have a model over an algebraic number field, and when it does, it will have many distinct models, none of which is to be preferred.

The above explanation for why $Y(N)$ has a canonical model over $\mathbb{Q}(\zeta_N)$ is that of the analysts.
The geometers have an entirely different explanation. For an elliptic curve $E$ over $\mathbb{C}$, the group $E(\mathbb{C})$, of elements of order $N$ is a free $\mathbb{Z}/N\mathbb{Z}$-module of rank 2 equipped with a skew-symmetric pairing $e_N$ taking values in the group of $N$th roots of 1 in $\mathbb{C}$. A level-$N$ structure on $E$ is a basis $(t_1, t_2)$ for $E(\mathbb{C})$ such that $e_N(t_1, t_2) = \mathbb{Z}_N$. For $N \geq 3$, the canonical model of $Y(N)$ represents the functor sending a $\mathbb{Q}[\mathbb{Z}_N]$-algebra $R$ to the set of isomorphism classes of elliptic curves over $R$ equipped with a level-$N$ structure.

Both explanations fail when $B \neq M_2(\mathbb{Q})$: then the curves are compact, so there are no cusps and no $q$-expansions, and they are not moduli varieties in any natural way. Thus both the analysts and the geometers were surprised when Shimura (in 1967) proved that all these curves do have canonical models over specific number fields. The theory of Shimura varieties, as distinct from the theory of moduli varieties, can be said to have been born with Shimura’s paper. Ihara (in 1968) attached Shimura’s name to these curves.

**Shimura Varieties, according to Shimura**

A complex manifold is symmetric if each point is an isolated fixed point of an involution. For example, $D_1$ is symmetric because it is homogeneous and $i$ is an isolated fixed point of the involution $z \rightarrow \left( \frac{1}{i} \right) z = -i/z$. A connected symmetric complex manifold is called a hermitian symmetric domain if it is isomorphic to a bounded open subset of $\mathbb{C}^n$ for some $n$. Every hermitian symmetric domain is simply connected, and so the Riemann mapping theorem shows that $D_1$ is the only hermitian symmetric domain of dimension one. The connected Shimura varieties are the quotients of hermitian symmetric domains by the actions of certain discrete groups, which I now describe.

The group of holomorphic automorphisms of a hermitian symmetric domain $D$ is a semisimple Lie group whose identity component we denote by $\text{Hol}(D)^\times$. To define a family of connected Shimura varieties covered by $D$, we need a semisimple algebraic group $G$ over $\mathbb{Q}$ and a surjective homomorphism $G(\mathbb{R}) \rightarrow \text{Hol}(D)^\times$ with compact kernel. The connected Shimura varieties are then the quotients $\Gamma \backslash D$ of $D$ by a torsion-free subgroup $\Gamma$ of $\text{Hol}(D)^\times$ containing the image of a congruence subgroup of $G(\mathbb{Q})$ as a subgroup of finite index.

Baily and Borel proved that, as in the curve case, the modular forms on $D$ relative to $\Gamma$ embed $\Gamma \backslash D$ as an algebraic subvariety of some projective space. Thus, each manifold $\Gamma \backslash D$ has a canonical structure as an algebraic variety over $\mathbb{C}$, and a later theorem of Borel shows that the algebraic structure is in fact unique.

Shimura introduced the notion of a canonical model for these algebraic varieties. This is a model of the variety over a specific number field that is uniquely determined by specifying the fields generated by the coordinates of certain special points. Shimura and his students Miyake and Shih proved the existence of canonical models for several fundamental families of connected Shimura varieties.

**Shimura Varieties, according to Deligne**

When Deligne was asked to report on Shimura’s work in a 1971 Bourbaki seminar, he rewrote the foundations. For Deligne, a Shimura variety is defined by a reductive group $G$ over $\mathbb{Q}$ and a $G(\mathbb{R})$-conjugacy class of homomorphisms $h : \mathbb{C}^\times \rightarrow G(\mathbb{R})$ satisfying certain axioms. The Shimura variety itself is a certain double coset space. The axioms ensure that, on the one hand, this double coset space is a finite disjoint union of the varieties considered in the preceding section and on the other hand, that it is the base space for a variation of Hodge structures. Sometimes the variation of Hodge structures arises from a family of abelian varieties, in which case the existence of a canonical model follows from the theory of moduli varieties. In other cases, Deligne was able to prove the existence of a canonical model by relating the Shimura variety to one that is a moduli variety. In the remaining cases, the existence of a canonical model was proved by the author and Borovoi (somewhat independently).

Shimura varieties interested Langlands as a source of Galois representations and as a test for his idea that all zeta functions are automorphic. In a 1974 lecture he introduced the term “Shimura variety” for the varieties defined by Deligne. Once the existence (and uniqueness) of their canonical models had been demonstrated, it became customary to refer to the canonical model as the Shimura variety (rather than the variety over $\mathbb{C}$). The connected components of these varieties are the canonical models of the preceding section.

**Further Reading**

For Shimura’s approach, I suggest looking first at his notes *Automorphic Functions and Number Theory* and his ICM talks. For Deligne’s approach there are the difficult original articles of Deligne and the author’s *Introduction to Shimura Varieties*.

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The Universe in Zero Words and In Pursuit of the Unknown

Reviewed by Gerald B. Folland

A decade ago, Graham Farmelo got a dozen scientists and science writers to contribute essays on the “great equations of modern science” and compiled them into an interesting and informative book titled It Must Be Beautiful [2]. That book has now, it seems, engendered twin children. This year, two well-known expositors of mathematics, Dana Mackenzie and Ian Stewart, have simultaneously and independently produced books that employ a list of “great equations” (24 of them for Mackenzie, 17 for Stewart) as a framing device for discussing mathematics and its impact on civilization. Do we have a case of overkill here? Perhaps. But let me address that question after examining the evidence.

The first point to be made is that, in spite of their common theme, the books are quite dissimilar. Farmelo’s book has already been reviewed in the Notices by Bill Faris [1], so I will say little about it here except to note a few points of comparison. Most importantly, the fact that it is the work of multiple authors, only one of whom is a mathematician, gives it a decidedly different flavor from the books of Mackenzie and Stewart under review, and its restriction to twentieth-century science gives it a narrower scope. Stewart does not assume much mathematical background on the part of his readers, and he tries to be very careful about explaining the meaning of the ingredients in his equations. In one of the early chapters he explains the concept of derivative, and thereafter he is willing to use it frequently so that some differential equations can be put on his list, but that is about as high as the mathematics goes. (Even integrals are described only briefly and used in only one chapter.) Mackenzie operates at a somewhat higher level of mathematical sophistication. He starts out simply enough—his first equation is “1 + 1 = 2”, which leads into a discussion of the development of arithmetic in ancient times—but in the later chapters he is not afraid to include some equations whose precise meaning will be over the heads of many of his readers, as long as he can say something interesting about their general significance on a nontechnical level.
Now, what sorts of equations have the authors found worthy of inclusion in these “Top n” lists?

To begin with, the winner of the popularity contest—the one equation that is featured in all three books—is of little intrinsic interest in mathematics and only a small part of a bigger picture in physics, but it is so famous that it could not be omitted. Can you guess what it is? I’ll give you a hint: one would be wrong, but not far wrong, to guess that the $E$ on its left-hand side is in honor of Einstein.

The other equations common to both Stewart and Mackenzie have a lot more mathematical meat attached to them: the Pythagorean theorem, Newton’s law of gravity, Maxwell’s equations, and the Black-Scholes equation. (The last of these, as the concluding topic of both books, has a parallel purpose in the two books, although the featured equations are different. For example, both books have a chapter on chaotic dynamics, but Stewart introduces it with the discrete logistic equation $x_{n+1} = kx_n(1-x_n)$, whereas Mackenzie uses the Lorenz differential equations with their “strange attractor” solutions. And they each have a chapter on quantum mechanics: Stewart chooses Schrödinger’s equation to frame it; Mackenzie chooses Dirac’s. (Farmelo has both.)

As for the rest, one will find most of the usual suspects either in the chapter headings or elsewhere in the texts, but the authors have had to stretch things a bit to fulfill their purposes. Five of Stewart’s seventeen “equations” are not actually equations, at least if an equation is an assertion that two apparently distinct things are equal. Three of them are just the definitions of the derivative, the normal distribution, and the Fourier transform, and one is just the defining relation $i^2 = -1$; the other ringer is an inequality, $dS \geq 0$. ($S$ stands for entropy, in case you were wondering.) Similarly, one of Mackenzie’s equations is $\pi = 3.141592653\ldots$, and while $\pi$ is a worthy topic of discussion, its decimal expansion is hardly its most interesting feature. In all these cases as well as others it quickly becomes clear that the equation that heads a chapter is merely what Alfred Hitchcock called “the McGuffin”: the device that sets the plot in motion.

And most of those plots are quite engaging. For example, Stewart’s chapter on the Pythagorean theorem begins with some remarks on its emergence in the geometry of ancient Greece and elsewhere, then leads the reader through a bit of trigonometry to Cartesian geometry, non-Euclidean geometry, and finally the apotheosis of the Pythagorean theorem in its infinitesimal form as the cornerstone of Riemannian geometry. Mackenzie’s most arcane offering is the Chern-Weil-Allendoerfer-Gauss-Bonnet formula, which leads into an account of the eventful life of S. S. Chern and his role in the development of modern differential geometry and its connections to quantum physics.

Stewart is writing for the general literate reader. He tries hard to keep the technicalities at a minimum, and he spends a lot of time discussing historical developments and the phenomena of the “real world”, whose study involves the mathematics in his equations. As a mathematician I sometimes wished that he would get to the point more quickly, but his discursive style is probably quite agreeable to his intended audience. As one would expect from such an experienced writer, he is generally successful in getting the essential points across in a nontechnical way without too much distortion. A few sentences here and there are obscure, and one equation (the Einstein gravitational equation including the cosmological constant, on page 236) is seriously garbled. The one chapter that I think quite unsatisfactory is the one on the second law of thermodynamics; I found Stewart’s description of the relation between heat and temperature puzzling and off-kilter, and his explanation of situations where the second law apparently fails is inadequate.

Stewart’s chapter on logarithms (equation: $\log(xy) = \log x + \log y$) focuses on their original employment as a (powerful!) labor-saving device for numerical calculations. But computers have now rendered that use obsolete, and Stewart is at a bit of a loss to come up with modern applications. The chapter ends rather lamely by pointing out that the decibel scale of sonic intensity is a logarithmic one and that to find the half-life of an isotope from its decay law $N = N_0 e^{-kt}$, one needs to know what $\log 2$ is. I think Stewart has missed a trick by not picking up on the great structural feature of his logarithmic equation: it is, to use a professional term that he would probably not want to employ,
one of the earliest examples of a group homomorphism. With a little work, he could have used it to introduce one of the great themes of modern mathematics—the exploitation of correspondences between apparently different structures and some of its many recent applications.

Mackenzie’s ideal readers have a little more mathematical background than Stewart’s; I envision them as bright undergraduates or high school seniors who are oriented toward mathematics and science or people to whom this description would have applied in the not-too-distant past. They should probably know some calculus, and they should be comfortable enough with symbolic expressions to be able to look at an unfamiliar one with more curiosity than distaste. Mackenzie’s chapters are pithier and generally more mathematically adventurous than Stewart’s (and therefore, for my taste, more fun to read). For the ideal reader just described, they should serve as inviting doorways into many intriguing areas of mathematics. Like Stewart, Mackenzie is skillful at sketching things with clarity and simplicity. His weak spot is the chapter on the Dirac equation, which contains several confusions and misstatements.

In summary, the books of Mackenzie and Stewart, as well as Farmelo, are all worthy additions to the popular scientific literature, and they are of sufficiently diverse character that their considerable overlap is not mere duplication. However, individually and collectively, they do demonstrate that the “great equations” conceit is not particularly natural or productive and that the attempt to shoehorn a wide range of mathematics into this format is a procrustean one. I don’t think we now have a surfeit of “great equations” books, but we do have a sufficiency.

References
Book Review

The Mathematical Writings of Évariste Galois

Reviewed by Charles W. Curtis

The Mathematical Writings of Évariste Galois
Peter M. Neumann
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The name Évariste Galois and the subject known today as Galois theory are familiar to anyone who has studied modern algebra. In his short life of twenty years, ended following a duel in May 1832, Galois created the foundations of a large part of algebra as it is studied today, together with individual results that have never lost their sparkle.

There were several French editions of his published work and other writings. These include the testamentary letter to his friend Auguste Chevalier, written on the eve of the fatal duel and published as Galois had requested in the Revue Encyclopédique in September 1832. Chevalier served as Galois’s literary executor, made copies of two of the most important unpublished works of Galois, and gave them to Joseph Liouville in 1843. Liouville published the Oeuvres Mathématiques d’Évariste Galois [10] in his Journal de Mathématiques pures et appliquées in 1846. Other editors of the Galois manuscripts were Jules Tannery, who published Manuscrits et Papiers inédits de Évariste Galois in 1906, and Robert Bourgne and Jean-Pierre Azra, whose critical edition Écrits et Mémoires Mathématiques d’Évariste Galois appeared in 1962.

Translations of the manuscripts into German and Italian have appeared, along with English translations of some of them. The book that is the subject of this review, by Peter M. Neumann, contains an English translation of all of Galois’s writings published by Liouville and Tannery and more, with the original on the facing page for purposes of comparison. The author has done a painstaking analysis of the manuscripts, so that the French edition is not simply a reissue of older ones, and has included images of some of the Galois manuscripts from the archives de l’Institut de France. The reproductions provide a fascinating counterpoint to the texts and the translations. The author has also included extensive commentary “focused on the symbols on the page, on the syntax, on establishing an accurate text.” He acknowledges that commentaries “on the semantics, the meaning of what Galois wrote, would be a quite different exercise” and “must be the subject of further studies.” Hints of what further mathematical studies might be are included at several places in the notes on individual items. Comments on some of the existing English translations appear, with comparison with the author’s version.

The translations begin with the five mathematical articles published in Galois’s lifetime, beginning with an article on continued fractions published when he was seventeen in Annales de Mathématiques pures et appliquées, edited and published by J. D. Gergonne. In an introductory note, the author states that the article received a friendly review and was cited as recently as 1962 by Davenport, who commented, however, that the material was implicit in earlier work of Lagrange. The fourth, “Sur la théorie des nombres”, published when Galois was eighteen, was of great interest and importance, as it contained the original version of a substantial part of the theory of finite fields.

A translation of the testamentary letter of 29 May 1832 addressed to Chevalier appears next. The letter contains a survey of Galois’s ideas on the subject of what is now called Galois theory, along with a remarkable new result (with a proof) concerning the simple groups $PSL(2,p)$ and some material on

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integrals of algebraic functions and the theory of elliptic functions.

Several of Galois’s works besides the Galois theory of equations led to new developments. A striking example is the result on the simple groups $PSL(2,p)$ contained in the letter to Chevalier. Half a century later Gierster [8] gave a determination of the subgroups of $PSL(2,p)$. This included a new proof of Galois’s result. It was taken up again in the last half of the twentieth century by J. H. Conway [4] in connection with exceptional properties of the known simple groups and the discovery of new nonabelian finite simple groups—the sporadic simple groups. Galois’s foray into group theory in the letter to Chevalier began with a summary of some properties of the group of linear fractional transformations

$$x \rightarrow \frac{ax + b}{cx + d}$$

with $x$ in the finite field $F$ of $p$ elements, for an odd prime $p$ and $ad - bc \neq 0$, which can be identified with the quotient $PSL(2,p)$ of the finite group $SL(2,p)$ of $2 \times 2$ matrices of determinant one by its center, of order 2. Galois stated (Neumann’s translation), “Thus simplified, the group has

$$\frac{(p + 1)p(p - 1)}{2},$$

permutations. But it is easy to see that it is not further decomposable properly unless $p = 2$ or $p = 3$.” In modern terminology, Galois stated that $PSL(2,p)$ is a simple group if $p \neq 2, 3$. As the group $PSL(2,p)$ has a subgroup of index $p + 1$, it has a transitive permutation representation on $p + 1$ elements. Galois raised the question as to whether $PSL(2,p)$ has a transitive permutation representation on a set of fewer than $p + 1$ elements, first pointing out that this is not possible for a set of fewer than $p$ elements. He then stated and gave an outline of a proof of the theorem that the group $PSL(2,p)$ has a transitive permutation representation on a set of $p$ elements when $p = 5, 7, 11$ and does not have a nontrivial permutation representation on a set of fewer than $p + 1$ elements if $p > 11$. The theorem applies to the simple groups $PSL(2,p)$ for $p \geq 5$. It can also be mentioned that the group $PSL(2,3)$ of order 12 has a transitive permutation representation on a set of 3 elements. Conway examined more closely the cases $p = 3, 5, 7, 11$ in Galois’s theorem, leading to exceptional properties of the groups $PSL(2,p)$ in these cases. For example, these include isomorphisms $PSL(2,3) \cong A_4, PSL(2,5) \cong A_5$, and a presentation of the sporadic Mathieu simple group $M_{12}$ of order $12 \cdot 11 \cdot 10 \cdot 9 \cdot 8$ related to a presentation of the simple group $PSL(2,11)$. Conway continued with an illustration of the way the exceptional permutation representations of the small simple groups $PSL(2,p)$ can arise in other situations by considering the permutation representation of Janko’s sporadic simple group $J$ of order 175560 on 266 letters, involving the simple group $PSL(2,11)$.

In a note preceding the translation of the article “Mémoire sur les conditions de résolubilité des équations par radicaux”, usually referred to as the First Memoir (Premier Memoir), Neumann states, “The memoir on the conditions for solubility of equations by radicals is undoubtedly Galois’s most important work. It is here that he presented his original approach to the theory of equations which has now become known as Galois Theory.” Galois had submitted it to the Académie des Sciences on 17 January 1831, only to have it rejected and returned to him on the basis of a referees’ report by Lacroix and Poisson. In the notes on the first memoir, Neumann provides a translation of the referees’ report on it, with comments on the report by J. Tits and the author and some history of further attempts by Galois to interest the Académie des Sciences in his work. In the testamentary letter, Galois gave his view on the situation: “Le premier est écrit, et malgré ce qu’en a dit Poisson, je le maintiens avec les corrections que j’y ai faites.” (Neumann’s translation: “The first [memoir] is written, and in spite of what Poisson has said about it, I stand by it with the corrections that I have made on it.”)

The purpose of the first memoir was to define a finite group, today called the Galois group, associated with a polynomial equation $f(x) = 0$ and to derive the necessary and sufficient conditions the group must satisfy in order for the equation to be solvable by radicals. The basic ideas about finite groups needed to carry this out were developed in the memoir for the first time and are part of the early history of finite group theory.

In his book Galois Theory [6], Harold Edwards gave an account of the subject “in a way that would not only explain it, but explain it in terms close enough to Galois’s own to make his memoir accessible to the reader.” With Neumann’s translation and commentary on the first memoir now available, Edwards has given a step-by-step presentation, addressed to “modern readers”, of the main results in the first memoir [7].

A modern approach to Galois theory (see for example [1]) is based on a study of the splitting field of a separable polynomial with coefficients in a base field. The Galois group of the field extension is the set of automorphisms of the splitting field that leave elements of the base field fixed. The main theorem of Galois theory is the statement that there is a one-to-one correspondence between subgroups of the Galois group and intermediate fields, which are subfields of the splitting field containing the base field. An intermediate field is a normal extension of the base field if and only if the corresponding subgroup of the Galois group is a normal subgroup.

The ideas involved in Galois’s description of the subfields of the splitting field of a polynomial in terms of the subgroups of the Galois group have appeared later in other parts of mathematics. For example, they were acknowledged in Chevalley’s ap-
proach to the notion of a covering space of a topological space and the Poincaré group (or fundamental group) associated with the simply connected covering space. Chevalley stated in his book Theory of Lie Groups [2, p. 27]: “The Poincaré group is the group of automorphisms of the simply connected covering space, playing therefore a role similar to that played by the Galois group of an algebraic extension.”

The comments I make in this review about Galois’s result in group theory in the testamentary letter and the reference to Chevalley’s comment about Galois in his Theory of Lie Groups represent my own expanded appreciation of Galois beyond the Galois theory of equations. This began when I heard Conway’s lecture on exceptional groups at Oxford (where I had been lecturing about Chevalley groups and thinking about simple groups) and realized that, at least for me, Galois’s result put his overall contribution in a new light. The reference to Chevalley’s book comes from a course on Lie groups which I gave at Wisconsin in the 1950s to an audience including students of R. H. Bing who all knew more topology than I did and were rather dismissive of Chevalley’s treatment of covering spaces. I developed the parallel with Galois theory in more detail than Chevalley and found it quite satisfying, even though the topologically inclined students were probably not impressed.

The second memoir, “Des équations primitives qui sont solubles par radicaux”, contains further development of the theory of permutation groups in connection with the problem stated in the title. As Neumann says, “That this is an old unfinished piece of work that Galois had intended to amplify, polish and publish seems clear.” With reference to the second memoir, the author says in an epilogue "Myths and Mysteries" (p. 386): “The Lettre testamentaire bears witness to the fertility of his mind and very strongly suggests that he had created much mathematics that goes a long way beyond what he had published and what he had drafted in the Premier Mémoire. One can—and many writers do—build an edifice of conjecture on the brief sketch he gave there. Much, though not all, of what he wrote about primitive soluble equations (or groups) and about the groups now known as PSL(2,p) is supported in part in the Second Mémoire.”

The remaining translations, in a chapter entitled “The Minor Mathematical Manuscripts”, include what are often fragments relating to the first and second memoirs and other topics, such as Galois’s explanation of how his work was independent of Abel’s work on the general equation of the fifth degree. On this point Galois stated (in Neumann’s translation), “but he has left nothing on the general discussion of the problem which has occupied us. Once and for all, what is remarkable in our theory is to be able to answer yes or no in all cases” (with the last few words crossed out and replaced by the single word “répondre”). This is surely an indication of Galois’s anticipation of the modern approach to parts of the mathematics of today, characterized by the search for general solutions to problems.

The items in the chapter are organized into dossiers from a volume of manuscripts in the library of the Institut de France. Neumann has “sought to reproduce [each] manuscript as accurately as possible in print, with all its crossings-out, emendations, additions, and quirks of writing.” Notes are included before and after each item, with detailed comparisons to corresponding parts of the material in the editions of Tannery and of Bourgne and Azra, and occasionally mathematical topics the author plans to explore. This part of the book with the texts and the accompanying notes fills in the sketchy picture we have of Galois’s mathematical persona in a particularly satisfying way and will be an important reference for further studies of Galois’s mathematics.

The collected works show that Galois’s thinking was not restricted to his group-theoretic approach to the theory of equations, complete and satisfying as it was. His results on exceptional permutation representations of the simple groups PSL(2,p) put him in the company of twentieth-century group theorists in their search for new nonabelian finite simple groups. Another topic that started with Galois and which would require a long and multifaceted article in order to describe its place in today’s mathematics is the theory of finite fields. I shall mention here only a few things about finite fields and linear groups.

The starting point is the great book of C. Jordan [9], Traité des substitutions et des équations algébriques, published in 1870, on linear groups over the finite field of p elements for a prime p, with applications to Galois theory. In the preface the author mentions works he consulted, beginning with the works of Galois, on which, he states, his book (of over 600 pages) is a commentary! He credits Galois for calling attention to the distinction of whether a group is simple or not. He defines what are now called the classical groups—the general linear group, the orthogonal group and the symplectic group—one on a finite dimensional vector space over the finite field of p elements. For each type of group, he calculates the order and the composition factors. In 1900 L. E. Dickson published Linear Groups, with an Exposition of the Galois Field Theory [5]. The first part of the book contains a thorough presentation of Galois’s theory of finite fields. The main point of the book is to carry over Jordan’s work on the classical groups over the field of p elements to the corresponding theory for classical groups over a general finite field. The nonabelian finite simple groups obtained as composition factors of the classical groups, along with twisted versions of them and the alternating groups, were the only known infinite families of nonabelian simple groups until Chevalley’s paper “Sur certains groupes simples” [3] gave new infinite families of nonabelian
finite simple groups associated with the exceptional simple Lie algebras.

The book, in the author’s words, “is conceived as a contribution to the history of mathematics.” It also gives a mathematically knowledgeable reader a chance to follow a series of groundbreaking mathematical events, from Galois’s invention of what he needed from group theory in order to solve the problem stated in the title of the first memoir to his first steps towards establishing group theory as an independent subject, beginning with the second memoir and continuing with his determination, in the letter to Chevalier, of the exceptional permutation representations of the linear fractional groups. It’s quite a story.

References
On June 20, 2011, the outstanding mathematician and teacher Alexander V. Abrosimov passed away in the city of Nizhny Novgorod in Russia, due to a serious illness.

Alexander Abrosimov was born on November 16, 1948, in the city of Kuibyshev (now Samara). In 1971 he graduated from the Department of Mechanics and Mathematics of the State University of Gorky (now Lobachevsky State University of Nizhny Novgorod).

Dr. Abrosimov undertook graduate studies in the Department of Mechanics and Mathematics of Lomonosov Moscow State University under the supervision of Professor Boris Shabat. In 1984 he defended his Ph.D. dissertation “Complex differential systems and the tangential Cauchy-Riemann equations”. Dr. Abrosimov was associate professor in the theory of functions subdepartment in the Department of Mechanics and Mathematics and Invited Lecturer in the Advanced School of General and Applied Physics (the base department of the Institute of Applied Physics and the Institute for Physics of Microstructures of the Russian Academy of Sciences).

Beginning with his first works in 1971–73, Abrosimov studied overdetermined systems of partial differential equations, where he successfully applied an original approach which he developed.

A bright mathematical work, “On locally biholomorphic equivalence of smooth hypersurfaces in $\mathbb{C}^2$”, was devoted to an explicit procedure enabling one to decide whether two given smooth real hypersurfaces are locally CR-diffeomorphic.

Subsequently, Abrosimov applied his original technique to describe CR-automorphisms of real quadrics of higher codimension. In this direction, he obtained

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important results and elaborated methods nowadays well known to CR-geometry specialists.

Firstly, Abrosimov proved that holomorphic automorphisms of a quadric of codimension two are furnished by birational transformations of degree two.

Secondly, he convincingly demonstrated the power of the machinery of differential algebra in CR-geometry. In particular, he proved that, under mild conditions, the stabilizer of a point in the group of automorphisms of a quadric in $\mathbb{C}^n$ is a linear group.

Thirdly, he was among the first researchers to look into a class of CR-manifolds of codimension one. To date, the class has remained a focus of active attention.

Overall, Alexander Abrosimov published more than twenty-five scientific works on complex analysis, including the fundamental paper "A description of locally biholomorphic automorphisms of standard quadrics of codimension two". Some of the works of Abrosimov in CR-geometry and adjacent fields in complex analysis are deemed pioneering.

Abrosimov was a brilliant teacher and lecturer; he enjoyed igniting the fire in students and inspiring them to learn and develop mathematics. He passed away, but his spirit of optimism and belief in cognizance of the world are alive in his disciples and will live on for years to come.


**Selected papers of Dr. A. V. Abrosimov**


The University of California
Cal Teach Program: Recruiting
Highly Qualified Future Teachers
of Mathematics and Science

Edward Landesman and Gretchen Andreasen

Every Tuesday and Friday morning, Ms. Lindsey Wilson's eighth grade Algebra 1A students at Mission Hill Middle School in Santa Cruz, California, had some extra excitement when University of California, Santa Cruz (UCSC) senior mathematics major Crystal Calderón ('12) came to class. Crystal led warm-up activities, helped students solve algebra problems, and created answer keys, all in an effort to prepare herself for a career as a mathematics teacher. Crystal's confidence in achieving her goal was bolstered by knowing that her host teacher, Ms. Wilson, was in Crystal's position a few short years ago—an undergraduate mathematics major and an intern in the University of California Cal Teach program. As a result of her participation in Cal Teach, Ms. Wilson won a scholarship to enroll in UCSC's one-year MA/teaching credential program, and she is now in her third year of a successful teaching career.

Crystal and Lindsey each have been the beneficiaries of an agreement made in 2005 between

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This article was written during the 2011–12 academic year; program data and personal experiences cited reflect this timing.

Members of the Editorial Board for Doceamus are: David Bressoud, Roger Howe, Karen King, William McCallum, and Mark Saul.

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*Source of data is the California Postsecondary Education Commission website, http://www.cpec.ca.gov/OnlineData/OnlineData.asp data for 2009.
education major that integrates a mathematics emphasis and a new science, technology, engineering, and mathematics (STEM) education minor. Mathematics majors participate in high numbers. Over one-third of participants in UCSC’s program have been mathematics majors, and over one-half of the internships have been in mathematics classrooms. Through the new sequence of courses and classroom field work, undergraduates are introduced to students at various grade levels within middle schools and high schools and at multiple levels of performance, ranging from honors to remedial. The students also encounter host teachers and schools in communities of varying socioeconomic status and cultural diversity.

At UCSC, as on other UC campuses, a Cal Teach Resource Center was established and serves as the campus’s central point for information about mathematics and science teaching careers and also coordinates the internship and academic programs. The center provides information to any interested undergraduate with appropriate mathematics or science preparation, to faculty and staff who may advise students, to prospective transfer students, and to professional scientists and engineers who may be considering career changes.

Statewide Efforts and California Community College Partnerships
Early in the formation of Cal Teach, the first author led a UC/California Community College (CCC) partnership to identify, support, and recruit community college students to teach mathematics and science. As a result, as many as twenty-five community colleges around the state developed internship programs similar to Cal Teach and formed relationships with their local UC campuses to ease the transfer of mathematics and science majors to the university. This year, for the first time, a UCSC Cal Teach mathematics major is working as a math tutor at UCSC’s nearest community college partner (Cabrillo College), with a goal of expanding the recruitment of future mathematics and science teachers to UC.

Frances Venegas, now a successful fourth-year science teacher at Harden Middle School in Salinas, California, transferred to UCSC from her local community college. Frances credits Cal Teach with introducing her to teaching and with altering her career path. Frances started college in 2003 after twenty-two years in the restaurant business, planning to become a marine biologist. After an academic quarter of field work in French Polynesia, she returned to campus, where she enrolled in a Cal Teach internship. This catalyzed her decision to teach. Frances’s experience reflects the importance of reaching out to community college transfer students in the Cal Teach recruitment process. The two-year California community colleges are the entry point to UC for many lower-income students from diverse backgrounds who are underrepresented as mathematics and science teachers. These transfer students often express an interest in teaching careers and in returning to their communities to assist future generations of students. For example, Frances is now teaching in the same low-income community where she has lived for many years.

Impact
Since UC began its Science and Mathematics Initiative in 2005, over five thousand undergraduates system-wide have completed a K–12 classroom internship. Currently, Cal Teach programs across the UC system coordinate about two thousand classroom placements each year. As Cal Teach undergraduates across the state have gained crucial experience for their own professional development, they have also enriched the classroom experience of hundreds of thousands of K–12 students across California.

The teachers who serve as classroom mentors welcome the energetic and inspired college students as an additional resource in their classrooms and value the exposure of their students to these successful role models. At UCSC alone, over fifty teachers will host interns in at least ten regional schools this year. Most of these mentor teachers continue to volunteer year after year. One skilled and generous host teacher of over twenty-five UCSC undergraduates says he is waiting for the right Cal Teach graduate to come along to fill his job so he can retire! He may soon get his wish. Approximately two hundred forty UCSC Cal Teach students have graduated, and seventy-five (nearly one-third of those graduates) have entered a teaching credential program. Of course, it is too early to have data on the relative effectiveness or retention of these recent Cal Teach graduates, but anecdotal evidence from school district collaborators suggests that the new teachers are thriving. One partner district is happily recruiting new teachers from the Cal Teach graduates, while another partner district was grateful to fill a midyear opening with a Cal Teach graduate. A third district reports that its new teachers with Cal Teach experience are “hitting the ground running.”

Sustaining and Extending the Model
To continue to thrive, the UC Cal Teach program will require the ongoing support of university faculty in the mathematics, science, engineering, and education departments, as well as partnerships with community colleges and K–12 schools. The good work developed among the many partners and the successes of these first years, along with help from alumni and private donors who understand the importance of producing future highly qualified
mathematics and science teachers, should help sustain the program.

The Cal Teach model can be replicated. The single most important requirement for building such a program is the designation of a staff or faculty member whose time is committed to developing and sustaining the program. This effort includes the coordination of partnerships among the many university, community college, and K–12 stakeholders, as well as concentrated interaction with the students who participate. Most, but not all, UC Cal Teach programs are housed in a division of mathematics, science, or engineering with partners in the school or department of education. This partnership and organizational structure help to ensure that academic planning and student support are tailored to meet the needs of future math and science teachers.

A successful program of internships along with academic seminars also requires financial support to ensure small class sizes and to cover the costs of placing students in K–12 classrooms. On most UC campuses, stipends are provided to K–12 teachers who host the interns and to the interns themselves. Most host teachers would participate without an honorarium, although the honoraria do help build a sense of professional responsibility and commitment to the Cal Teach students. Similarly, many students would participate without internship “stipends”, but the stipends help recruit a greater number of students and reinforce the value of their career choice. Details of the Cal Teach programs vary from campus to campus, depending upon local campus traditions and strengths. However, the basic model—engaging greater numbers of STEM majors to explore and prepare for future careers in K–12 teaching—has been implemented successfully on UC campuses throughout the state. The Cal Teach model can be replicated throughout the country. For further information about the program, the second author can be contacted at calteach@ucsc.edu.

Acknowledgment
Professor Landesman retired from the University of California in February 2011, but he continues to support future teachers through fundraising for UCSC’s Cal Teach program. Dr. Andreasen serves as the director of the UC Santa Cruz Cal Teach program, collaborating with UC and CCC colleagues around the state.

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**THE CHINESE UNIVERSITY OF HONG KONG**

Applications are invited for:-

**Department of Mathematics**

**Assistant Professor**

(Ref. 1213/003(576)/2) (Closing date: March 15, 2013)

The Department invites applications for an Assistant Professorship in all areas of mathematics. Applicants should have a relevant PhD degree and an outstanding profile in research and teaching. Appointment will normally be made on contract basis for up to three years initially commencing August 2013, which, subject to mutual agreement, may lead to longer-term appointment or substantiation later.

**Salary and Fringe Benefits**

Salary will be highly competitive, commensurate with qualifications and experience. The University offers a comprehensive fringe benefit package, including medical care, a contract-end gratuity for an appointment of two years or longer, and housing benefits for eligible appointee. Further information about the University and the general terms of service for appointments is available at [http://www.personnel.cuhk.edu.hk](http://www.personnel.cuhk.edu.hk).

The terms mentioned herein are for reference only and are subject to revision by the University.

**Application Procedure**

Please send full resume, copies of academic credentials, a publication list and/or abstracts of selected published papers, together with names, addresses and fax numbers/e-mail addresses of three referees to whom the applicants’ consent has been given for their providing references (unless otherwise specified), to the Personnel Office, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong (Fax: (852) 3943 1462) by the closing date. The Personal Information Collection Statement will be provided upon request. Please quote the reference number and mark ‘Application - Confidential’ on cover.

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**CENTRE INTERFACULTAIRE BERNOLLI**

**CIB**

**CALL FOR PROPOSALS**

The Bernoulli Center (CIB), funded jointly by the Swiss National Science Foundation and the Swiss Federal Institute of Technology in Lausanne, has started its activity in March 2002. Its mission is to support research in mathematics and its applications, to organize and host thematic programs, to provide a supportive and stimulating environment for researchers, and to launch and foster collaborations between mathematicians working in different areas as well as mathematicians and other scientists.

The CIB launches a call for proposals of four one-semester programs during the period **July 1, 2014 - June 30, 2016**. A thematic program consists of a six months period (January 1 - June 30 or July 1 - December 31) of concentrated activity in a specific area of current research interest in the mathematical sciences. In exceptional cases, one year and three month programs will also be considered.

Those who are interested in organizing a program at the CIB should submit a **two page letter of intent by April 1st, 2013**. This letter should give the names of the organizers, of the potential visitors, and outline the program. For more details see [http://cib.epfl.ch](http://cib.epfl.ch).

École Polytechnique Fédérale de Lausanne
Centre Interfacultaire Bernoulli (CIB)
SB CIB-GE
AAC034 (Bâtiment AAC)
Station 15
CH-1015 Lausanne
Morton’s Fork was named after Cardinal Morton who was Lord Chancellor of England in the reign of King Henry VII. By visiting noblemen of the time, he would judge their tax for the coming year. If the hospitality he was given was economical, it was reasoned that his host was saving money and could afford a large gift to the King. If, on the contrary, the hospitality was sumptuous, he was evidently wealthy and could afford a large gift to the King. These arguments were the two prongs of the Fork.

Commercial publishers have gripped research mathematicians in a similar fork. On the one hand, whilst carrying out our research, we need—indeed demand—total access to the literature. If we want to consult a paper, we will do whatever we need to do to find it...in the old days, we would look in our filing cabinets, then colleagues’ cabinets, then search libraries or telephone more distant colleagues. These days we are more likely to start at the arXiv or Google before resorting to hard-copy search. The methods may have altered, but the purpose has not. We need to check or use previous work and nothing will stop us until we find it in some form or other. This is the first prong of the fork. The other is that, once we have produced a piece of new research, we want everyone to see it. We don’t hide it under a bushel; we want to give it away for all to see. We eagerly talk about it to colleagues and students, freely give lectures on it (in all gory detail if asked). We do the same for everyone else’s research, including anonymous refereeing, editorial advising, and so on. This is the second prong of the fork.

These two prongs, (a) that we demand access to all other research and (b) that we offer our research and research-related services for free, have given our publishers a huge lever over us. We create a product (published research), give it away free, and then buy it back with a totally inelastic demand. Given the current financial ethos under which companies exist only to make money, incidentally providing a service, it is not at all surprising that we are now paying exorbitant fees for access to our research. The usual countervailing mechanism in capitalism—competition—is totally absent in this market because there is no competition between journals. Each publishes a different set of papers. The Annals (a well-run, academically-owned, moderately-priced journal) is not in competition with Inventiones (an exorbitantly overpriced Springer journal), although they are of similar standard in a similar subject, because they each carry a different set of papers which we all need to read. We need permanent access to both of them. The only journals to which we don’t need access are the (very few) journals which publish only low-level papers.

This situation came home to me with full force about seventeen years ago when I was chair of the University of Warwick Mathematics Department. My research partner Brian Sanderson was Library Representative, and we faced the annual journal cutting exercise. We reasoned: Journals are produced by the community, largely using free labor; mathematicians even do their own

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large extent on our own unpaid labor. Rob Kirby, recognizing that this model was unsustainable in the long run, started a nonprofit publishing company, Mathematical Sciences Publishers, based at Berkeley, to take over production. The story of MSP needs a separate article to do it justice. Here it is enough to say that MSP has properly paid staff and has given *Geometry & Topology* and our other ventures a permanent stable home. We are no longer fully open access because the economic climate has made this impossible but we are still extremely low-priced and intend to remain so.

In its own terms, *Geometry & Topology* has been an unparalleled success. The electronic versus nonelectronic dichotomy has vanished since we started and all journals are now produced as we have always done, with a primary electronic version published before the print version. However, in terms of changing the ethos of academic publication and reducing overall prices, it has been a dismal failure. There has been no change in the gloomy vice-like grip in which commercial publishers hold our libraries. The current move towards “open access” publishing has no value whatsoever unless the ownership of journals is changed at the same time. By shifting an exorbitant publication cost from library to author, nothing is changed. What is needed is concerted government action to buy back the rights to our, predominantly publicly funded, research from the commercial journals and pass ownership of the journals over to the academic community to run as we run *Geometry & Topology*. In this way the publication cost, however financed, will be reduced to a fair sustainable level. It will be expensive in the short term, but it will lead to a situation where we can all once again afford to consult our own research.
Mathematics People

Viehmann Awarded von Kaven Prize

EVA VIEHMANN of the Technical University of Munich has been awarded the 2012 von Kaven Award in mathematics “in recognition of her outstanding research in the field of arithmetic algebraic geometry.” The prize, which is administered by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), carries a cash award of 10,000 euros (approximately US$13,000).

Viehmann was honored for her work on the Langlands program, which consists of a wide-ranging series of conjectures that relate algebraic number theory to representation theory of algebraic groups. The program, according to the prize citation, “has developed into an important and highly relevant field of mathematical research.” Viehmann, “through her investigations into the global structure of moduli spaces of \( p \)-divisible groups and into the definition of local \( G \)-shtukas, has contributed new and original findings in this specialized area.”

The von Kaven prize is funded from the proceeds of the von Kaven Foundation, which was established in 2004 by mathematician Herbert von Kaven, who died in 2009 at the age of 101.

—From a DFG announcement

Prizes of the Canadian Mathematical Society

MATTHEW KENNEDY of Carleton University has been awarded the 2012 Doctoral Prize of the Canadian Mathematical Society (CMS). In his Ph.D. thesis at the University of Waterloo he provided “a detailed structure theorem for an important class of linear operators, namely row isometries, which can be used to generate families of wavelets used for data compression. The structure theorem sheds new light on this area of application.”

The prize citation states, “The research Kennedy completed in his doctoral studies is related to an important class of algebras and operators. In his thesis entitled 'Free semigroup algebras and the structure of an isometric tuple' he made great strides towards completing the structure theory of free semigroup algebras, in particular fully resolving three questions that have been recognized to be of central importance to this project for at least a decade.

Furthermore, he generalized the classical Lebesgue-von Neumann-Wold decomposition of Hilbert space isometries to the situation of isometric \( n \)-tuples.”

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

MELANIA ALVAREZ of the University of British Columbia and the Pacific Institute for the Mathematical Sciences (PIMS) has been awarded the 2012 Adrien Pouliot Award of the Canadian Mathematical Society in recognition of her contributions to mathematics education in Canada. She has focused largely on working with First Nations students to improve their mathematical education and reduce their dropout rates. She also helps organize the Elementary Mathematics Contest (ELMACON), problem-solving workshops for students at elementary and secondary schools, and math workshops for elementary and secondary school teachers, and engages in active fundraising to support a wide range of education activities.

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

—From CMS announcements

Shiller Awarded 2012 CME/MSRI Prize

ROBERT SHILLER of Yale University has been awarded the 2012 CME Group-MSRI Prize in Innovative Quantitative Applications. Shiller is co-creator of the Case-Shiller Index of U.S. house prices and author of the book *Irrational Exuberance*, which warned about the possible bursting of speculative bubbles. The annual prize is awarded to an individual or a group to recognize originality and innovation in the use of mathematical, statistical, or computational methods for the study of the behavior of markets and, more broadly, of economics. The award carries a cash prize of US$25,000.

—Elaine Kehoe
NDSEG Fellowships Awarded

Fourteen young mathematicians have been awarded National Defense Science and Engineering Graduate (NDSEG) Fellowships by the Department of Defense (DoD) for 2012. The fellowships are sponsored by the United States Army, Navy, and Air Force. As a means of increasing the number of U.S. citizens trained in disciplines of military importance in science and engineering, DoD awards fellowships to individuals who have demonstrated ability and special aptitude for advanced training in science and engineering. The following are the names of the fellows in mathematics, their institutions, and the offices that awarded the fellowships: DANIEL BEYLKIN, Yale University, Air Force Office of Scientific Research (AFOSR); ISSAC BUIENROSTRO, Stanford University, AFOSR; MY HUYNH, Stanford University, AFOSR; MARKUS KLEIGL, Princeton University, AFOSR; ANDREW LI, Massachusetts Institute of Technology, Office of Naval Research (ONR); ALEXANDER LUEDTKE, Harvard University, ONR; HANNAH MANUEL, Princeton University, ONR; EMILY MEISSEN, University of Arizona, AFOSR; DEREK OLSON, University of Minnesota, Twin Cities, ONR; ZOHAR STRINKA, University of Michigan, Ann Arbor, Army Research Office (ARO); ILA VARMA, Princeton University, AFOSR; CHELSEA WEAVER, University of California Davis, ONR, ANDREW WILSON, University of California San Diego, AFOSR; and JASON XU, University of Washington, ARO.

—From an NDSEG announcement

B. H. Neumann Awards Given

The Australian Mathematics Trust has awarded several B. H. Neumann Awards for service to the mathematics profession. JANINE McINTOSH of the Australian Mathematical Sciences Institute has been a primary school teacher and a member of the Mathematics Challenge for Young Australians Problems Committee, is an author of a series of textbooks, and provides professional development for teachers. GRAHAM K. MEIKLEJOHN, state director for Queensland Australian Mathematics Competition (AMC), is a coauthor of several resource books for mathematics teachers. WEN-HSIEN SUN is a mathematics book publisher and mathematics bookstore owner in Beijing and Taipei; he hosted the International Mathematics Competition in Taipei in 2012 and is the Taiwan national director for the AMC.

—From an Australian Mathematics Trust announcement

Worldwide Search for Talent

City University of Hong Kong is a dynamic, fast-growing university that is pursuing excellence in research and professional education. As a publicly-funded institution, the University is committed to nurturing and developing students’ talent and creating applicable knowledge to support social and economic advancement. Currently, the University has six Colleges/Schools. Within the next two years, the University aims to recruit 100 more scholars from all over the world in various disciplines, including science, engineering, business, social sciences, humanities, law, creative media, energy, environment, and other strategic growth areas.

Applications and nominations are invited for:

Chair Professor/Professor
Associate Professor/Assistant Professor
Department of Mathematics [Ref. A/094/49]

Duties: Conduct research in areas of Applied Mathematics including Analysis and Applications, Mathematical Modelling (including biological/physical/financial problems), Scientific Computation and Numerical Analysis, and Probability and Statistics; teach undergraduate and postgraduate courses; supervise research students; and perform any other duties as assigned.

Requirements: A PhD in Mathematics/Applied Mathematics/Statistics with an excellent research record.

Salary and Conditions of Service
Remuneration package will be driven by market competitiveness and individual performance. Excellent fringe benefits include gratuity, leave, medical and dental schemes, and relocation assistance (where applicable). Initial appointment will be made on a fixed-term contract.

Information and Application
Further information on the posts and the University is available at http://www.cityu.edu.hk, or from the Human Resources Office, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong [Fax: (852) 2788 1154 or (852) 3442 0311/email: hrjjob@cityu.edu.hk].

Please send the nomination or application with a current curriculum vitae to Human Resources Office. Applications and nominations will receive full consideration until the positions are filled. Please quote the reference of the post in the application and on the envelope. Shortlisted candidates for the post of Assistant Professor will be requested to arrange for at least 3 reference reports sent directly by their referees to the Department, specifying the position applied for. The University reserves the right not to fill the positions. Personal data provided by applicants will be used strictly in accordance with the University’s personal data policy, a copy of which will be provided upon request.

The University also offers a number of visiting positions through its “CityU International Transition Team” for current graduate students and for early-stage and established scholars, as described at http://www.cityu.edu.hk/provost/cityu_international_transition.htm.

City University of Hong Kong is an equal opportunity employer and we are committed to the principle of diversity. We encourage applications from all qualified candidates, especially those who will enhance the diversity of our staff.
AWM Announces Two New Research Prizes

The Executive Committee of the Association for Women in Mathematics (AWM) has established two new research prizes.

The AWM-Microsoft Research Prize in Algebra and Number Theory will highlight exceptional research in some area of algebra by a woman early in her career. The prize is made possible by a generous contribution from Microsoft Research. When reviewing nominations for this award, the field will be broadly interpreted to include number theory, cryptography, combinatorics, and other applications, as well as more traditional areas of algebra.

The AWM-Sadosky Research Prize in Analysis will highlight exceptional research in analysis by a woman early in her career. The prize is funded by generous contributions from family and friends of former AWM president Cora Sadosky (1940–2010). When reviewing nominations for this award, the field will be broadly interpreted to include all areas of analysis.

Both prizes will be awarded every other year, with the first prizes presented at the AWM Reception at the Joint Mathematics Meetings in Baltimore, Maryland, in January 2014. The recipients will receive a cash prize and an honorary plaque and will be featured in an article in the AWM newsletter. Candidates should be women within ten years of receiving the Ph.D. or who have not yet received tenure. For full consideration, nominations should be submitted by February 15, 2013.

For further information on both prizes and nomination materials, see the website [http://www.awm-math.org](http://www.awm-math.org).

—From an AWM announcement

STaR Program for Early Career Mathematics Educators

The National Science Foundation (NSF) funds the STaR (Service, Teaching and Research) program, consisting of a summer institute, an academic year networking via electronic means, and a regroup session in conjunction with the annual meeting of the Association of Mathematics Teacher Educators (AMTE).

The fourth cohort of STaR Fellows will meet for a Summer Institute in Park City, Utah, the week of July 14–19, 2013, in conjunction with the Park City Mathematics Institute (PCMI). Eligibility is limited to new faculty members with a doctorate in mathematics education in their first or second year of a tenure-track appointment as a mathematics educator at a U.S. institution of higher education. The faculty appointment may be in a department of mathematics or in a school, college, or department of education.

For more information about the STaR program, see the website [http://matheddb.missouri.edu/star/](http://matheddb.missouri.edu/star/) or contact Robert Reys, Curators’ Professor of Mathematics Education, University of Missouri, at reysr@missouri.edu. The deadline for applications is December 15, 2012. Applications are available at [matheddb.missouri.edu/star/application.php](http://matheddb.missouri.edu/star/application.php).

—Robert Reys, University of Missouri, Columbia

MfA Fellowship Program

The Math for America Foundation (MfA) sponsors the MfA Fellowship Program, which trains mathematically talented individuals to become high school mathematics teachers in New York City, Boston, Los Angeles, Washington, D.C., or Utah. The fellowship provides an aggregate stipend of up to US$100,000 over five years; a full-tuition scholarship for a master’s-level teaching or teacher credentialing program at one of MfA’s partner universities; and ongoing support mechanisms, including mentoring and professional development.

Candidates should hold a bachelor’s degree with substantial coursework in mathematics and should be new to teaching and able to demonstrate a strong interest in teaching. Candidates must be U.S. citizens or permanent residents of the United States. The deadline for applications is February 5, 2013. For priority consideration for the Los Angeles, New York City, Utah, and Washington, D.C., fellowships, the deadline is January 2, 2013. For more detailed information, see the website at [http://www.mathforamerica.org/](http://www.mathforamerica.org/).

—From an MfA announcement
Mathematics Opportunities

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

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


—From an NSF announcement

NDSEG Fellowships

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

The NDSEG Fellowship Program is open only to applicants who are citizens or nationals of the United States. NDSEG Fellowships are intended for students at or near the beginning of their graduate studies in science or engineering. Applicants must have received or be on track to receive their bachelor’s degree by fall of 2013. Fellowships are tenable only at U.S. institutions of higher education offering doctoral degrees in the scientific and engineering disciplines specified. Fellows will receive full tuition and stipends for 12-month tenures: US$30,500 for the first year, US$31,000 for the second year, and US$31,500 for the third year. Applications are encouraged from women, persons with disabilities, and minorities, including members of ethnic minority groups such as African American, American Indian and Alaska Native, Asian, Native Hawaiian and other Pacific Islander, Hispanic, or Latino.

Complete applications must be submitted electronically by December 14, 2012. Application forms are available online at http://ndseg.asee.org/apply_online. For further information, see http://ndseg.asee.org/.

—From an NDSEG announcement

News from the Bernoulli Center

Call for Proposals. The Bernoulli Center (CIB), funded jointly by the Swiss National Science Foundation and the Swiss Federal Institute of Technology in Lausanne, began its activity in March 2002. Its mission is to support research in mathematics and its applications, to organize and host thematic programs, to provide a supportive and stimulating environment for researchers, and to launch and foster collaborations between mathematicians working in different areas as well as mathemicians and other scientists.

The CIB is launching a call for proposals of four one-semester programs to be held during the period July 1, 2014–June 30, 2016. A thematic program consists of a six-month period (January 1–June 30 or July 1–December 31) of concentrated activity in a specific area of current research interest in the mathematical sciences. In exceptional cases, one-year and three-month programs will also be considered.

Those who are interested in organizing a program at the CIB should submit a two-page letter of intent by April 1, 2013. This letter should give the names of organizers and potential visitors, and outline the program. For more details, see http://cib.epfl.ch/.

—From a CIB announcement
For Your Information

Departments Coordinate Job Offer Deadlines

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

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

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

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

Therefore, we propose that mathematics departments again collectively enter into the same agreement for the upcoming cycle of recruiting, with the deadline set for Monday, February 4, 2013. The NSF has already agreed that it will complete its review of applications by January 25, 2013, at the latest and that all applicants will be notified electronically at that time.

The American Mathematical Society facilitated the process by sending an email message to all doctoral-granting mathematics and applied mathematics departments and mathematics institutes endorsing this agreement was widely announced on the AMS website beginning November 1, 2012, and is updated weekly.

We ask that you view a proposed updated version of last year’s formal agreement at [http://www.ams.org/employment/postdoc-offers.html](http://www.ams.org/employment/postdoc-offers.html) along with last year’s list of adhering departments.

**Important:** To streamline this year’s process for all involved, we ask that you notify Ellen Maycock at the AMS (ejm@ams.org) if and only if:

1. your department is not listed and you would like to be listed as part of the agreement; or
2. your department is listed and you would like to withdraw from the agreement and be removed from the list.

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

—Donald McClure, AMS Executive Director
Ellen Maycock, AMS Associate Executive Director

New PIMS Headquarters

The University of British Columbia (UBC) headquarters for the Pacific Institute for the Mathematical Sciences (PIMS) has moved to a new state-of-the-art, centrally located facility on the fourth floor of the brand new Earth Sciences Building (ESB) at UBC.

This impressive building is centrally located at UBC’s Point Grey Campus, and PIMS’s new space includes a reception area, offices for administration, offices for up to twenty-four visitors and postdoctoral fellows, and lab workspace for ten graduate students. It also boasts a dedicated video-conferencing room and a spacious lounge. In addition, an array of classrooms throughout the building is available for PIMS seminars and workshops.

The $75 million ESB is home to Earth, Ocean, and Atmospheric Sciences, Statistics, PIMS, and the dean’s office of the Faculty of Science. It is the largest panelized wood building and the largest application of cross-laminated timber in North America. The building uses over 1,300 tons of British Columbia-sourced and engineered cross-laminated timber.

The ESB was made possible by generous investments from the British Columbia government, partners in the minerals industry, UBC Science alumnus Ross Beaty, and the Canada Wood Council.

PIMS looks forward to welcoming all members of the mathematical sciences community to our new site!

—PIMS announcement
2012 Trjitzinsky Memorial Awards Presented

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

For the 2012 awards, the AMS chose seven geographically distributed schools to receive one-time awards of US$3,000 each. The mathematics departments at those schools then chose students to receive the funds to assist them in pursuit of careers in mathematics. The schools are selected in a random drawing from the pool of AMS institutional members.

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

Following are the names of the selected schools for 2012, the names of the students receiving Trjitzinsky awards, and brief biographical sketches of the students.

University of California, Berkeley: ANAKAREN SANTANA. Santana was born and raised in Monterrey, Mexico, and graduated from high school with high honors. At Berkeley she is studying for a double major in mathematics and art practice. She works as a physics tutor.

University of Denver: EMILY MAVADDAT. Mavaddat was inspired to pursue a mathematics major by her AP calculus teacher at Ridgefield High School in Connecticut. As a member of the National Honor Society, she was a peer tutor; she also volunteered with the National Charity League, helping at community events such as Special Olympics. She is a giant slalom racer and loves skiing great mountains.

Hendrix College: MATTHEW P. LARSON. Larson is a double major in mathematics and philosophy at Hendrix College. His goal is to attend graduate school to continue study in mathematics.

Lebanon Valley College: ABIGAIL M. SKELTON. Skelton is a third-year student majoring in mathematics and German. She has participated in summer research in quantum information science with the Mathematical Physics Research Group at Lebanon Valley College and presented results at the undergraduate poster session at the 2012 Joint Mathematics Meeting. She is a peer tutor and participates in the Putnam Exam Team. She wants to continue to study mathematics in graduate school.

University of Missouri, St. Louis: RYAN Uding. Uding participated in mathematics competitions from grade school through high school. He has been working full time in a variety of industrial occupations to support himself and the costs of his education. He plans to graduate in May 2013 with a B.S. in mathematics and hopes to pursue a graduate degree in analytic number theory or analysis.

Pennsylvania State University: BENJAMIN HEEBNER. Heebner is a third-year student majoring in actuarial mathematics and minoring in economics and statistics. In each of the past four years he has volunteered for a week at an overnight camp for children who have experienced abuse, neglect, or abandonment. He enjoys playing and watching all sports and spending time with family and friends.

Purdue University Calumet: TYLER R. BILLINGSLEY. Billingsley is doing research involving polynomial factoring in computer algebra systems and plans to attend graduate school to study pure math.

—Elaine Kehoe

Project NExT Fellows Chosen

Six mathematicians have been selected as AMS Project NExT fellows for the 2012–2013 academic year. Their names, affiliations, and areas of research are: EMILY BRALEY, Duke University, algebraic geometry and combinatorics; STEVE BUTLER, Iowa State University, spectral graph theory; NEIL EPSTEIN, George Mason University, commutative algebra; JOEL LOUSMMA, University of Oklahoma, geometric group theory; KATHERINE MORRISON, University of Northern Colorado, algebraic coding theory; BLERTA SHTULLA, Mount Holyoke College, applied mathematics.

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

—Aparna Higgins, Director, Project NExT

MSC/SKOS—The New Implementation of the MSC as a Linked Open Dataset

Mathematical Reviews and Zentralblatt MATH collaborate in developing and maintaining the Mathematics Subject Classification (MSC). The MSC is used by their services, and generally in the mathematics profession and related fields, to organize the mathematics literature. The current version, MSC2010, is the result of a careful public revision process, culminating in its public release in January 2010. Now we are pleased to announce MSC2010 availability as a Linked Open Dataset, a modernized form following the standard called SKOS (Simple Knowledge Organization System) of the World Wide Web Consortium (W3C). SKOS is one of the newer standards set out for the developing Semantic Web and is based on RDF (Resource Description Framework). The new MSC/SKOS version results from the effort to make the MSC more available to the Semantic Web movement and on the Internet. It will be maintained as the authoritative source of the MSC, from which other forms may be derived, and will be available as linked data at http://msc2010.org/resources/MSC/2010/MSC2010. This is a large authority file in XML form. For other forms of the data perhaps more suitable for special applications, see http://msc2010.org/resources/MSC/2010/info/.

The MSC/SKOS preserves the contents of MSC2010. It offers a new format better suited to the Semantic Web and adds authoritative translations into Chinese, Russian, and Italian. In addition, there are cross-references to earlier MSC versions and to some other mathematics classification systems, such as the Dewey system. It is expected that similar information will be added, in ways made possible by the new format, as a result of ongoing efforts to improve the MSC.

Comments about the MSC in general can be submitted through a Web form at http://msc2010.org/feedback or by email to feedback@msc2010.org. All information concerning MSC is shared fully by Mathematical Reviews and Zentralblatt MATH.

—Graeme Fairweather, Executive Editor, Mathematical Reviews

Gert-Martin Greuel, Editor-in-Chief, Zentralblatt MATH

Free Grant Writing Workshop Offered

The American Mathematical Society, in conjunction with the National Science Foundation Directorate for Education & Human Resources (NSF-EHR), is pleased to offer a FREE workshop entitled “Writing a Competitive Grant Proposal to NSF-EHR”. This grant writing workshop will be held prior to the start of the Joint Mathematics Meetings on Monday, January 7, 2013, from 3:00 p.m. to 6:00 p.m. at the San Diego Marriott Marquis & Marina Hotel.

Workshop Goals:

- Familiarize participants with current direction/priorities in EHR
- Familiarize participants with key EHR education research and development programs
- Consider common issues of competitive proposals
- Prepare participants to write a competitive proposal

Topics covered will include: discussion of key programs in EHR; the merit review process and merit review criteria; discussion of scenarios—short passages drawn from proposals in the EHR portfolio designed to stimulate discussion about strengths and weaknesses of a proposal; and the opportunity to discuss possible proposal ideas with program officers.

This free workshop is open to all interested participants who have registered by December 14th at http://www.ams.org/profession/RSVPForm. NSF-EHRGrantWritingWorkshop2013.pdf

—from the AMS Washington Office

Deaths of AMS Members

STEVE A. CORNING, of Lombard, Illinois, died on June 4, 2012. Born on May 16, 1956, he was a member of the Society for 6 years.

JAMES A. JENKINS, of St. Louis, Missouri, died on September 16, 2012. Born on September 23, 1923, he was a member of the Society for 67 years.

BANWARILAL SHARMA, professor, University of Allahabad, India, died on September 26, 2012. Born on May 20, 1935, he was a member of the Society for 40 years.

CLEON R. YOHE, professor, Washington University, died on June 26, 2012. Born on July 8, 1941, he was a member of the Society for 47 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”. Request 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.

**Information for Notices Authors**
The Notices welcomes unsolicited articles for consideration for publication, as well as proposals for such articles. The following provides general guidelines for writing Notices articles and preparing them for submission. Contact information for Notices editors and staff may be found on the Notices website, http://www.ams.org/notices.

**Upcoming Deadlines**

**November 15, 2012**: Nominations for 2013 Vasil A. Popov Prize. See http://imi.cas.sc.edu/popov-prize-call-nominations/.


**December 1, 2012**: Applications for PIMS Postdoctoral Fellowships. See http://www.pims.math.ca/scienc
tific/postdoctoral or contact: assistant.director@pims.

**Where to Find It**

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

**AMS Bylaws**—January 2012, p. 73

**AMS Email Addresses**—February 2012, p. 328

**AMS Ethical Guidelines**—June/July 2006, p. 701

**AMS Officers 2010 and 2011 Updates**—May 2012, p. 708

**AMS Officers and Committee Members**—October 2012, p. 1290

**Conference Board of the Mathematical Sciences**—September 2012, p. 1128

**IMU Executive Committee**—December 2011, p. 1606

**Information for Notices Authors**—June/July 2012, p. 851

**Mathematics Research Institutes Contact Information**—August 2012, p. 979

**National Science Board**—January 2012, p. 68

**NRC Board on Mathematical Sciences and Their Applications**—March 2012, p. 444

**NRC Mathematical Sciences Education Board**—April 2011, p. 619

**NSF Mathematical and Physical Sciences Advisory Committee**—May 2012, p. 697

**Program Officers for Federal Funding Agencies**—October 2012, p. 1284 (DoD, DoE); December 2012, p. 1585 (NSF Mathematics Education)

**Program Officers for NSF Division of Mathematical Sciences**—November 2012, p. 1469
December 1, 2012: Applications for AMS Centennial Fellowships. See 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; prof-serv@ams.org; 401-455-4105.


December 15, 2012: Applications for AMS Epsilon Fund grants. See http://www.ams.org/programs/edu-support/epsilon/emp-epsilon or contact the AMS Membership and Programs Department, email: prof-serv@ams.org; telephone: 800-321-4267, ext. 4170.


January 13, 2013: Applications for Jefferson Science Fellows Program. See email jsf@nas.edu, telephone 202-334-2643, or see the website http://sites.nationalacademies.org/PGA/Jefferson/PGA_046612.

January 31, 2013: Entries for AWM Essay Contest. Contact the contest organizer, Heather Lewis, at hlewis5@naz.edu.

February 1, 2013: Applications for AWM Travel Grants, Mathematics Education Research Travel Grants, Mathematics Mentoring Travel Grants, and Mathematics Education Research Mentoring Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants; or telephone: 703-934-0163; e-mail: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Walpes Mill Road, Suite 200, Fairfax, VA 22030.


March 31, 2013: Applications for IPAM graduate summer school on computer vision. See www.ipam.ucla.edu.

April 1, 2013: Proposals for thematic programs for 2014-2016 at the Bernoulli Center (CIB), Lausanne, Switzerland. See “Mathematics Opportunities” in this issue.

April 15, 2013: Applications for fall 2013 semester of Math in Moscow. See http://www.mccme.ru/mathimmoscow, or write to: 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/mimmoscow, or by writing to: 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, 2013: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants; or telephone: 703-934-0163; e-mail: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Walpes Mill Road, Suite 200, Fairfax, VA 22030.


**NSF Mathematics Education Staff**

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

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**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.*


Flatland, by Edwin A. Abbott, with notes and commentary by William F. Lindgren and Thomas F. Banchoff.


Mathematics Calendar

December 2012

1–8 August 2013 Activities Academic Year 2012-2013, Centre de Recerca Matemàtica, Bellaterra, Barcelona.

2–5 Inaugural meeting of the Australian and New Zealand Association of Mathematical Physics (ANZAMP), Cumberland resort, Lorne, Victoria, Australia. (Sept. 2012, p. 1165)

*3 SmartGridSec12 – First Open EIT ICT Labs Workshop on Smart Grid Security, The Berlin Co-location Centre, Berlin, Germany.
Description: There is a clear need in Europe to integrate the fragmented research and development efforts in securing the Smart Grid. This workshop will be a venue to share and consolidate results, plan joint work, and create networks to accomplish these ambitions.
Submission deadline: Of full paper (5-10 pages), extended abstract (2-5 pages) or short paper (2-5 pages): October 31, 2012.
Information: http://www.easychair.org/conferences/?conf=smartgridsec12.

3–7 Combinatorial Commutative Algebra and Applications, Mathematical Sciences Research Institute, Berkeley, California. (May 2012, p. 718)

3–16 ICTS Program: Groups, Geometry and Dynamics, CEMS, Kumaun University, Almora, Uttarakhand, India. (Sept. 2012, p. 1165)


4–6 New Zealand Mathematical Society Colloquium, Massey University, Palmerston North, New Zealand. (Sept. 2012, p. 1166)

6–8 Thailand-Japan Joint Conference on Computational Geometry and Graphs TJCCGG2012, Department of Mathematics, Silpakorn University, Bangkok, Thailand. (Oct. 2012, p. 1302)

7–9 International Conference on Frontiers of Mathematical Sciences with Applications (ICFMSA-2012), Calcutta Mathematical Society, Kolkata, India. (Sept. 2012, p. 1166)

7–9 17th Annual Conference of Gwalior Academy of Mathematical Sciences and National Symposium on Computational Mathematics and Information Technology, Department of Mathematics, Division of CSE, Jaypee University of Engineering & Technology, A. B. Road, Raghogarh Distt. Guna-M.P, India-473226. (Nov. 2012, p. 1479)

9–13 15th International Conference of International Academy of Physical Sciences (CONIAPS XV), Rajamangala University of Technology Thanyaburi, Pathumthani, Thailand. (Nov. 2012, p. 1480)

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 mathcal1@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/.


10–14 Reproducibility in Computational and Experimental Mathematics, Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, Rhode Island. (Sept. 2012, p. 1166)

10–21 VI-MSS Event: Winter School and Conference on Computational Aspects of Neural Engineering, Bangalore, India. (Sept. 2012, p. 1166)

* 11–13 5th Minimeeting on Differential Geometry, Centre for Research in Mathematics (CIMAT), Guanajuato, Mexico.

Description: This is the fifth of a series of annual events (school/workshop) held in CIMAT.

Aim: The aim of the 5th Minimeeting on Differential Geometry is to bring distinguished U.S. based mathematicians to CIMAT to deliver a series of lectures for researchers and postgraduate students working in the area of Differential Geometry, in order to enrich and stimulate the research environment in Mexico and provide a space for academic interactions.

Guest Speakers: Howard Jacobowitz (Rutgers University), Distinguished Professor Guest of the Mexican Academy of Sciences (AMC) and the United States-Mexico Foundation for Science (FUMEC); John Ratcliffe (Vanderbilt University).

Registration/Support: There is no registration fee. There will be some financial support for local expenses for participants, mainly graduate students who wish to attend the conference.

Information: https://sites.google.com/site/5meetingdg/.


16–22 Commutative Rings, Integer-Valued Polynomials and Polynomial Functions, Graz University of Technology, Graz, Austria. (Nov. 2011, p. 1495)

* 17–19 Aspects of Topology in Geometry and Physics, Mathematical Institute, University of Oxford, Oxford, United Kingdom.

Description: The conference aims to gather leading researchers to showcase topological ideas in a variety of current research developments. It marks and honours the 70th birthday of Graeme Segal.

Speakers: Michael Atiyah, David Ben-Zvi, Kevin Costello, Simon Donaldson, Nigel Hitchin, Michael Hopkins (Astor Lecturer), Soren Galatius, Maxim Kontsevich, Gregory Moore, Constantin Teleman.

Information: https://people.maths.ox.ac.uk/tillmann/ASPECTS.html.

* 17–19 7th International Young Researchers Workshop on Geometry, Mechanics and Control, Institute for the Mathematical Sciences (ICMAT (CSIC-UM-UC3M-UCM)), Madrid, Spain.

Description: The conference will be the seventh in a series of workshops that have previously taken place in Madrid (2006, 2007), Barcelona (2008), Ghent (2009), La Laguna (2010), and Coimbra (2012). Its goal is to bring together young researchers working in geometric mechanics and control theory and to offer a platform to present the results of their research to an international audience. The main idea of this conference is to offer 3 courses of 4 hours which serve as an introduction to different topics related to geometric structures in mechanics and control theory. The courses will be at a Ph.D. level, so the young researchers would, at the end of the workshop, access to the recent literature on the corresponding topics. Along with the courses, there will be short talks (30 minutes) by the participants willing to present their results. Moreover, there will be a poster session.


17–20 9th IMA International Conference on Mathematics in Signal Processing, Austin Court, Birmingham, United Kingdom. (Nov. 2011, p. 1495)


17–21 International Conference on the Theory, Methods and Applications of Nonlinear Equations, Department of Mathematics, Texas A&M University-Kingsville, Kingsville, Texas. (Feb. 2012, p. 340)

17–22 The Legacy of Srinivasa Ramanujan—An International Conference, University of Delhi, Delhi, India. (Oct. 2012, p. 1302)

18–21 5th HiPC Student Research Symposium (SRS) *** Held in conjunction with the 19th International Conference on High Performance Computing (HiPC 2012), Pune, India. (Nov. 2012, p. 1480)

21–23 6th International Conference of IMBIC on “Mathematical Sciences for Advancement of Science and Technology” (MSAST 2012), Salt Lake City, Kolkata, West Bengal, India. (Sept. 2012, p. 1167)


26–January 1 International Conference: Mathematical Science and Applications, Abu Dhabi University, College of Arts and Science, Department of Applied Sciences and Mathematics, Abu Dhabi, United Arab Emirates. (Sept. 2012, p. 1167)


27–30 Eighth International Triennial Calcutta Symposium on Probability and Statistics, Department of Statistics, Calcutta University, Kolkata, West Bengal, India. (Nov. 2011, p. 1495)

28–31 International Conference on Mathematical Sciences (ICMS2012), Shri Shivali Education Society’s Science College, Nagpur, Maharashtra, India. (Sept. 2012, p. 1167)


January 2013


* 3–5 National Workshop Computer Applications based on Modern Algebra, Manipal Institute of Technology, Manipal University Manipal-576 104, Karnataka, India.

Description: Algebra is often described as the language of mathematics and computer science. Historically, the terms algebra and algorithm originate from the same source. Algebra is so beautiful that many people naturally possess the ability to understand and apply algebra in real life problems. The aim of the workshop is to highlight the concepts from modern algebra and demonstrate their applications in computer science. Indeed, it is encouraging to note that computer algebra has evolved as a discipline linking advanced algebra to methods of computer science and thus offering many tools. The workshop will focus on algorithms and algebraic computations, finite fields and applications, algebraic codes, data mining, soft computing techniques, algebraic cryptography, and recent developments in these areas. The workshop will provide an ideal platform for the faculty, researchers, and the students in the vari-
ous disciplines of science and engineering to reinforce their knowledge. The participants of this workshop will also benefit from recent trends of modern algebra and its applications.


* 7–11 ANODE 2013 conference, John Butcher 80th birthday, Auckland, New Zealand.

Description: The conference in the year in which John Butcher turns 80 marks his lifelong contributions to numerical analysis.

Plenary lectures: The following mathematicians have agreed to present lectures: Kevin Burrage (Oxford and Brisbane), John Butcher (Auckland), Rob Corless (London, Ontario), Robert McLachlan (Palmston North), Linda Petzold (Santa Barbara), Chus Sanz-Serna (Valladolid), Zaiju Shang (Beijing), Gerhard Wanner (Geneva). In addition, there will be a full programme of contributed lectures and offers to present contributed lectures are warmly welcomed.

Information: Registration is now open at http://jcbutcher.com/d/ANODE2013 for the ANODE 2013 conference.

7–12 Iwasawa Theory, Representations, and the $p$-adic Langlands Program, University of Münster, Münster, Germany. (Jan. 2012, p. 106)


14–May 24 Noncommutative Algebraic Geometry and Representation Theory, Mathematical Sciences Research Institute, Berkeley, California. (Oct. 2011, p. 1323)

14–February 1 Winter School on Mathematical Physics, Universidad Nacional Autonoma de Mexico, Mexico City, Mexico. (Oct. 2012, p. 1302)

17–19 Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Disease Dynamics 2013: Immunization, a True Multi-Scale Problem, PIMS, Vancouver, British Columbia, Canada. (Sept. 2012, p. 1168)

21–25 AIM Workshop: Online databases - from L-functions to combinatorics, International Centre for Mathematical Sciences Edinburgh, Scotland, United Kingdom. (Sept. 2012, p. 1168)

* 21–25 Masterclass: Recursion from matrix models to quantum algebraic geometry by Eynard and Orantin, QGM, Aarhus University, Aarhus, Denmark.

Description: The main topics have their roots in matrix model theory, which has a universal behavior observed in many physical phenomena, such as solid state physics, quantum chaos, mesoscopic conductors, nuclear physics, quantum chromodynamics, string theory, and also in mathematics, such as the distribution of Riemann zeta function zeroes. Some important aspects of matrix model theory were further developed in the work of Eynard, and this work provided the initial impetus for a vast generalization in the seminal work of Eynard and Orantin, extending the scope of application of matrix model methods to an even greater class of theories, now called Eynard-Orantin invariants. Important examples of Eynard-Orantin invariants give intersection numbers over moduli space, simple Hurwitz numbers, lattice points in moduli space of curves, and Chern-Simons invariants of 3-manifolds, thus connecting with deep combinatorial, topological and geometrical aspects of physics and mathematics.


* 28-February 1 International Conference on Fluids And Variational Methods, University of Leipzig, Leipzig, Germany.

Description: The aim of the conference is to bring together experts from fluid dynamics and the calculus of variations. Fluid dynamics inherently involves transport and dissipation phenomena. Nevertheless, techniques that have been developed in the context of the calculus of variations have on several occasions proved to be very successful: the Scheffer-CKN partial regularity theory originates from geometric measure theory and minimal surface regularity; the generalized flow of Brenier finds its origin in the theory of Young measures and the Monge-Kantorovich displacement problem; Baire category techniques for existence were first used for variational problems from material science. Our hope is that in Leipzig, building on the tradition of Leon Lichtenstein, this conference will result in further synergies and a flow of ideas in both directions.

Information: http://www.math.uni-leipzig.de/~fluids2013/.

28-February 1 Introductory Workshop: Noncommutative Algebraic Geometry and Representation Theory, Mathematical Sciences Research Institute, Berkeley, California. (Aug. 2011, p. 1014)

* 28-February 1 Topological recursion and quantum algebraic geometry, QGM, Aarhus University, Aarhus, Denmark.


* 30-February 1 The Third International Conference on Digital Information Processing and Communications (ICDIPC2013), Islamic Azad University (IAU), Dubai, UAE.

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.


February 2013


4–8 The Second Biennial International Group Theory Conference, Dogus University, Istanbul, Turkey. (Sept. 2012, p. 1169)


5–7 International Conference on Mathematical Sciences and Statistics (ICMSS2013), Kuala Lumpur, Malaysia. (Sept. 2012, p. 1169)

6–8 Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Models and Methods in Ecology and Epidemiology, CRM, Montréal, Canada. (Sept. 2012, p. 1169)

11–14 The AMSI Workshop on Graph C*-algebras, Leavitt path algebras and symbolic dynamics, University of Western Sydney, Australia. (Nov. 2012, p. 1480)


11–14 Interactions between Analysis and Geometry, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2011, p. 1325)

13–15 IAENG International Conference on Operations Research 2013 (COR’13), Royal Garden Hotel, Hong Kong, China. (Sept. 2012, p. 1170)

* 15–16 29th Southeastern Analysis Meeting (SEAM 2013), Virginia Tech, Blacksburg, Virginia.

Description: This is the 29th edition of an annual meeting held in the southeastern United States in Analysis.

Traditional topics: Function-theoretic operator theory—the mathematics at the intersection of operator theory, classical complex analysis, harmonic analysis, and several complex variables—and its related areas and fields of application including operator algebras, operator spaces and operator systems; systems and control theory; scattering theory and mathematical physics; algebraic and semi-algebraic geometry (both classical and noncommutative).

Featured speakers: Fritz Gesztesy (University of Missouri), Palle E.T. Jorgensen (University of Iowa), Dmitry S. Kaluzhninyi-Verbovetskyi (Drexel University), and Anna Skripka (University of New Mexico).

In addition to the featured speakers there will be contributed half-hour talks.

Funding: From the National Science Foundation for junior participants is expected.


18–22 84th Annual Meeting of GAMM (The International Association of Applied Mathematics and Mechanics), University of Novi Sad, Novi Sad, Serbia. (Sept. 2012, p. 1170)

* 18–22 Masterclass: Soergel bimodules and Kazhdan-Lusztig conjectures by Williamson and Elias, QGM, Aarhus University, Aarhus, Denmark.

Description: This will be a course about Coxeter groups, their Hecke algebras, Kazhdan-Lusztig polynomials and Soergel bimodules. It will culminate in an algebraic proof of the Kazhdan-Lusztig conjecture (a character formula for highest weight modules over a complex simple Lie algebra, which up until recently had difficult geometric proofs) and a proof of the positivity of Kazhdan-Lusztig polynomials (a conjecture which has been open for over thirty years). Along the way ideas from categorification, higher algebra and Hodge theory play an essential role.

Information: http://qgm.au.dk/currently/events/show/artikel/masterclass-marts-2013/.


April 2013

Description: The goals of the conferences are to bring together distinguished scientists whose specialties involve mathematics and neighboring disciplines, to give their perspectives on current research and directions for further research in the area of their expertise. The conference will provide a medium for the exchange of information and ideas among mathematical scientists from diverse backgrounds, and space for Mathematical Scientists outside of Cameroon to engage actively in the development of Mathematics in the Cameroon sub-region, in particular, and Africa in general. The 2013 conference will accommodate talks from all areas of Mathematics, to close an adjoining two-week summer school on Stochastic Analysis, Financial and Actuarial Mathematics with Applications.


May 2013

5–9 Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Major and Neglected Diseases in Africa, Ottawa, Canada. (Sept. 2012, p. 1171)


12–17 Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program Impact of climate change on biological invasions and population distributions, BIRS, Banff, Canada. (Sept. 2012, p. 1172)


19–23 SIAM Conference on Applications of Dynamical Systems (DS13), Snowbird Ski and Summer Resort, Snowbird, Utah. (Oct. 2011, p. 1326)

* 19–24 FEMTEC 2013 - 4th International Congress on Computational Engineering and Sciences, Stratosphere Hotel, Las Vegas, Nevada.

Description: FEMTEC 2013 is the 4th event in a successful series of interdisciplinary international conferences. It promotes modern technologies and practices in scientific computing and visualization, and strengthens the interaction between researchers and practitioners in all areas of computational engineering and sciences. Main thematic areas include: Multiphysics coupled problems, Higher-order computational methods, computing with Python, GPU computing, and cloud computing. Application areas: Theoretical results as well as applications are welcome. Application areas include, but are not limited to: Computational electromagnetics, civil engineering, nuclear engineering, mechanical engineering, nonlinear dynamics, fluid dynamics, climate and weather modeling, computational ecology, wave propagation, acoustics, geophysics, geomechanics and rock mechanics, hydrology, subsurface modeling, biomechanics, bioinformatics, computational chemistry, stochastic des and others.


19–25 15th International Conference on Functional Equations and Inequalities, Ustron (near the borders with the Czech Republic and Poland), Poland. (Sept. 2012, p. 1172)

25–27 10th Hstam International Congress on Mechanics, Technical University of Crete, Chania, Crete, Greece. (Sept. 2012, p. 1172)
26–30 The 19th International Conference on Difference Equations and Applications, Sultan Qaboos University, Muscat, Oman. (Sept. 2012, p. 1172)

27–31 Summer School on Topics in Space-Time Modeling and Inference, Aalborg University, Department of Mathematical Sciences, Aalborg, Denmark. (Nov. 2012, p. 1481)

*27–June 7 Masterclass: (u,v,w knots)x(topology, combinatorics, low and high algebra) by Dror Bar-Natan (University of Toronto), QGM, Aarhus University, Aarhus, Denmark.

Description: When appropriately read using the language of “finite type invariants”, “Jacobi diagrams”, and “expansions”, the combinatorics underlying various knot theories turns out to be the same as the combinatorics underlying various classes of Lie algebras, thus establishing a bijection between certain hard problems in knot theory and certain hard problems in Lie theory, enriching both subjects.


30–June 1 Dynamical systems and statistical physics (91th Encounter between Mathematicians and Theoretical Physicists), Institut de Recherche Mathématique Avancée, Strasbourg, France.

Description: The 91th Encounter between Mathematicians and Theoretical Physicists will take place at Institut de Recherche Mathématique Avancée (University of Strasbourg and CNRS) on May 30–June 1st, 2013. The theme will be: “Dynamical systems and statistical physics”.

Invited speakers: Viviane Baladi (Copenhagen), Jean-René Chazottes (Ecole Polytechnique), Bertrand Eynard (CEA), Vladimir Fock (Strasbourg), Giovanni Gallavotti (Rome), François Ledrappier (Paris), Rémi Monasson (ENS Paris), Samuel Petite (Amiens), Hans Rugh (Orsay), Klaus Schmidt (Vienna) and Maher Younan (Genève). Some of the talks will be survey talks intended for a general audience. Ph.D. students welcome.

Registration: Is required (and free of charge) at this link. Hotel booking can be asked for through the registration link. For practical and other questions please contact the organizers: Charles Bœbel: charles.boube@unistra.fr and Athanase Papadopoulos: papad@unistra.fr.

Information and Registration: http://www-irma.u-strasbg.fr/article1321.html.

June 2013

3–7 MEGA 2013: Effective Methods in Algebraic Geometry, Goethe University, Frankfurt am Main, Germany. (Sept. 2012, p. 1172)

*3–9 Summer school on Finsler geometry with applications to low-dimensional geometry and topology, Department of Mathematics, University of the Aegean, Karlovassi, Island of Samos, Greece.

Description: The focus of this Summer School will be on the following thematic areas: Finsler geometry, dynamics, hyperbolic geometry, projective geometry, systolic geometry, Teichmüller theory. There will be a series of short courses given by Norbert A’Campo (University of Basel), Ivan Babenko (University of Montpellier), Gilles Courtois (Ecole Polytechnique), Bertrand Deroin (University of Paris XI) and Marc Troyanov (EPFL, Lausanne). The Summer School is primarily intended for Ph.D. students but all researchers are also welcome. Besides the courses, there will be a series of specialized lectures.

Organizing committee: Athanase Papadopoulos (University of Strasbourg), Georgios Tsapogas (University of the Aegean), Mohammed Uluda (Galahatasary university, Istanbul) and Constantin Vernicos (University of Montpellier). For questions and practical details contact the organisers.


3–28 Focus Program on Noncommutative Geometry and Quantum Groups, Fields Institute for Research in Mathematical Sciences, Toronto, Ontario, Canada. (Sept. 2012, p. 1172)


5–9 4th Novi Sad Algebraic Conference–NSAC 2013, Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad, Novi Sad, Serbia. (Sept. 2012, p. 1173)

10–14 AIM Workshop: Automorphic forms and harmonic analysis on covering groups, American Institute of Mathematics, Palo Alto, California. (Nov. 2012, p. 1481)


10–14 Computational Methods and Function Theory 2013, Shantou University, Shantou, Guangdong, China. (Sept. 2012, p. 1173)

*10–14 Pde’s, Dispersion, Scattering theory and Control theory, University of Monastir, Monastir, Tunisia.

Organizers: Kais Ammari, Université de Monastir, Tunisia; email: kais.ammari@fsm.rnu.tn, Gilles Lebeau, Université Nice, Sophia Antipolis, France; email: Gilles.Lebeau@unice.fr.

Topics: Control theory, scattering theory, dispersion theory, Pde’s theory.

Courses: Control theory, E. Zuazua; Dispersion, L. Robbiano.


*10–20 Recent Advances in Hodge Theory: Period Domains, Algebraic Cycles, and Arithmetic, UBC Campus, Vancouver, B.C., Canada.

Description: A four-day summer school for graduate students and postdocs, followed by a six-day research conference on the asymptotics, symmetries, and arithmetic of periods, as well as related representation theory and geometry. Each day will concentrate on a specific topic: Algebraic cycles and the Hodge conjecture, Arithmetic aspects of cycles and period maps, Period domains and their compactifications, Mumford-Tate groups and representation theory, Automorphic forms and automorphic cohomology (6) Relative completion of the fundamental group.


*11–13 4th International Conference on Mathematical and Computational Applications, Celal Bayar University, Applied Mathematics and Computation Center, Manisa, Turkey.

Description: The first of these conference series was organized in Manisa (Turkey) in 1996, the second in Baku (Azerbaijan) in 1999, and the third in Konya (Turkey) in 2002. This international conference is devoted to original research in the field of engineering, natural sciences or social sciences where mathematical and/or computational techniques are necessary for solving specific problems. The aim of the conference is to provide a medium by which a wide range of experience can be exchanged among researchers from diverse fields such as engineering (electrical, mechanical, civil, industrial, aeronautical, nuclear, etc.), natural sciences (physics, mathematics, chemistry, biology, etc.) or social sciences (administrative sciences, economics, political sciences, etc.). The papers may be theoretical where mathematics is used in a nontrivial way or computational
or combination of both. Papers containing only experimental techniques and abstract mathematics without any sign of application are discouraged.

Information: http://icmca2013.cbu.edu.tr/.

* 12–14 Tenth edition of the Advanced Course in Operator Theory and Complex Analysis, Sevilla, Spain. Invited speakers: Filippo Bracci, Università "Tor Vergata" (Italy); James Brennan, University of Kentucky (Kentucky); Alexander Olevskii, Tel Aviv University (Israel); Tatiana Smirnova-Nagnibeda, Université de Genève (Switzerland). Apart of attending the course, you may also have the opportunity to deliver a contributed talk. Please feel free to pass on this information to any colleague who might be interested in our conference.

Information: You can find further information about the courses at http://congreso.us.es/ceacyto/2013.

* 16–23 51st International Symposium on Functional Equations, Rzeszów, Poland.

Topics: Functional equations and inequalities, mean values, functional equations on algebraic structures, Hyers-Ulam stability, regularity properties of solutions, conditional functional equations, functional-differential equations, iteration theory; applications of the above, in particular to the natural, social, and behavioral sciences.

Local Organizer: Józef Tabor, Institute of Mathematics, University of Rzeszów al. Rejtana 16 A, PL-35-959 Rzeszów, Poland; email: tabor@univ.rzeszow.pl.

Scientific committee: J. Aczél (Honorary Chair; Waterloon, ON, Canada), W. Benz (Honorary Member, Hamburg, Germany), Z. Daróczy (Honorary Member, Debrecen, Hungary), L. Reich (Honorary Member, Graz, Austria), R. Ger (Chair; Kotowice, Poland), Zs. Fáles (Debrecen, Hungary), J. Rätz (Bern, Switzerland), J. Schweiger (Graz, Austria), and A. Sklar (Chicago, IL, USA).

Information: Participation at these annual meetings is by invitation only. Those wishing to be invited to this or one of the following meetings should send details of their interest and, preferably, publications (paper copies) and/or manuscripts with their postal and e-mail address to: Roman Ger, Institute of Mathematics, Silesian University, Bankowa 14, PL-40-007 Katowice, Poland, email: roman-ger@us.edu.pl before February 15, 2013.


17–28 Algebraic Topology, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1481)


22–29 Physics and Mathematics of Nonlinear Phenomena 2013, Hotel Le Sirene, Gallipoli, South of Italy. (Oct. 2012, p. 1303)

* 24–July 5 Séminaire de Mathématiques Superieures 2013: Physics and Mathematics of Link Homology, Montreal, Canada.

Description: Homology theories of knots and links is a burgeoning field at the interface of mathematics with theoretical physics. The 2013 edition of the SMS will bring together leading researchers in mathematics and mathematical physics working in this area, with the aim to educate a new generation of scientists in this exciting subject. The school will provide a pedagogical review of the current state of the various constructions of knot homologies, and also encourage interactions between the communities in order to facilitate development of the unified picture.

Information: http://www.msri.org/web/msri/scientific/workshops/summer-graduate-workshops/show/-/event/Wm9461.

26–29 International Symposium on Symbolic and Algebraic Computation (ISSAC), Northeastern University, Boston, Massachusetts. (Nov. 2012, p. 1481)


July 2013


1–5 Erdős Centennial, Budapest, Hungary. (Sept. 2012, p. 1173)

1–5 International conference on Sampling Theory and Applications 2013, Jacobs University, Bremen, Germany. (Sept. 2012, p. 1173)

1–5 The 6th Pacific Rim Conference on Mathematics 2013, Sapporo Convoerence Center, Sapporo City, Japan. (Nov. 2012, p. 1481)

1–5 Preconditioning of Iterative Methods—Theory and Applications 2013 (PIM 2013), Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic. (Oct. 2012, p. 1303)

1–12 New Geometric Techniques in Number Theory, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1481)

2–5 The 4th International Conference on Matrix Analysis and Applications, Konya, Turkey. (Nov. 2012, p. 1481)


8–10 SIAM Conference on Control and Its Applications (CT13), Town and Country Resort and Convention Center, San Diego, California. (Sept. 2012, p. 1174)


8–12 Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Climate Change and the Ecology of Vector-borne Diseases, Fields Institute, CDM, Toronto, Canada. (Sept. 2012, p. 1174)

* 15–19 Finite Dimensional Integrable Systems 2013, CIRM, Marseille, France.

Description: Non-linear ordinary and partial differential equations describe a large number of physical phenomena and geometrical problems. An effective method to handle them is associated to ‘integrable systems’ providing means to find exact solutions or to analyse the solutions without knowing them. Our conference will deal with finite-dimensional integrable systems, the most classical part of the general theory. Recently, new methods have been developed, based on branches of mathematics (and physics) such as complex analysis, symplectic geometry, representation theory, computer algebra, general relativity, etc. The conference will bring together experts in mathematics and mathematical physics in this rapidly evolving field: integrable geodesic flows, integrable systems on Lie algebras, obstructions to integrability, symplectic and Poisson geometry, separation of variables, discrete integrable systems, quantum integrability, applications to physics.

15–20 Stochasticity in Biology: Is Nature Inherently Random?, Montreal, Canada. **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. **Information:** [http://www.crm.umontreal.ca/act/theme/theme_2013_2_en/biodiversity_environment13_e.php](http://www.crm.umontreal.ca/act/theme/theme_2013_2_en/biodiversity_environment13_e.php).

20–25 European Meeting of Statisticians, Eotvos Lorand University, Budapest, Hungary. (Sept. 2012, p. 1174)


* 22–26 Positivity VII, Leiden University, Leiden, The Netherlands. **Description:** The seventh Positivity conference on ordered structures and their applications is jointly organized by Leiden University and Delft University of Technology. It is the Zaanen Centennial Conference, on the occasion of the 100th birthyear of Adriaan Cornelis Zaanen. **Invited speakers, all confirmed:** Francesco Altomare (Bari, Italy), Wolfgang Arendt (Ulm, Germany), Qingying Bu (University, Mississippi, USA), Arjan van der Sluijs (Amsterdam, The Netherlands), Guillermo Curbera (Sevilla, Spain), Julio Flores (Madrid, Spain), Yehoram Gordon (Haifa, Israel), Rien Kaashoek (Amsterdam, The Netherlands), Coenraad Labuschagne (Johannesburg, South Africa), Boris Mordukhovich (Detroit, Michigan, USA), Jan van Neerven (Delft, The Netherlands), Ioannis Polyrakis (Athens, Greece), Abdelaziz Rhandi (Salerno, Italy), Evgeny Semenov (Voronezh, Russia), Fedor Sukochev (Sydney, Australia), Jun Tomiyama (Tokyo, Japan). **Information:** [http://websites.math.leidenuniv.nl/positivity2013/](http://websites.math.leidenuniv.nl/positivity2013/).


* 29–August 9 Introduction to the Mathematics of Seismic Imaging, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2012, p. 1482)

August 2013


5–9 1st Mathematical Congress of the Americas, Guanajuato, Mexico. (Sept. 2012, p. 1174)

5–9 XXII Rolf Nevanlinna Colloquium, Helsinki, Finland. (Aug. 2011, p. 1014)

* 11–17 3rd Mile High Conference on Nonassociative Mathematics, University of Denver, Denver, Colorado. **Description:** An international conference on all aspects of nonassociative mathematics, including quasigroups, loops, latin squares, Lie algebras, Jordan algebras, octonions and nonassociative structures in physics. **Main speakers (tentative):** Alberto Elduque, University of Zaragoza, Spain; Pavel Kolesnikov, Sobolev Institute of Mathematics, Russia; Peter Plaumann, University of Erlangen-Nuremberg, Germany; Susanne Pumpluen, University of Nottingham, UK; Jonathan Smith, Iowa State University, USA.

Program and organizing committee: Murray Bremner, University of Saskatchewan, Canada; John Huerta, Australian National University, Australia; Michael Kinyon (co-chair), University of Denver, USA; Eric Moorhouse, University of Wyoming, USA; Petr Vojtechovský (co-chair), University of Denver, USA. **Information:** [http://www.math.du.edu/milehigh](http://www.math.du.edu/milehigh).

12–15 International Conference on Algebra in Honour of Patrick Smith and John Clark’s 70th Birthdays, Balikesir, Turkey. (Nov. 2012, p. 1482)

* 12–16 AIM Workshop: Computable stability theory, American Institute of Mathematics, Palo Alto, California. **Description:** This workshop, sponsored by AIM and the NSF, will be devoted to the interplay between stability theory and computable model theory. **Information:** [http://www.aimath.org/ARCC/workshops/computestab.html](http://www.aimath.org/ARCC/workshops/computestab.html).

* 12–16 Branching Diffusions and Random Trees, Montreal, Canada. **Description:** One of the most compelling images to result from Darwin’s theory of evolution is that of the tree of life. Inherent in this picture is the idea that when members of a species are geographically separated, over time they may evolve to a point where it makes sense to view them as different species. These are the branch points in the tree of life. Probability theory has developed powerful stochastic spatial models that can be used to understand and model the behavior of such migrating and evolving populations. In particular, the theories of branching random walk and branching diffusions are fundamental in population biology and genetics. **Information:** [www.crm.umontreal.ca/act/theme_theme_2013_2_en/branching_diffusions13_e.php](http://www.crm.umontreal.ca/act/theme_theme_2013_2_en/branching_diffusions13_e.php).

* 19–September 13 Infectious Disease Dynamics, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. **Description:** On January 1, 2013, it will be 20 years since Epidemic Models started as a 6-month programme in the first year of the Isaac Newton Institute for Mathematical Sciences. Since then the field has grown enormously. The complexity and non-linearity of infection dynamics, as well as effects of prevention and control, are such that mathematical and statistical analysis is essential for insight and prediction, now more than ever before. Much research is no longer devoted to generic insights into dynamics, but rather to very precise insights into focussed questions regarding specific infectious diseases. The four-week programme will: take stock of progress in the last twenty years, to assess where we are today and provide a synthesis, take a systematic look at the use of models to inform public health decisions, and to analyse where and why models fail in their predictions, set the agenda for future research and in particular determine the main challenges. **Information:** [http://www.newton.ac.uk/programmes/IDD/](http://www.newton.ac.uk/programmes/IDD/).


19–December 20 Optimal Transport: Geometry and Dynamics, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)

22–23 Connections for Women on Optimal Transport: Geometry and Dynamics, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)


26–30 Introductory Workshop on Optimal Transport: Geometry and Dynamics, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)
Mathematics Calendar


Description: Quantum information is currently one of the most dynamic and exciting areas of science and technology. Its breadth of significance ranges from deep fundamental issues of the ultimate physical limits of information processing and foundations of quantum mechanics, to the technological exploitation of quantum physics for exponentially enhanced computing power and novel possibilities for communication and information security. A notable aspect of many of the most important recent developments is the importance of increasingly sophisticated techniques from mathematics and theoretical computer science. Among the challenges addressed will be: additivity violations of capacities and minimal output entropies; weak additivity; for certain quantities? Existence of bound entanglement with non-positive partial transpose? Is there a quantum version of the PCP theorem? A number of workshops will take place during the programme. For full details see: http://www.newton.ac.uk/programmes/MQI/ws.html.

Information: http://www.newton.ac.uk/programmes/MQI/.

September 2013

1–August 31, 2014 Call for Research Programmes 2013-2014, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain. (Sept. 2012, p. 1175)

*1–December 20 Research Program on Automorphisms of Free Groups: Algorithms, Geometry and Dynamics, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.

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.


3–4 Connections for Women: Mathematical General Relativity, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1175)

*3–6 CAI 2013: 5th Conference on Algebraic Informatics, ERISCS and IML, Aix-Marseille University, IGESA, Porquerolles Island, France. (Sept. 2012, p. 1175)

3–6 CAI 2013: 5th Conference on Algebraic Informatics, ERISCS and IML, Aix-Marseille University, IGESA, Porquerolles Island, France.

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.


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)

11–13 14th IMA Conference on Mathematics of Surfaces, University of Birmingham, United Kingdom. (Sept. 2012, p. 1176)

*16–20 Mathematics for an Evolving Biodiversity, Montreal, Canada.

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.


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.


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/.

*23–27 Mathematics of Sequence Evolution: Biological Models and Applications, Montreal, Canada.

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.


October 2013

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

7–11 Coalescent Theory: New Developments and Applications, Montreal, Canada.

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.


18–20 2013 Fall Central Section Meeting, Washington University, St. Louis, Missouri. (Sept. 2012, p. 1176)

21–25 Mathematics of Planet Earth 2013 - Pan-Canadian Thematic Program - Sustainability of Aquatic Ecosystem Networks, AARMS, New Brunswick, Canada. (Sept. 2012, p. 1176)


**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/](http://www.newton.ac.uk programmes/MFE/).

**November 2013**

2–3 2013 Western Fall Section Meeting, University of California Riverside, Riverside, California. (Sept. 2012, p. 1176)

*4–8 Biodiversity and Environment: Viability and Dynamic Games Perspectives, Montreal, Canada.

**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.


*12–14 The Second International Conference on Informatics Engineering & Information Science (ICIEIS2013), University Technology Malaysia (UTM), Kuala Lumpur, Malaysia.

**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.


**Information:** [http://sdiwc.net/conferences/2013/iciei2013/](http://sdiwc.net/conferences/2013/iciei2013/).

18–22 Evolution Problems in General Relativity, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2012, p. 1176)


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.

**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.

**Information:** Further information on SODA14, ALENEX14 and ANALCO14 will be posted at [http://www.siam.org/meetings/soda14/](http://www.siam.org/meetings/soda14/) in April, 2013.

* 6–July 4 Free Boundary Problems and Related Topics, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

**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/](http://www.newton.ac.uk programmes/FRB/).

**March 2014**

* 31–April 3 SIAM Conference on Uncertainty Quantification (UQ14), Hyatt Regency Savannah, Savannah, Georgia.

**Description:** The call for submissions will be available at: [http://www.siam.org/meetings/uq14/](http://www.siam.org/meetings/uq14/) in early April, 2013.

**Information:** [http://www.siam.org/meetings/uq14/](http://www.siam.org/meetings/uq14/).
Algebra and Algebraic Geometry

Introduction to Quantum Graphs
Gregory Berkolaiko and Peter Kuchment, Texas A&M University, College Station, TX

A “quantum graph” is a graph considered as a one-dimensional complex and equipped with a differential operator (“Hamiltonian”). Quantum graphs arise naturally as simplified models in mathematics, physics, chemistry, and engineering when one considers propagation of waves of various nature through a quasi-one-dimensional (e.g., “meso-” or “nano-scale”) system that looks like a thin neighborhood of a graph. Works that currently would be classified as discussing quantum graphs have been appearing since at least the 1930s, and since then, quantum graphs techniques have been applied successfully in various areas of mathematical physics, mathematics in general and its applications. One can mention, for instance, dynamical systems theory, control theory, quantum chaos, Anderson localization, microelectronics, photonic crystals, physical chemistry, nano-sciences, superconductivity theory, etc.

Quantum graphs present many non-trivial mathematical challenges, which makes them dear to a mathematician’s heart. Work on quantum graphs has brought together tools and intuition coming from graph theory, combinatorics, mathematical physics, PDEs, and spectral theory.

This book provides a comprehensive introduction to the topic, collecting the main notions and techniques. It also contains a survey of the current state of the quantum graph research and applications.

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

Contents: Operators on graphs. Quantum graphs; Quantum graphs—Some special topics; Spectra of quantum graphs; Spectra of periodic graphs; Spectra of quantum graphs—Special topics; Quantum chaos on graphs; Some applications and generalizations; Appendix A. Some notions of graph theory; Appendix B. Linear operators and operator-functions; Appendix C. Structure of spectra; Appendix D. Symplectic geometry and extension theory; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 186


Dualities and Representations of Lie Superalgebras
Shun-Jen Cheng, Academia Sinica, Taipei, Taiwan, and Weiqiang Wang, University of Virginia, Charlottesville, VA

This book gives a systematic account of the structure and representation theory of finite-dimensional complex Lie superalgebras of classical type and serves as a good introduction to representation theory of Lie superalgebras. Several folklore results are rigorously proved (and occasionally corrected in detail), sometimes with new proofs. Three important dualities are presented in the book, with the unifying theme of determining irreducible characters of Lie superalgebras. In order of increasing sophistication, they are Schur duality, Howe duality, and super duality. The combinatorics of symmetric functions is developed as needed in connections to Harish-Chandra homomorphism as well as irreducible characters for Lie superalgebras. Schur-Sergeev duality for the queer Lie superalgebra is presented from scratch with complete detail. Howe duality for Lie superalgebras is presented in book form for the first time. Super duality is a new approach developed in the past few years toward understanding the Bernstein-Gelfand-Gelfand category of modules for classical Lie superalgebras. Schur-Sergeev duality for the queer Lie superalgebra is presented from scratch with complete detail. Howe duality for Lie superalgebras is presented in book form for the first time. Super duality is a new approach developed in the past few years toward understanding the Bernstein-Gelfand-Gelfand category of modules for classical Lie superalgebras. Super duality relates the representation theory of classical Lie superalgebras directly to the representation theory of classical Lie algebras and thus gives a solution to the irreducible character problem of Lie superalgebras via the Kazhdan-Lusztig polynomials of classical Lie algebras.

Contents: Lie superalgebra ABC; Finite-dimensional modules; Schur duality; Classical invariant theory; Howe duality; Super duality; Symmetric functions; Bibliography; Index.

Graduate Studies in Mathematics, Volume 144


To subscribe to email notification of new AMS publications, please go to http://www.ams.org/bookstore-email.
Topics in Noncommutative Geometry

Guillermo Cortiñas, Universidad de Buenos Aires, Argentina, Editor

Luis Santaló Winter Schools are organized yearly by the Mathematics Department and the Santaló Mathematical Research Institute of the School of Exact and Natural Sciences of the University of Buenos Aires (FCEN).

This volume contains the proceedings of the third Luis Santaló Winter School, which was devoted to noncommutative geometry and held at FCEN July 26–August 6, 2010.

Topics in this volume concern noncommutative geometry in a broad sense, encompassing various mathematical and physical theories that incorporate geometric ideas to the study of noncommutative phenomena. It explores connections with several areas including algebra, analysis, geometry, topology and mathematical physics.

Bursztyn and Waldmann discuss the classification of star products of Poisson structures up to Morita equivalence. Tsygan explains the connections between Kontsevich’s formality theorem, noncommutative calculus, operads and index theory. Hoefel presents a concrete elementary construction in operad theory. Meyer introduces the subject of C*-algebraic crossed products. Rosenberg introduces Kasparov’s KK-theory and noncommutative tori and includes a discussion of the Baum-Connes conjecture for K-theory of crossed products, among other topics. Lafont, Ortiz, and Sánchez-García carry out a concrete computation in connection with the Baum-Connes conjecture. Zuk presents some remarkable results in the connections between Connes’ noncommutative geometry and quantum field theory. Karoubi demonstrates a construction of twisted K-theory of crossed products. Tabuada surveys the theory of noncommutative motives.

This item will also be of interest to those working in algebra, geometry and topology, and mathematical physics.

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

Contents: H. Bursztyn and S. Waldmann, Classifying Morita equivalent star products; B. Tsygan, Noncommutative calculus and operads; E. Hoefel, Some elementary operadic homotopy equivalences; R. Meyer, Actions of higher categories on C*-algebras; J. Rosenberg, Examples and applications of noncommutative geometry and K-theory; J.-F. Lafont, I. J. Ortiz, and R. J. Sánchez-García, Rational equivariant K-homology of low dimensional groups; A. Zuk, Automata groups; B. Mesland, Spectral triples and KK-theory: A survey; R. Trinchero, Deformations of the canonical spectral triples; M. Karoubi, Twisted bundles and twisted K-theory; G. Tabuada, A guided tour through the garden of noncommutative motives.

Clay Mathematics Proceedings, Volume 16


Recent Developments in Lie Algebras, Groups and Representation Theory

Kailash C. Misra, North Carolina State University, Raleigh, NC; Daniel K. Nakano, University of Georgia, Athens, GA, and Brian J. Parshall, University of Virginia, Charlottesville, VA, Editors

This book contains the proceedings of the 2009–2011 Southeastern Lie Theory Workshop Series, held October 9–11, 2009 at North Carolina State University, May 22–24, 2010, at the University of Georgia, and June 1–4, 2011 at the University of Virginia.

Some of the articles, written by experts in the field, survey recent developments while others include new results in Lie algebras, quantum groups, finite groups, and algebraic groups.

Contents: P. N. Achar, Perverse coherent sheaves on the nilpotent cone in good characteristic; C. P. Bendel, D. K. Nakano, and C. Pillen, On the vanishing ranges for the cohomology of finite groups of Lie type II; M. Bennett, Type II; J. Kujawa, The generalized Kac-Wakimoto conjecture and support varieties for the Lie superalgebra osp(m|2n); S. Kumar, An approach towards the Kollár-Peskine problem via the instanton moduli space; G. Lusztig, Characteristic polynomials and fixed spaces of semisimple elements; D. J. Hemmer, “Frobenius twists” in the representation theory of the symmetric group; J. Du, Structures and representations of affine q-Schur algebras; A. Francis and L. Jones, Multiplicative bases for the centres of the group algebra and Iwahori-Hecke algebra of the symmetric group; R. L. Griess, Jr., Moonshine paths and a VOA existence proof of the Monster; R. Guralnick and G. Malle, Group algebras of a simple Lie algebra; D. K. Nakano, On the vanishing ranges for the cohomology of finite groups of Lie type.

Procedures of Symposia in Pure Mathematics, Volume 86

This is the proceedings volume of an international conference entitled Complex Analysis and Potential Theory, which was held to honor the important contributions of two influential analysts, Kohur N. GowriSankaran and Paul M. Gauthier, in June 2011 at the Centre de Recherches Mathématiques (CRM) in Montreal. More than fifty mathematicians from fifteen countries participated in the conference. The twenty-four surveys and research articles contained in this book are based on the lectures given by some of the most established specialists in the fields. They reflect the wide breadth of research interests of the two honorees: from potential theory on trees to approximation on Riemann surfaces, from universality to inner and outer functions and the disc algebra, from branching processes to harmonic extension and capacities, from harmonic mappings and the Harnack principle to integration formulae in $C^n$ and the Hartogs phenomenon, from fine harmonicity and plurisubharmonic functions to the binomial identity and the Riemann hypothesis, and more. This volume will be a valuable resource for specialists, young researchers, and graduate students from both fields, complex analysis and potential theory. It will foster further cooperation and the exchange of ideas and techniques to find new research perspectives.

Titled in this series are co-published with the Centre de Recherches Mathématiques.


Differential Equations

Wave Front Set of Solutions to Sums of Squares of Vector Fields

Paolo Albano and Antonio Bove, Università di Bologna, Italy

Contents: Introduction; The Poisson-Treves stratification; Standard forms for a system of vector fields; Nested strata; Bargman pseudodifferential operators; The "a priori" estimate on the FBI side; A single symplectic stratum; A single nonsymplectic stratum; Microlocal regularity in nested strata; Known cases and examples; Appendix A. A bracket lemma; Appendix B. Nonsymplectic strata do not have the reproducing bracket property; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 221, Number 1039

The Regularity of General Parabolic Systems with Degenerate Diffusion

Verena Bögelein and Frank Duzaar, University of Erlangen Nuremberg, Germany, and Giuseppe Mingione, University of Parma, Italy

Contents: Introduction and results; Technical preliminaries; Tools for the p-caloric approximation; The p-caloric approximation lemma; Caccioppoli and Poincaré type inequalities; Approximate A-caloricity and p-caloricity; DeBenedetto & Friedman regularity theory revisited; Partial gradient regularity in the case $p > 2$; The case $p < 2$; Partial Lipschitz continuity of $u$; Bibliography.

Memoirs of the American Mathematical Society, Volume 221, Number 1041

Mathematics Subject Classification: 35K55, 35K65, 35K67, Individual member US$45.60, List US$76, Institutional member US$60.80, Order code MEMO/221/1041

The Kohn-Sham Equation for Deformed Crystals

Weinan E, Princeton University, NJ, and Jianfeng Lu, Duke University, Durham, NC

Contents: Introduction; Perfect crystal; Stability condition; Homogeneously deformed crystal; Deformed crystal and the extended Cauchy-Born rule; The linearized Kohn-Sham operator; Proof of the results for the homogeneously deformed crystal; Exponential decay of the resolvent; Asymptotic analysis of the Kohn-Sham equation; Higher order approximate solution to the Kohn-Sham equation; Proofs of Lemmas 5.3 and 5.4; Appendix A. Proofs of Lemmas 9.3 and 9.9; Bibliography.

Memoirs of the American Mathematical Society, Volume 221, Number 1040

Mathematics Subject Classification: 35K55, 35K65, 35K67, Individual member US$41.40, List US$60, Institutional member US$55.20, Order code MEMO/221/1040

Collected Papers of John Milnor

VI. Dynamical Systems (1953–2000)

Araceli Bonifant, University of Rhode Island, Kingston, RI, Editor

This book, the sixth in the series "Collected Papers of John Milnor", contains all of Milnor's work on Real and Complex Dynamics from 1953 to 1999, plus one paper from 2000.

These papers provide important and fundamental material in real and complex dynamical systems. Many of them have become classics in the field. Several questions addressed in them continue to be important in current research. Having them together in the same volume gives readers a taste of all the great mathematics developed by the author in the different areas of dynamics. In some cases, there have been minor corrections or clarifications, as well as references to more recent work which answers questions raised by the author.

John Milnor's papers are accompanied by introductions that put them in perspective with respect to the current state of the field. There is also an index to facilitate searching the book for specific topics.

Contents: Part I. Real dynamics: Introduction to Part I; The characteristics of a vector field in the two-sphere (1953); On the concept of attractor (1983); On the concept of attractor: Correction and remarks (1985); Directional entropies of cellular automaton-maps (1986); On the entropy geometry of cellular automata (1988); Non-expansive Hénon maps (1988); with W. Thurston, On iterated maps of the interval (1988); with S. P. Dawson, R. Galeeva, and C. Tresser, A monotonicity conjecture for real cubic maps (1995); with C. Tresser, On entropy and monotonicity for real cubic maps (2000) (with an appendix by A. Douady and P. Sentenac); Fubini foiled: Katok's paradoxical example in measure theory (1997); Part II. Complex dynamics: Introduction to Part II; with S. Friedland, Dynamical properties of plane polynomial automorphisms (1989); Self-similarity and hairiness in the Mandelbrot set (1989); Remarks on iterated cubic maps (1992); Geometry and dynamics of quadratic rational maps (1993) (with an appendix by J. Milnor and T. Lei); with M. Lyubich, The Fibonacci unimodal map (1993); with L. Goldberg, Fixed points of polynomial maps. Part II. Fixed point portraits (1993); The mathematical work of Curt McMullen (1999); Index.

Collected Works, Volume 19

Mathematics Subject Classification: 37-XX, 54H20, 26A18, 28D20, 32Hxx, 32S70, 28A35, 68Q80, 01A70, AMS members US$87.20, List US$109, Order code CWORKS/19.6
Large Networks and Graph Limits
László Lovász, Eötvös Loránd University, Budapest, Hungary

Recently, it became apparent that a large number of the most interesting structures and phenomena of the world can be described by networks. Developing a mathematical theory of very large networks is an important challenge. This book describes one recent approach to this theory, the limit theory of graphs, which has emerged over the last decade. The theory has rich connections with other approaches to the study of large networks, such as “property testing” in computer science and regularity partition in graph theory. It has several applications in extremal graph theory, including the exact formulations and partial answers to very general questions, such as which problems in extremal graph theory are decidable. It also has less obvious connections with other parts of mathematics (classical and non-classical, like probability theory, measure theory, tensor algebras, and semidefinite optimization).

This book explains many of these connections, first at an informal level to emphasize the need to apply more advanced mathematical methods, and then gives an exact development of the theory of the algebraic theory of graph homomorphisms and of the analytic theory of graph limits.

This is an amazing book: readable, deep, and lively. It sets out this emerging area, makes connections between old classical graph theory and graph limits, and charts the course of the future.

—Persi Diaconis, Stanford University

This book is a comprehensive study of the active topic of graph limits and an updated account of its present status. It is a beautiful volume written by an outstanding mathematician who is also a great expositor.

—Noga Alon, Tel Aviv University, Israel

Modern combinatorics is by no means an isolated subject in mathematics, but has many rich and interesting connections to almost every area of mathematics and computer science. The research presented in Lovász’s book exemplifies this phenomenon. This book presents a wonderful opportunity for a student in combinatorics to explore other fields of mathematics, or conversely for experts in other areas of mathematics to become acquainted with some aspects of graph theory.

—Terence Tao, University of California, Los Angeles, CA

László Lovász has written an admirable treatise on the exciting new theory of graph limits and graph homomorphisms, an area of great importance in the study of large networks. It is an authoritative, masterful text that reflects Lovász’s position as the main architect of this rapidly developing theory. The book is a must for combinatorialists, network theorists, and theoretical computer scientists alike.

—Bela Bollobás, Cambridge University, UK

This item will also be of interest to those working in applications.
Conference Board of the Mathematical Sciences, and National Council of Teachers of Mathematics.

The audience for this report includes all who teach mathematics to teachers—mathematicians, statisticians, and mathematics educators—and all who are responsible for the mathematical education of teachers—department chairs, educational administrators, and policy-makers at the national, state, school-district, and collegiate levels.

This series is published in cooperation with the Mathematical Association of America.

Contents: School mathematics and teachers’ mathematics; The mathematical education of teachers: Traditions, research, current context; Recommendations: Mathematics for teachers; Roles for mathematicians; Elementary teachers; Middle grades teachers; High school teachers; Appendix A. Selected references and information sources; Appendix B. The common core state standards: Overview of content; Appendix C. The common core state standards for mathematical practice.

CBMS Issues in Mathematics Education, Volume 17


Geometry and Topology

Analysis, Geometry and Quantum Field Theory

Clara L. Aldana, Max Planck Institute for Gravitational Physics, Golm, Germany, Maxim Braverman, Northeastern University, Boston, MA, Bruno Iochum, Aix-Marseille Université, France, and Carolina Neira Jiménez, Universität Regensburg, Germany, Editors

This volume contains the proceedings of the conference “Analysis, Geometry and Quantum Field Theory” held at Potsdam University in September 2011, which honored Steve Rosenberg’s 60th birthday.

The papers in this volume cover a wide range of areas, including Quantum Field Theory, Deformation Quantization, Gerbes, Loop Spaces, Index Theory, Determinants of Elliptic Operators, K-theory, Infinite Rank Bundles and Mathematical Biology.

This item will also be of interest to those working in mathematical physics.

Contents: M. G. Eastwood and J. A. Wolf, A duality for the double fibration transform; P. Hekmati and M. Mathai, T-duality of current algebras and their quantization; Y. Maeda and A. Sako, Deformation quantization of instantons on $\mathbb{R}^4$; J. Mickelsson, The Chern character of certain infinite rank bundles arising in gauge theory; A. Larrain-Hubach, K-theories for classes of infinite rank bundles; K. Waldorf, A construction of string 2-group models using transgression-regression technique; A. Cardona, Extended symmetries and Poisson algebras associated to twisted Dirac structures; S. T. Melo, T. Schick, and E. Schrohe, C*-algebra approach to the index theory of boundary value problems; B. Booß-Bavnbek, Towards a nano geometry? Geometry and dynamics on nano scale; T. Lüdmatainen, Optimal Riemannian metric for a volumorphism and a mean ergodic theorem in complete global Alexandrov nonpositively curved spaces; C. Bär, Renormalized integrals and a path integral formula for the heat kernel on a manifold; S. Paycha, Affine transformations on symbols; C. L. Aldana, Determinants of Laplacians on non-compact surfaces; S. Scott, Calculation of the variation of $\det_D$; G. Misiolek and T. Yoneda, Ill-posedness examples for the quasi-geostrophic and the Euler equations.

Contemporary Mathematics, Volume 584


Diffeology

Patrick Iglesias-Zemmour, CNRS, Marseille, France, and The Hebrew University of Jerusalem, Israel

Diffeology is an extension of differential geometry. With a minimal set of axioms, diffeology allows us to deal simply but rigorously with objects which do not fall within the usual field of differential geometry: quotients of manifolds (even non-Hausdorff), spaces of functions, groups of diffeomorphisms, etc. The category of diffeology objects is stable under standard set-theoretic operations, such as quotients, products, co-products, subsets, limits, and co-limits. With its right balance between rigor and simplicity, diffeology can be a good framework for many problems that appear in various areas of physics.

Actually, the book lays the foundations of the main fields of differential geometry used in theoretical physics: differentiability, Cartan differential calculus, homology and cohomology, diffeological groups, fiber bundles, and connections. The book ends with an open program on symplectic diffeology, a rich field of application of the theory. Many exercises with solutions make this book appropriate for learning the subject.

Contents: Diffeology and diffeological spaces; Locality and diffeologies; Diffeological vector spaces; Modeling spaces, manifolds, etc.; Homotopy of diffeological spaces; Cartan-De Rham calculus; Diffeological groups; Diffeological fiber bundles; Symplectic diffeology; Solutions of exercises; Afterword; Notation and vocabulary; Bibliography.

Mathematical Surveys and Monographs, Volume 185

From Riches to Raags: 3-Manifolds, Right-Angled Artin Groups, and Cubical Geometry

Daniel T. Wise, McGill University, Montreal, QC, Canada

This book presents an introduction to the geometric group theory associated with nonpositively curved cube complexes. It advocates the use of cube complexes to understand the fundamental groups of hyperbolic 3-manifolds as well as many other infinite groups studied within geometric group theory.

The main goal is to outline the proof that a hyperbolic group $G$ with a quasiconvex hierarchy has a finite index subgroup that embeds in a right-angled Artin group. The supporting ingredients of the proof are sketched: the basics of nonpositively curved cube complexes, walls and dual CAT(0) cube complexes, special cube complexes, the combination theorem for special cube complexes, the combination theorem for cubulated groups, cubical small-cancellation theory, and the malnormal special quotient theorem. Generalizations to relatively hyperbolic groups are discussed. Finally, applications are described towards resolving Baumslag's conjecture on the residual finiteness of one-relator groups with torsion, and to the virtual specialness and virtual fibering of certain hyperbolic 3-manifolds, including those with at least one cusp.

The text contains many figures illustrating the ideas.

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

A co-publication of the AMS and CBMS.

Contents: Overview; Nonpositively curved cube complexes; Cubical disk diagrams, hyperplanes, and convexity; Special cube complexes; Virtual specialness of malnormal amalgams; Wallspaces and their dual cube complexes; Finiteness properties of the dual cube complex; Cubulating malnormal graphs of cubulated groups; Cubical small-cancellation theory; Walls in cubical small-cancellation theory; Annular diagrams; Virtually special quotients; Hyperbolicity and quasiconvexity detection; Hyperbolic groups with a quasiconvex hierarchy; The relatively hyperbolic setting; Applications; Bibliography; Index of notation and defined terms.

CBMS Regional Conference Series in Mathematics, Number 117


Logic and Foundations

Potential Wadge Classes

Dominique Lecomte, Université Paris 6, France

Contents: Introduction; A condition ensuring the existence of complicated sets; The proof of Theorem 1.10 for the Borel classes; The proof of Theorem 1.11 for the Borel classes; The proof of Theorem 1.10; The proof of Theorem 1.11; Injectivity complements; Bibliography.

Memoirs of the American Mathematical Society, Volume 221, Number 1038


Mathematical Physics

Mathematical Aspects of Quantization

Sam Evens, Michael Gekhtman, Brian C. Hall, Xiaobo Liu, and Claudia Polini, University of Notre Dame, IN, Editors

This book is a collection of expository articles from the Center of Mathematics at Notre Dame’s 2011 program on quantization.

Included are lecture notes from a summer school on quantization on topics such as the Cherednik algebra, geometric quantization, detailed proofs of Willwacher’s results on the Kontsevich graph complex, and group-valued momentum maps.

This book also includes expository articles on quantization and automorphic forms, renormalization, Berezin-Toeplitz quantization in the complex setting, and the commutation of quantization with reduction, as well as an original article on derived Poisson brackets.

The primary goal of this volume is to make topics in quantization more accessible to graduate students and researchers.

Contents: Y. Berest and P. Samuelson, Dunkl operators and quasi-invariants of complex reflection groups; V. A. Dolgushev and C. L. Rogers, Notes on algebraic operads, graph complexes, and Willwacher’s construction; E. Lerman, Geometric quantization: A crash course; E. Meinrenken, Lectures on group-valued moment maps and Verlinde formulas; T. Barron, Quantization and automorphic forms; Y. Berest, X. Chen, F. Eshmatov, and A. Ramadoss, Noncommutative Poisson structures, derived representation schemes and Calabi-Yau algebras; A. Kar and S. G. Rajeev, Renormalization by any means necessary; M. Schlichenmaier, Berezin-Toeplitz quantization and star products for compact Kähler manifolds;
New AMS-Distributed Publications

J. Śniatycki, Commutation of geometric quantization and algebraic reduction.

Contemporary Mathematics, Volume 583


New AMS-Distributed Publications

Geometry and Topology

Large Scale Geometry

Piotr W. Nowak, Polish Academy of Sciences, Warsaw, Poland, and Guoliang Yu, Texas A & M University, College Station, TX

Large scale geometry is the study of geometric objects viewed from a great distance. The idea of large scale geometry can be traced back to Mostow’s work on rigidity and the work of Švarc, Milnor, and Wolf on growth of groups. In the last decades, large scale geometry has found important applications in group theory, topology, geometry, higher index theory, computer science, and large data analysis.

This book provides a friendly approach to the basic theory of this exciting and fast growing subject and offers a glimpse of its applications to topology, geometry, and higher index theory. The authors have made a conscientious effort to make the book accessible to advanced undergraduate students, graduate students, and non-experts.

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

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Metric spaces and large scale geometry; Asymptotic dimension and decomposition complexity; Amenability; Property A; Coarse embeddings; Group actions on Banach spaces; Coarse homology; Survey of applications; References; Index.

EMS Textbooks in Mathematics, Volume 13

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

ALABAMA

UNIVERSITY OF ALABAMA
Department of Mathematics

The Department of Mathematics at the University of Alabama invites applications for a tenure-track Assistant Professor position in the area of probability/statistics with a focus on non-parametric statistics and computing. The appointment will begin on August 16, 2013. Candidates must possess a doctorate in mathematics, statistics, or a closely related field. Applicants must apply online at [http://facultyjobs.ua.edu](http://facultyjobs.ua.edu) and arrange for at least three letters of recommendation, one of which must address teaching, to be sent to mathematics@as.ua.edu. The review process starts on December 1, 2012, and continues until the position is filled. The University of Alabama is an Equal Opportunity/Affirmative Action Employer and continues to actively seek diversity among its employees. Women and minority candidates are strongly encouraged to apply. Hiring for this position is contingent upon funding. More information about the department and the university is available at [http://math.ua.edu](http://math.ua.edu).

HARVEY MUDD COLLEGE
Department of Mathematics
Tenure-Track and Postdoctoral Positions

Harvey Mudd College invites applications for: (1) a tenure-track professorship, or (2) a teaching-research postdoctoral fellowship. All areas of the mathematical sciences will be considered. Successful candidates will have a Ph.D., demonstrated teaching excellence, and a strong research program that contributes to our many undergraduate research activities. As recipient of the inaugural AMS Award for Exemplary Program, the department is a recognized leader in teaching, undergraduate research mentoring, and educational outreach. Half of our graduates go to Ph.D. programs. HMC is an Equal Opportunity Employer. Apply at [MathJobs.org](http://mathjobs.org).

SAN DIEGO STATE UNIVERSITY
Department of Mathematics and Statistics
Tenure-track Assistant Professor Position in Applied and Computational Mathematics

The Department of Mathematics and Statistics at San Diego State University invites applications for a tenure-track Assistant Professor position in applied and computational mathematics, beginning in Fall 2013. Focused research areas include but are not limited to dynamical systems, nonlinear waves, applied PDEs, numerical analysis, climate science and mathematical biology.

Candidates must have a Ph.D. in mathematics or a closely related field, and demonstrate outstanding research potential. Candidates must also demonstrate enthusiasm and ability to teach undergraduate and graduate level mathematics. Preference may be given to candidates in the focused research areas described above and to those who would be able to augment or interact with existing groups within the department and the Computational Science Research Center. The successful candidate will have the opportunity to participate in our joint Ph.D. program in Computational Science, as well as in our MA and MS programs in pure and applied mathematics.

Applications should include: a cover letter, curriculum vita, a description of research program, a statement of teaching philosophy, and three letters of recommendation, which must address teaching, to be sent to [mathematics@as.sdsu.edu](mailto:mathematics@as.sdsu.edu). The review process starts on October 29, 2012 and continues until the position is filled. The University of Alabama is an Equal Opportunity/Affirmative Action Employer and continues to actively seek diversity among its employees. Women and minority candidates are strongly encouraged to apply. Hiring for this position is contingent upon funding. More information about the department and the university is available at [http://math.sdsu.edu](http://math.sdsu.edu).

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 2012 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: January 2013 issue-October 29, 2012; February 2013 issue-November 28, 2012; March 2013 issue-January 2, 2013; April 2013 issue-January 30, 2013; May 2013-February 29, 2013; June/July 2013 issue-April 26, 2013. 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 classifieds@ams.org. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.
recommendation sent directly to the search committee. Applications should be addressed to:
Professor Ricardo Carretero
Chair, Search Committee
Department of Mathematics and Statistics
San Diego State University
5500 Campanile Dr.
San Diego, CA 92182-7720
Review of applications will begin on October 15, 2012, and continue until the position is filled.
SDSU is an Equal Opportunity Employer and does not discriminate against persons on the basis of race, religion, national origin, sexual orientation, gender, gender identity and expression, marital status, age, disability, pregnancy, medical condition, or covered veteran status.

UCLA
Department of Mathematics
The Department of Mathematics invites applications for temporary and visiting appointments in the categories 1-4 below. Depending on the level, candidates must give evidence of potential or demonstrated distinction in scholarship and teaching.
Temporary Positions:
(1) E.R. Hedrick Assistant Professorships. Salary is $63,000 and appointments are for three years. The teaching load is four one-quarter courses per year.
(2) Computational and Applied Mathematics (CAM) Assistant Professorships. Salary is $63,000, and appointments are for three years. The teaching load is normally reduced by research funding to two quarter courses per year.
(3) Program in Computing (PIC) Assistant Adjunct Professorships. Salary is $67,500. Applicants for these positions must show strong promise in teaching and research in an area related to computing. The teaching load is four one-quarter programming courses each year and one additional course every two years. Initial appointments are for one year and possibly longer, up to a maximum service of four years.
(4) Assistant Adjunct Professorships and Research Postdocs. Normally appointments are for one year, with the possibility of renewal. Strong research and teaching background required. The salary range is $54,800-$61,300. The teaching load for Adjuncts is six one-quarter courses per year.
Applications and supporting documentation must be submitted electronically via www.mathjobs.org. All letters of evaluation are subject to UCLA campus policies on confidentiality. Refer potential reviewers to the UCLA Statement of Confidentiality at: http://www.math.
ucla.edu/people/confidentiality.pdf
For fullest consideration, all application materials should be submitted on or before December 7, 2012. A Ph.D. is required for all positions.
The university is an Equal Opportunity/Affirmative Action Employer. UCLA and the Department of Mathematics have a strong commitment to the achievement of excellence in teaching and research and diversity among its faculty and staff. The University of California asks that applicants complete the Equal Opportunity Employer survey for Letters and Science at the following URL: http://cis.ucla.edu/facultysurvey. Under Federal law, the University of California may employ only individuals who are legally authorized to work in the United States as established by providing documents specified in the Immigration Reform and Control Act of 1986.

UNIVERSITY OF CONNECTICUT
Department of Mathematics
Assistant Professor, Tenure-Track
The department has several positions, starting in the Fall 2013 with priority on logic, analysis, stochastic processes preferably with financial mathematics, numerical solutions of PDE’s and optimization.
See http://www.mathjobs.org/jobs to retrieve information and to apply online. For questions or requests regarding additional information please email the Hiring Committee at mathhiring@uconn.edu.

UNIVERSITY OF CONNECTICUT
Department of Mathematics
Professor, Tenured
The department seeks to hire a distinguished senior mathematician to hold the Stuart and Joan Sidney Professorship of Mathematics, starting in the Fall 2013. Highly qualified candidates in all mathematical disciplines are encouraged to apply.
See http://www.mathjobs.org/jobs to retrieve information and to apply online. For questions or requests for additional information please email the Hiring Committee of the Department of Mathematics at sjshiring@math.uconn.edu.

AMERICAN UNIVERSITY
Washington, DC
The College of Arts and Sciences at American University (Washington, DC) invites applications for a full-time, tenure-line, Assistant Professor position, beginning in August 2013, in computational neuroscience (broadly defined, including but not limited to neural networks, simulation, image processing, and bio-informatics). The appointee’s tenure home and departmental affiliation will depend on his or her research background, but we are most interested in applicants who would have at least a joint affiliation with the Department of Computer Science. Applicants must have a Ph.D. in a relevant discipline. Teaching and postdoctoral experience are preferred. Responsibilities include: teaching and curriculum development; establishing an internationally recognized research program, preferably one that can involve undergraduate research participation; strengthening connections to neurosciences across campus; and service to the appointee’s home department and the wider university. American University has made other recent hires in neuroscience, is presently seeking to fill other positions in computer science, and benefits from proximity to other scientific institutions in the Washington area. (For example, NIH is three metro stops from the AU campus.) The College of Arts and Sciences offers a variety of degrees at the undergraduate, masters, and doctoral levels. For more information about our programs, visit http://www.american.edu/cas/CompNeuroSearch. Applicants should submit a cover letter, curriculum vitae, teaching statement, and research statement, and applicants must arrange for three letters of recommendation to be sent directly to the search committee. Materials can be submitted online (highly preferred) at http://academicjobsonline.org/ajo or via email to CompNeuroSearch@american.edu, or in hard copy to Computational Neuroscience Search Committee, Department of Mathematics and Statistics, American University, Washington, DC 20016-8050. Applications received by December 10, 2012, will receive full consideration. American University is an EEO/AA institution, committed to a diverse faculty, staff, and student body. Women and minority candidates are strongly encouraged to apply. American University offers employee benefits to same-sex domestic partners of employees and prohibits discrimination on the basis of sexual orientation/preference and gender identity/expression.

DISTRICT OF COLUMBIA
AMERICAN UNIVERSITY
Washington, DC
The College of Arts and Sciences at American University (Washington, DC) invites applications for a full-time, tenure-line, Assistant Professor position, beginning in August 2013, in computational neuroscience (broadly defined, including but not limited to neural networks, simulation, image processing, and bio-informatics). The appointee’s tenure home and departmental affiliation will depend on his or her research background, but we are most interested in applicants who would have at least a joint affiliation with the Department of Computer Science. Applicants must have a Ph.D. in a relevant discipline. Teaching and postdoctoral experience are preferred. Responsibilities include: teaching and curriculum development; establishing an internationally recognized research program, preferably one that can involve undergraduate research participation; strengthening connections to neurosciences across campus; and service to the appointee’s home department and the wider university. American University has made other recent hires in neuroscience, is presently seeking to fill other positions in computer science, and benefits from proximity to other scientific institutions in the Washington area. (For example, NIH is three metro stops from the AU campus.) The College of Arts and Sciences offers a variety of degrees at the undergraduate, masters, and doctoral levels. For more information about our programs, visit http://www.american.edu/cas/CompNeuroSearch. Applicants should submit a cover letter, curriculum vitae, teaching statement, and research statement, and applicants must arrange for three letters of recommendation to be sent directly to the search committee. Materials can be submitted online (highly preferred) at http://academicjobsonline.org/ajo or via email to CompNeuroSearch@american.edu, or in hard copy to Computational Neuroscience Search Committee, Department of Mathematics and Statistics, American University, Washington, DC 20016-8050. Applications received by December 10, 2012, will receive full consideration. American University is an EEO/AA institution, committed to a diverse faculty, staff, and student body. Women and minority candidates are strongly encouraged to apply. American University offers employee benefits to same-sex domestic partners of employees and prohibits discrimination on the basis of sexual orientation/preference and gender identity/expression.
INDIANA UNIVERSITY BLOOMINGTON
Department of Mathematics
Zorn Research Postdoctoral Fellowships

The Department of Mathematics seeks applications for two Zorn Research Postdoctoral Fellowships beginning in the fall of 2013. There are three-year, non-tenure-track positions with reduced teaching loads. Outstanding candidates with a recent Ph.D. in any area of pure or applied mathematics are encouraged to apply; a minimum requirement is a Ph.D. in mathematics. Zorn fellows are paired with mentors with whom they have compatible research interests. The department maintains strong research groups in all of the principal fields of mathematics. Bloomington is located in the forested hills of southern Indiana and offers a rich variety of musical and cultural attractions.

Applicants should submit an AMS cover sheet, a curriculum vitae, a research statement, and a teaching statement using the online service provided by the AMS at: http://www.mathjobs.org. If unable to do so, you may send application materials to the address below. Applicants should arrange for four letters of recommendation, including one evaluating teaching experience. Please ask reference writers to submit their letters electronically through http://www.mathjobs.org. If they are unable to do so, they may also send their letters to the following address: Zorn Postdoctoral Fellowships Search Committee, Department of Mathematics, Indiana University, 831 East 3rd Street, Rawles Hall, Bloomington, IN 47405-7106. Applications should be received by December 15, 2012. Indiana University is an Equal Opportunity/Affirmative Action Employer.

KANSAS STATE UNIVERSITY
Visiting Assistant Professor

Applicants are invited for a tenure-track Assistant Professor position to commence August 4, 2013. Applications are invited from exceptional candidates for a tenure-track assistant professor position in algebraic geometry and for a tenure-track assistant professor position in probability theory expected to begin as early as August 18, 2013. The University of Kansas is especially interested in hiring faculty members who can contribute to four key campus-wide strategic initiatives: (1) Sustaining the Planet, Powering the World; (2) Promoting Well-Being, Finding Cures; (3) Building Communities, Expanding Opportunities; and (4) Harnessing Information, Multiplying Knowledge. For more information, see http://www.provost.ku.edu/planning/themes. Ph.D. or ABD in math or a related field is expected by the start date of the appointment; commitment to excellence in teaching in mathematics and computer science is essential. Applicants must have a commitment to excellence in teaching. A Ph.D. in mathematics or a Ph.D. dissertation completed by 12/20/13 is required. Preference will be given to applications with background in mathematics and/or teaching with technology, as well as applicants whose research interests mesh well with current department faculty. Letters of application, current vita, minimum three letters of reference, at least one of which addresses the applicant’s teaching ability, and a statement of teaching philosophy must be submitted online through mathjobs.org. Screening of applications begins November 1, 2012, and continues until the position is closed. The successful candidate should have strong research credentials as well as strong teaching, should demonstrate a strong commitment to mentoring students, and should value working with colleagues and students from diverse backgrounds. Applications are invited from exceptional candidates for a tenure-track assistant professor position in algebraic geometry and for a tenure-track assistant professor position in probability theory expected to begin as early as August 18, 2013. The University of Kansas is especially interested in hiring faculty members who can contribute to four key campus-wide strategic initiates: (1) Sustaining the Planet, Powering the World; (2) Promoting Well-Being, Finding Cures; (3) Building Communities, Expanding Opportunities; and (4) Harnessing Information, Multiplying Knowledge. For more information, see http://www.provost.ku.edu/planning/themes. Ph.D. or ABD in math or a related field is expected by the start date of the appointment; commitment to excellence in teaching in mathematics and computer science is essential. Applicants must have a commitment to excellence in teaching. A Ph.D. in mathematics or a Ph.D. dissertation completed by 12/20/13 is required. Preference will be given to applications with background in mathematics and/or teaching with technology, as well as applicants whose research interests mesh well with current department faculty. Letters of application, current vita, minimum three letters of reference, at least one of which addresses the applicant’s teaching ability, and a statement of teaching philosophy must be submitted online through mathjobs.org. Screening of applications begins November 1, 2012, and continues until the position is closed. The successful candidate should have strong research credentials as well as strong teaching, should demonstrate a strong commitment to mentoring students, and should value working with colleagues and students from diverse backgrounds. Applications are invited from exceptional candidates for a tenure-track assistant professor position in algebraic geometry and for a tenure-track assistant professor position in probability theory expected to begin as early as August 18, 2013. The University of Kansas is especially interested in hiring faculty members who can contribute to four key campus-wide strategic initiates: (1) Sustaining the Planet, Powering the World; (2) Promoting Well-Being, Finding Cures; (3) Building Communities, Expanding Opportunities; and (4) Harnessing Information, Multiplying Knowledge. For more information, see http://www.provost.ku.edu/planning/themes. Ph.D. or ABD in math or a related field is expected by the start date of the appointment; commitment to excellence in teaching in mathematics and computer science is essential. Applications must be submitted electronically via http://www.mathjobs.org. Screening of applications begins November 1, 2012, and continues until the position is closed. Kansas State University is an Equal Opportunity Employer and actively seeks diversity among its employees and encourages applications from women and minorities. A background check is required.
JOHNS HOPKINS UNIVERSITY
Department of Mathematics
J. J. Sylvester Assistant Professor

Subject to availability of resources and administrative approval, the Department of Mathematics invites applications for non-tenure-track two-year Assistant Professor positions beginning July 1, 2013. The J.J. Sylvester Assistant Professorship is a position offered to recent Ph.D.'s with 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, 2012. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

JOHNS HOPKINS UNIVERSITY
Tenure-track Position in Financial Mathematics

The Department of Applied Mathematics and Statistics at Johns Hopkins University invites applications to fill a tenure-track position in financial mathematics. Exceptionally qualified candidates at all ranks will be considered. A successful candidate must have a doctorate in mathematics, applied mathematics, or a closely related field and will be expected to develop a successful research program in financial mathematics. The Department of Applied Mathematics and Statistics currently has ten tenure-track or tenured faculty members in the fields of probability, statistics, discrete mathematics, optimization, partial differential equations, and wavelet analysis. Electronic submission of applications to http://mathjobs.org is strongly preferred. If necessary, paper applications may be sent to: Faculty Search Committee: Financial Mathematics Department of Applied Mathematics and Statistics Johns Hopkins University 100 Whitehead Hall 3400 N. Charles Street Baltimore, MD 21218-2682 USA Applications should include a cover letter describing the principal expertise of the applicant, a statement of teaching philosophy, a statement of research interests and experiences, and a curriculum vitae. Junior applicants should arrange to have 3-5 letters of recommendation sent. Applicants awarded a Ph.D. in June 2010 or later should provide photocopies of graduate transcripts. For full consideration, applications should be received by December 31, 2012. The department is committed to building a diverse educational environment; women and minorities are strongly encouraged to apply. The Johns Hopkins University is an EEO/AA Employer.

UNIVERSITY OF MARYLAND BALTIMORE COUNTY
Department of Mathematics and Statistics

The Department of Mathematics and Statistics at the University of Maryland Baltimore County (UMBC) invites applications for two tenure-track faculty positions in Applied Mathematics at the rank of Assistant Professor, or at a higher level for exceptionally well qualified candidates, starting in the fall of 2013. The successful candidate should have a Ph.D. in mathematics or a related field, have an active, independent research program, strong potential for obtaining external funding, and a commitment to excellence in teaching. Preference will be given to candidates who are able to interact with existing groups in the Department, conduct interdisciplinary research, and strengthen connections to other research groups on campus. Applications with postdoctoral teaching experience are encouraged. The Department offers BS, MS and Ph.D. degrees in applied mathematics and in statistics and successful applicants should actively contribute to the success of these programs. For more information see: http://www.math.umbc.edu A complete application should include a cover letter, C.V., summary of current research program, teaching statement, and three letters of reference. All application materials should be submitted to MathJobs.org. Screening of applicants will commence December 1, 2012, and will continue until the position is filled. Applications from minorities, women and people with disabilities are especially encouraged. UMBC is an NSF-ADVANCE institution and an Affirmative Action/Equal Opportunity Employer.

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, 2013. 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: 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 or do not wish to do so, 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, 2012. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

BOSTON COLLEGE
Postdoctoral Position

The Department of Mathematics at Boston College invites applications for a postdoctoral position beginning September 2013. This position is intended for a new or recent Ph.D. with outstanding potential in research and excellent teaching. This is a 3-year Visiting Assistant Professor position, and carries a 2-1 annual teaching load. Research interests should lie within number theory, representation theory, algebraic geometry or related areas. Candidates should expect to receive their Ph.D. prior to the start of the position and have received the Ph.D. no earlier than Spring 2012. Applications must include a cover letter, description of research plans, teaching statement, curriculum vitae, and four or more letters of recommendation, with at least one addressing the candidate's teaching qualifications. Applications received no later than January 1, 2013, will be assured our fullest consideration.

Please submit all application materials through MathJobs.org. Applicants may learn more about the department, its faculty and its programs and about Boston College at: http://www.bc.edu/math Email inquiries concerning this position may be directed to: postdoc-search@bc.edu. Boston College is an Affirmative Action/Equal Opportunity Employer. Applications from women, minorities and
individuals with disabilities are encouraged.

WILLIAMS COLLEGE
Department of Mathematics and Statistics

Williams College invites applications for one tenure-track position in mathematics, beginning fall 2013, at the rank of assistant professor (in an exceptional case, a more advanced appointment may be considered). We are seeking a highly qualified candidate who has demonstrated excellence in teaching, who will establish an active and successful research program, and who will have a Ph.D. by the time of appointment. Williams College is a private, coeducational, residential, highly selective liberal arts college with an undergraduate enrollment of approximately 2,000 students. The teaching load is two courses per 12-week semester and a winter term course every other January. Applicants are encouraged to apply electronically at: http://mathjobs.org or send a vita and have three letters of recommendation on teaching and research sent to Satyan Devadoss, Chair of the Hiring Committee, Department of Mathematics and Statistics, Williams College, 18 Hoxsey Street, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluations of applications will begin on or after November 15, 2012, and will continue until the position is filled. All offers of employment are contingent upon completion of a background check. Further information is available upon request. For more information on the Department of Mathematics and Statistics, visit http://math.williams.edu/. Williams College is a coeducational liberal arts institution located in the Berkshire Hills of western Massachusetts with easy access to the culturally rich cities of Albany, Boston, and New York City. The college is committed to building and supporting a diverse population of students, and to fostering an inclusive faculty, staff, and curriculum. Williams has built its reputation on outstanding teaching and scholarship and on the academic excellence of its students. Please visit the Williams College website: http://www.williams.edu/ Beyond meeting fully its legal obligations for non-discrimination, Williams College is committed to building a diverse and inclusive community where members from all backgrounds can live, learn, and thrive.

WILLIAMS COLLEGE
Department of Mathematics and Statistics

The Williams College Department of Mathematics and Statistics invites applications for a visiting position in mathematics for the 2013-2014 year, at the rank of assistant professor. Preference will be given to candidates who will have a Ph.D. in mathematics by September 2013. Applicants are encouraged to apply electronically at http://mathjobs.org or please send a vita and have three letters of recommendation on teaching and research sent to the Visitor Hiring Committee, Department of Mathematics and Statistics, Williams College, 18 Hoxsey Street, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluations of applications will begin on or after November 15, 2012, and will continue until the position is filled. All offers of employment are contingent upon completion of a background check. Further information is available upon request. For more information on the Department of Mathematics and Statistics, visit http://math.williams.edu/. Williams College is a coeducational liberal arts institution located in the Berkshire Hills of western Massachusetts with easy access to the culturally rich cities of Albany, Boston, and New York City. The college is committed to building and supporting a diverse population of students, and to fostering an inclusive faculty, staff, and curriculum. Williams has built its reputation on outstanding teaching and scholarship and on the academic excellence of its students. Please visit the Williams College website: http://www.williams.edu/ Beyond meeting fully its legal obligations for non-discrimination, Williams College is committed to building a diverse and inclusive community where members from all backgrounds can live, learn, and thrive.

MICHIGAN
MICHIGAN STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics at Michigan State University will have two tenure-track positions to begin fall 2013. It is expected that successful applicants will be appointed at the rank of Assistant Professor, but truly outstanding candidates for appointment at higher ranks will be considered. Candidates will be evaluated on their merits in both research and teaching, and excellence is essential in both. Preference will be given to candidates with at least 2 years of experience beyond the Ph.D. Outstanding candidates from all mathematical research areas will be considered. Applicants should send a vita, statement on research and teaching, and should arrange for at least 4 letters of recommendation to be sent, one of which must specifically address the applicant’s ability to teach, and apply on-line at this link: https://www.math.msu.edu/ Applications received by December 15, 2012, will receive first consideration. For more information about this position, please visit our website: http://www.math.msu.edu/activities/recruiting/. Dartmouth is committed to diversity and encourages applications from women and minorities.

NEW HAMPSHIRE
DARTMOUTH COLLEGE
Department of Mathematics

The Department of Mathematics anticipates a tenure-track opening with initial appointment as an Assistant Professor in the 2013-2014 academic year. The successful applicant will have a research profile with a concentration in computational or applied mathematics. Applicants should apply online at www.mathjobs.org. Position ID: APACM #3874. Applications received by December 15, 2012, will receive first consideration. For more information about this position, please visit our website: http://www.math.dartmouth.edu/activities/recruiting/. Dartmouth is committed to diversity and encourages applications from women and minorities.

MONTANA
MONTANA TECH
The University of Montana

The Department of Mathematical Sciences is seeking qualified applicants for two positions, Assistant Professor: Doctorate in mathematics and experience teaching a wide range of mathematical topics are required. Instructor: Master’s degree in mathematics or mathematics education and experience teaching a wide range of mathematical topics are required. For more information visit http://www.mtech.edu/employment.
DARTMOUTH COLLEGE
Department of Mathematics

The Department of Mathematics anticipates a tenure-track opening with initial appointment in the 2013-2014 academic year, for a mathematician working in either topology or number theory. The appointment is for candidates at any rank. Applicants should apply online at www.mathjobs.org. Position ID: TTPNT #3873. Applications received by December 15, 2012, will receive first consideration. For more information about this position, please visit our website: http://www.math.dartmouth.edu/activities/recruiting/. Dartmouth is committed to diversity and encourages applications from women and minorities.

NORTH CAROLINA
THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO
Assistant/Associate Professor
Computational Mathematics

The University of North Carolina at Greensboro, Department of Mathematics and Statistics seeks applications for two tenure-track positions in computational mathematics at the Assistant Professor rank beginning 8/1/2013. Experienced candidates may also be considered for appointment at the rank of Associate Professor. Candidates must hold or anticipate a Ph.D. in mathematics or closely related area by August 1, 2013. Competitive applicants will have research that complements our Ph.D. program in computational mathematics. Preference will be given to candidates in mathematical biology and computational PDEs. Excellence in both teaching and research is expected.

Application materials should be submitted electronically to http://www.mathjobs.org. Review of applications will begin on December 15, 2012, and will be continued until filled.

UNIVERSITY OF TEXAS AT SAN ANTONIO
(UTSA)
Assistant Professor
Mathematics

The University of Texas at San Antonio (UTSA) invites applications for one tenure-track position at the rank of Assistant Professor in Mathematics starting in Fall 2013. The successful candidate will be expected to have Ph.D. degree in mathematics by the time of appointment, strong research record, and demonstrated evidence of excellent teaching ability. Information on the mathematics program, the full version of this job announcement, and details on what to include in an application can be viewed at http://math.utsa.edu. This position is pending budget approval. Applicants who are selected for interviews must be able to show proof that they will be eligible and qualified to work in the United States by time of hire. UTSA is an Affirmative Action/Equal Employment Opportunity Employer.

TEXAS
TEXAS TECH UNIVERSITY
Department of Mathematics and Statistics

The Department of Mathematics and Statistics at Texas Tech University (M&S) invites applications for three tenure-track assistant professor positions beginning fall 2013. A Ph.D. degree at the time of appointment is required. M&S has active research groups in both pure and applied mathematics (see http://www.math.ttu.edu/FacultyStaff/research). The department fosters a spirit of interdisciplinary collaboration across areas of mathematics as well as with engineering and the physical and biological sciences. M&S is seeking candidates who will be engaged in nationally visible scholarship, establish externally-funded research programs, interact with the existing research groups in the department, involve graduate students in their research, and show excellence in teaching at the undergraduate and graduate levels.

It is anticipated that one of the positions will be in statistics, one in numerical analysis, and one in another area compatible with the department’s existing research programs. Candidates with very strong records who will bring externally sponsored research to Texas Tech will be considered for associate or full professor ranks.

Please apply for position numbers T96800 for Statistics, T96232 for Numerical Analysis, and T96376 for all other areas, at http://jobs.texastech.edu. Include a completed AMS standard cover sheet and a vita.

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

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

Review of applications will begin immediately.

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

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

VIRGINIA
UNIVERSITY OF VIRGINIA
Department of Mathematics
Pitts Instructorship

The Department of Mathematics at the University of Virginia invites applications for a Pitts Instructorship beginning August 25, 2013. This position carries a three-year appointment. Candidates whose research interests fit in with the strengths of the department’s faculty are encouraged to apply. Preference will be given to candidates who have received their Ph.D. within the last three years. Candidates must have a Ph.D. by the time of appointment, an outstanding research record, and demonstrated teaching success. Information about the department may be found at: http://artsandsciences.virginia.edu/mathematics/index.html

Applications should be received by January 15, 2013, to receive full consideration; however posting will remain open until filled. Early application is recommended.

To apply, submit the following required documents electronically through http://www.mathjobs.org: A cover letter, an AMS Standard Cover Sheet, a curriculum vitae, a publication list, a description of research, and a statement about teaching interests and experience. The applicant must also have four letters of recommendation submitted, of which one must support the applicant’s effectiveness as a teacher.

In addition, all candidates are required to complete a Candidate Profile through the University of Virginia’s employment system, which is Jobs@UVA (https://jobs.virginia.edu). Search for posting number 0611032 and follow the directions for applying to this posting to submit CV with a publication list, statement of research interest, and statement of teaching philosophy.

Questions regarding the application process for Jobs@UVA should be directed to: zk4g@virginia.edu.

For additional information about the position contact: mathematics-hiring@virginia.edu.

The university will perform background checks on all new faculty hires prior to making a final offer of employment.

The University of Virginia is an Equal Opportunity/Affirmative Action Employer. Women, minorities, veterans, and persons with disabilities are encouraged to apply.

NOTICES OF THE AMS

DECEMBER 2012
The Department of Mathematics is accepting applications to fill one position for a Faculty Associate, beginning August 26, 2013. A successful candidate will demonstrate strong qualifications in mathematics and mathematics education. A master's degree in mathematics or math education is required; preference will be given to a Ph.D. Experience with mathematics courses for pre-service and/or in-service teachers is also preferred. Duties include teaching 4 courses per year and updating courses for elementary education and special education majors. Additional information regarding this position can be found at the UW job site http://www.ahr.wisc.edu/weblisting/Unclassified/PVLSummary.aspx?pvlnum=74671.

An application packet should include a cover letter, a curriculum vitae, a statement of mathematics teaching philosophy and a detailed history of Mathematics/ Mathematics Education courses taught. Application packets should be submitted electronically to http://www.mathjobs.org. Applicants should also arrange to have three to four letters of recommendation sent to mathjobs.org. To ensure full consideration, completed application packets must be received by January 2, 2013. The Department of Mathematics is committed to increasing the number of women and minority faculty. The University of Wisconsin-Madison is an Affirmative Action, Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding applicants and nominees must be released upon request. Finalists cannot be guaranteed confidentiality. A background check may be required prior to employment. For more info about the UW Mathematics Department please see our website http://www.math.wisc.edu.

Applications are invited for appointment as Postdoctoral Fellow (2-3 posts) in the Department of Mathematics, from September 1, 2013, or as soon as possible thereafter, on a two-year term and with the possibility of renewal. An earlier start date can be discussed if a successful candidate finds it desirable. Applicants should possess a Ph.D. degree. Preference will be given to those who have obtained their Ph.D. degrees within the last 6 years and whose areas of expertise fall within the following areas of concentration: algebra and number theory; geometry and Lie groups; optimization, theoretical computer science and information theory; several complex variables and complex geometry; and probability theory, stochastics and mathematical finance. They are expected to show strong potential in mathematical research. The appointees will be associated with the Institute of Mathematical Research (IMR, http://http://www0.imr.hk.math/) and will be primarily engaged in mathematical research. They will also take active roles in the activities of IMR and contribute to the academic activities as assigned by the Head of the Department of Mathematics.

A highly competitive salary commensurate with qualifications and experience will be offered. Annual leave and medical benefits will be provided.

Applicants should send a completed application form, together with a C.V. containing information on educational experience, including the title of the thesis and the name of the thesis supervisor, a list of publications, a survey of past research experience, a description of current research interests and a research plan for the next few years by e-mail to mrapostdoc@maths.hku.hk. Please indicate clearly Ref.: 201200919 and (Post-doctoral Fellow (2-3 posts) in the Department of Mathematics) in the subject of the email. Application forms (341/1111) can be obtained at http://www.hku.hk/aptunit/form-ext.doc. Further particulars can be obtained at http://jobs.hku.hk/. Closes January 31, 2013.

The University thanks applicants for their interest, but advises that only shortlisted applicants will be notified of the application result.

The University is an Equal Opportunity Employer and is committed to a No-Smoking Policy.

SINGAPORE

NATIONAL UNIVERSITY OF SINGAPORE (NUS)
Department of Mathematics

Applications are invited for appointment as Postdoctoral Fellow (2-3 posts) in the Department of Mathematics at the National University of Singapore (NUS). NUS invites applications for tenured, tenure-track and visiting positions at all levels, beginning in August 2013.

NUS is a research intensive university that provides quality undergraduate and graduate education. The Department of Mathematics has about 65 faculty members and teaching staff whose expertise covers major areas of contemporary mathematical research.

We seek promising scholars and established mathematicians with outstanding track records in any field of pure and applied mathematics. The department, housed in a newly renovated building equipped with state-of-the-art facilities, offers internationally competitive salary with start-up research grants, as well as an environment conducive to active research, with ample opportunities for career development. The teaching load for junior faculty is kept especially light.

The department is particularly interested in, but not restricted to, considering applicants specializing in any of the following areas:

- Analysis and Ergodic Theory
- Number Theory, Arithmetic Geometry
- Computational Science, especially Biomedical Imaging and Computational Material Sciences
- Probability, Stochastic Processes, and Financial Mathematics
- Combinatorics and Discrete Mathematics

Application materials should be sent to the Search Committee via email (as PDF files): search@math.nus.edu.sg.

Please include the following supporting documentation in the application:
1. an American Mathematical Society Standard Cover Sheet;
2. a detailed CV including publications list;
3. a statement (max. of 3 pages) of research accomplishments and plan;
4. a statement (max. of 2 pages) of teaching philosophy and methodology. Please attach evaluation on teaching from faculty members or students of your current institution, where applicable;
5. at least three letters of recommendation including one which indicates the candidate’s effectiveness and commitment in teaching.

Please ask your referees to send their letters directly to search@math.nus.edu.sg.

Enquiries may also be sent to this email address. Review process will begin on 15 October, and will continue until positions are filled.

For further information about the department, please visit http://www.math.nus.edu.sg.
The American Association for the Advancement of Science (AAAS), founded in 1848, is the world’s largest general scientific society, with over 120,000 individual and institutional members. The AAAS is divided into twenty-four disciplinary-based sections, including Section A (Mathematics). The 2013 annual meeting of the AAAS will be held in Boston on February 14–28. The theme of this year’s meeting is “The Beauty and Benefits of Science”, and this year’s meeting features sessions that are part of Mathematics of Planet Earth 2013 (mpe2013.org).

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

- Understanding and Communicating Uncertainty in Climate Change Science, organized by Richard L. Smith, University of North Carolina. (MPE 2013 symposium; scheduled speakers: Murali Haran, Leonard Smith, and Mark Berliner.)
- Compressive Sensing: Sensing Sparse Phenomena in Theory and Practice, organized by Mark Davenport, Stanford University. (Scheduled speakers: Mark Davenport, Justin Romberg, Dave Brady, Anna Gilbert, and Rachel Ward.)
- Multi-scale Study of Cancer, organized by Mark Alber, University of Notre Dame and Jill Mesirov, the Broad Institute of Harvard and MIT. (Scheduled speakers: Martin Nowak, Kathleen Wilkie, and Philip Maini.)

Other symposia that will be of interest to the mathematical community include:

- Understanding and Communicating Uncertainty in Climate Change Science, organized by Richard L. Smith, University of North Carolina. (MPE 2013 symposium; scheduled speakers: Murali Haran, Leonard Smith, and Mark Berliner.)
- Compressive Sensing: Sensing Sparse Phenomena in Theory and Practice, organized by Mark Davenport, Stanford University. (Scheduled speakers: Mark Davenport, Justin Romberg, Dave Brady, Anna Gilbert, and Rachel Ward.)
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The above symposia are only a few of the more than 150 AAAS symposia this year in the physical, life, social, and biological sciences. For further information, including the schedule of talks, go to www.aaas.org/meetings. Section A acknowledges the generous contributions of the American Mathematical Society for travel support for speakers this year.

The AAAS Annual Meeting is the showcase of American science, and the AAAS seeks the active participation by mathematicians and mathematics educators. Looking ahead, the AAAS Program Committee is genuinely interested in offering symposia each year on topics in pure and applied mathematics. For example, in recent years there have been symposia on subjects such as the collective behavior of animals and people, the mathematics of medical imaging, quantum computing, and the changing nature of mathematical proof.

The 2014 meeting will be February 13–17, 2014 in Chicago, and the Steering Committee for Section A seeks organizers and speakers who can present substantial new material in an accessible manner to a large scientific audience. All are invited to attend the Section A Committee business meeting in Boston on Friday, February 15, 2013, at 7:00 PM, where we will brainstorm ideas for symposia. In addition, I invite you to send me, and encourage your colleagues to send me, ideas for future AAAS annual meeting symposia.

The following are the members of the Steering Committee for Section A from February 2012 to February 2013:

**Chair:** Jill Mesirov (Broad Institute of MIT and Harvard)
**Chair-Elect:** Juan Meza (University of California, Merced)
**Retiring Chair:** John H. Ewing (Math for America)
**Secretary:** Edward Aboufadel (Grand Valley State University)
**Members at Large:**
- Tony Chan (Hong Kong University of Science and Technology)
- Mary Ellen Bock (Purdue University)
- Joceline Lega (University of Arizona)
- Sheldon Katz (University of Illinois, Urbana-Champaign)

—Edward Aboufadel, Secretary of Section A of the AAAS
aboufade@gvsu.edu
Meetings & Conferences of the AMS

San Diego, California
San Diego Convention Center and San Diego Marriott Hotel and Marina
January 9–12, 2013
Wednesday – Saturday
Meeting #1086
Joint Mathematics Meetings, including the 119th Annual Meeting of the AMS, 96th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of Notices: October 2012
Program first available on AMS website: November 1, 2012
Program issue of electronic Notices: January 2012
Issue of Abstracts: Volume 34, Issue 1

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Oxford, Mississippi
University of Mississippi
March 1–3, 2013
Friday – Sunday
Meeting #1087
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: December 2012
Program first available on AMS website: December 13, 2012
Program issue of electronic Notices: March 2013
Issue of Abstracts: Volume 34, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: December 4, 2012

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses
Patricia Hersh, North Carolina State University, An interplay of combinatorics with topology.
Daniel Krashen, University of Georgia, Topology, arithmetic, and the structure of algebraic groups.
Washington Mio, Florida State University, Taming shapes and understanding their variation.
Slawomir Solecki, University of Illinois at Urbana-Champaign, An abstract approach to Ramsey theory with applications.

Special Sessions
Algebraic Combinatorics (Code: SS 1A), Patricia Hersh, North Carolina State University, and Dennis Stanton, University of Minnesota.
Approximation Theory and Orthogonal Polynomials (Code: SS 5A), David Benko, University of South Alabama, Erwin Mina-Diaz, University of Mississippi, and Edward Saff, Vanderbilt University.
Banach Spaces and Operators on Them (Code: SS 4A), Qingying Bu and Gerard Buskes, University of Mississippi, and William B. Johnson, Texas A&M University.
Commutative Algebra (Code: SS 3A), Sean Sather-Wagstaff, North Dakota State University, and Sandra M. Spirito, University of Mississippi.
Connections between Matroids, Graphs, and Geometry (Code: SS 10A), Stan Dziobiak, Talmage James Reid, and Haidong Wu, University of Mississippi.

Dynamical Systems (Code: SS 8A), Alexander Grigo, University of Oklahoma, and Sasa Kocic, University of Mississippi.

Fractal Geometry and Ergodic Theory (Code: SS 2A), Manav Das, University of Louisville, and Mrinal Kanti Roychowdhury, University of Texas-Pan American.

Graph Theory (Code: SS 7A), Laura Sheppardson and Bing Wei, University of Mississippi, and Hehui Wu, McGill University.

Homology and Cohomology of Arithmetic Groups (Code: SS 11A), Avner Ash, Boston College, Darrin Douc, Brigham Young University, and David Pollack, Wesleyan University.

Modern Methods in Analytic Number Theory (Code: SS 6A), Nathan Jones and Micah B. Milinovich, University of Mississippi, and Frank Thorne, University of South Carolina.

Set Theory and Its Applications (Code: SS 9A), Christian Rosendal, University of Illinois at Chicago, and Slawomir Solecki, University of Illinois at Urbana-Champaign.

Session for Contributed Talks

There will also be a session for 10-minute contributed talks. Please see the abstracts submission form at http://www.ams.org/cgi-bin/abstracts/abstract.pl. The deadline for all submissions is December 4, 2012.

Accommodations

Participants should make their own arrangements directly with the properties listed below. Special rates for the meeting have been negotiated and are available at the properties shown below for the period of February 28–March 3, 2013, except where noted. When making reservations participants should state that they are with the American Mathematical Society meeting on campus. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation. The deadline for reservations is February 14, 2013.

University Inn Oxford, 1101 Bickerstaff Dr., Oxford, MS 38655; phone: 662-234-9500; fax: 662-234-9330. US$70 for single/double (note that no rooms are available at this rate on Thursday night, March 28). Rooms are equipped with a coffee maker, microwave, and refrigerator. Rates include complimentary hot/cold breakfast buffet, free wired/wireless Internet access. There are several popular restaurants within a mile or so. Distance to the meeting site is 1.6 miles. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation. The deadline for reservations is February 8, 2013.

Super 8 Oxford, 2201 Jackson Ave., West, Oxford, MS 38655; phone: 662-234-7013; fax: 662-236-4378. US$72.99 for single/double. Rooms are equipped with refrigerators, microwaves, and coffee makers. Rates include complimentary continental breakfast with some hot items, free high-speed wireless, heated outdoor pool, and on-site fitness room. University Mall is across the street; a variety of restaurants and cocktail lounges are within easy walking distance. Distance to the meeting site is 1.5 mi. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation. The deadline for reservations is February 7, 2012.

Other options for accommodations: For other types of accommodations, please see the website maintained by the Oxford Convention and Visitors Bureau at www.oxfordcvb.com/lodging.html.

Dining on Campus

There are a number of dining options in the Student Union Food Court, open 7:00 a.m. to 9:00 p.m. on Friday, and 10:00 a.m. to 8:00 p.m. on Saturday and Sunday. There are many other options if one walks about 1/2 mile west on University Ave. out to N. Lamar Blvd.

Local Information and Maps

The University of Mississippi Department of Mathematics website is found at www.olemiss.edu/depts/mathematics/. A campus map is found at www.olemiss.edu; click on “MAP” in the links references at the top of the page.

Other Activities

AMS Book Sale: Stop by the on-site AMS bookstore and review the newest titles from the AMS, enjoy up to 25% off all AMS publications, or take home an AMS t-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

Please watch the AMS website at http://www.ams.org/meetings/sectional/sectional.html and follow
this link for this meeting for information on regulations, fees, and locations to park near the buildings where sessions will be held.

**Registration and Meeting Information**

The meeting will take place on the campus of the University of Mississippi. Registration will be conducted in Hume Hall (also the location of the Department of Mathematics) and sessions will be held in Hume Hall, The Ole Miss Union, and Fulton Chapel. The registration desk will be open Friday, 1:00 p.m.—5:00 p.m., and Saturday, 7:30 a.m.—4:00 p.m. Fees are US$53 for AMS members, US$74 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on-site by cash, check, or credit card.

**Travel Information**

The Oxford Convention and Visitors Bureau website includes a wealth of information about the Oxford area, including maps, a restaurant guide, and a wealth of information about the sites to see. The area may be best known as the home of Nobel Prize winning author William Faulkner. Successful author John Grisham also has a home in Oxford.

The nearest large airport is Memphis International Airport (MEM) 2491 Winchester Road Suite 113 Memphis, TN 38116-3856; (901) 922-8000. The airport is about 75 miles north of Oxford, about a 1 1/4 hour drive. There are no shuttles to the campus; cab fare would be US $182.50 each way (fixed rate).

**Getting to the campus by car:**

From Memphis, TN (north of campus): Take I-55 south for 63 miles, then take the Batesville/Oxford exit. Merge onto MS-6 and proceed east toward Oxford for 26 miles. When you reach Oxford, take the second exit, Coliseum Drive, onto campus. Or, take US-78 for 52 miles and exit at Holly Springs/Oxford and merge onto MS-7 south for 31 miles. Once in Oxford take the 4th exit onto MS-6 and proceed west. Take the 3rd exit, Coliseum Drive, onto campus.

From Jackson, MS (south of campus): Take I-55 north for 150 miles, then take the Batesville/Oxford exit and follow as described above.

From Tupelo, MS (east of campus): Take MS-6 west for 53 miles, then take the 6th exit, Coliseum Drive, onto campus.

**Car Rental**

Hertz is the official car rental company for the meeting. To make a reservation accessing our special meeting rates online at www.hertz.com, click on the box “I have a discount”, and type in our convention number (CV): 04N30003. You can also call Hertz directly at 800-654-2240 (U.S. and Canada) or 405-749-4434 (other countries). At the time this announcement was prepared, rates were US$28.49 to US$71.49 per day on the weekend. At the time of your reservation, the meeting rates will be automatically compared to other Hertz rates and you will be quoted the best comparable rate available.

**Weather**

Early March weather can be quite variable with temperatures ranging from the high 50s into the 80s, so dressing in layers is advised. Passing showers are a possibility.

**Information for International Participants**

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at http://sites.nationalacademies.org/pga/visas/ and http://travel.state.gov/visa/visa_1750.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to dls@ams.org.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of “binding” or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:
  - family ties in home country or country of legal permanent residence
  - property ownership
  - bank accounts
  - employment contract or statement from employer stating that the position will continue when the employee returns;
* Visa applications are more likely to be successful if done in a visitor’s home country than in a third country;
* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;
* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;
* If travel plans will depend on early approval of the visa application, specify this at the time of the application;
* Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the websites above for the most up-to-date information.
Chestnut Hill, Massachusetts

Boston College

April 6–7, 2013  
Saturday – Sunday

Meeting #1088  
Eastern Section

Associate secretary: Steven H. Weintraub

Announcement issue of Notices: January 2013  
Program first available on AMS website: February 21, 2013  
Program issue of electronic Notices: April 2013  
Issue of Abstracts: Volume 34, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 18, 2012  
For abstracts: February 12, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Roman Bezrukavnikov, Massachusetts Institute of Technology, Title to be announced.

Marston Conder, University of Auckland, Title to be announced.

Alice Guionnet, Ecole Normale Supérieure de Lyon, Title to be announced.

Yanir Rubinstein, Stanford University, Title to be announced.

Special Sessions

Algebraic and Geometric Structures of 3-manifolds (Code: SS 3A), Ian Biringer, Tao Li, and Robert Meyerhoff, Boston College.

Algorithmic Problems of Group Theory and Applications to Information Security (Code: SS 14A), Delaram Kahrobaei, City University of New York Graduate Center and New York College of Technology, and Vladimir Shpilrain, City College of New York and City University of New York Graduate Center.

Arithmetic Dynamics and Galois Theory (Code: SS 6A), John Cullinan, Bard College, and Farshid Hajir and Siman Wong, University of Massachusetts, Amherst.

Combinatorics and Classical Integrability (Code: SS 16A), Amanda Redlich and Shabnam Beheshti, Rutgers University.

Commuting Matrices and the Hilbert Scheme (Code: SS 11A), Anthony Iarrobino, Northeastern University, and Leila Khatami, Union College.


Counting and Equidistribution on Symmetric Spaces (Code: SS 5A), Dubi Kelmer, Boston College, and Alex Kontorovich, Yale University.

Discrete Geometry of Polytopes (Code: SS 10A), Barry Monson, University of New Brunswick, and Egon Schulte, Northeastern University.


History and Philosophy of Mathematics (Code: SS 7A), James J. Tattersall, Providence College, and V. Frederick Rickey, United States Military Academy.

Homological Invariants in Low-dimensional Topology. (Code: SS 1A), John Baldwin, Joshua Greene, and Eli Grigsby, Boston College.

Homology and Cohomology of Arithmetic Groups (Code: SS 13A), Avner Ash, Boston College, Darrin Doud, Brigham Young University, and David Pollack, Wesleyan University.

Hopf Algebras and their Applications (Code: SS 9A), Timothy Kohl, Boston University, and Robert Underwood, Auburn University Montgomery.

Moduli Spaces in Algebraic Geometry (Code: SS 4A), Dawei Chen and Maksym Fedorchuk, Boston College, and Joe Harris and Yu-Jong Tzeng, Harvard University.

Real and Complex Dynamics of Difference Equations with Applications (Code: SS 12A), Ann Brett, Johnson and Wales University, and M. R. S. Kulenovic, University of Rhode Island.

Recursion and Definability (Code: SS 15A), Rachel Epstein, Harvard University, Karen Lange, Wellesley College, and Russell Miller, Queens College and City University of New York Graduate Center.

Research by Undergraduates and Students in Post-Baccalaureate Programs (Code: SS 8A), Chi-Keung Cheung, Boston College, David Damiano, College of the Holy Cross, Steven J. Miller, Williams College, and Suzanne L. Weekes, Worcester Polytechnic Institute.

Topology and Generalized Cohomologies in Modern Condensed Matter Physics (Code: SS 17A), Claudio Chamon and Robert Kotiuga, Boston University.

Boulder, Colorado

University of Colorado Boulder

April 13–14, 2013  
Saturday – Sunday

Meeting #1089  
Western Section

Associate secretary: Michel L. Lapidus

Announcement issue of Notices: January 2013  
Program first available on AMS website: February 28, 2013  
Program issue of electronic Notices: April 2013  
Issue of Abstracts: Volume 34, Issue 2
Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: December 26, 2012
For abstracts: February 19, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses
Gunnar Carlsson, Stanford University, Title to be announced.
Jesus A. De Loera, University of California, Davis, Title to be announced.
Brendan Hassett, Rice University, Title to be announced.
Raphael Rouquier, University of California Los Angeles, Title to be announced.

Special Sessions
Advances in Mathematical Biology (Code: SS 16A), Liming Wang, California State University, Los Angeles, and Jiongguo Liu, Colorado State University.

Algebraic Geometry (Code: SS 14A), Sebastian Casalaina-Martin, University of Colorado, Renzo Cavalieri, Colorado State University, Brendan Hassett, Rice University, and Jonathan Wise, University of Colorado.

Algebras, Lattices and Varieties (Code: SS 5A), Keith A. Kearnes and Ágnes Szendrei, University of Colorado, Boulder.

Analysis of Dynamics of the Incompressible Fluids (Code: SS 18A), Mimi Dai and Congming Li, University of Colorado, Boulder.

Arithmetic Statistics and Big Monodromy (Code: SS 23A), Jeff Achter, Colorado State University, and Chris Hall, University of Wyoming.

Associative Rings and Their Modules (Code: SS 1A), Greg Oman and Zaki Mesyan, University of Colorado, Colorado Springs.

Cluster Algebras and Related Combinatorics (Code: SS 6A), Greg Musiker, University of Minnesota, Kyungyong Lee, Wayne State University, and Li Li, Oakland University.

Combinatorial Avenues in Representation Theory (Code: SS 21A), Richard Green, University of Colorado Boulder, Anne Shepler, University of North Texas, and Nathaniel Thiem, University of Colorado Boulder.

Combinatorial and Computational Commutative Algebra and Algebraic Geometry (Code: SS 7A), Hirotachi Abo, University of Idaho, Zach Teitler, Boise State University, and Alexander Woo, University of Idaho.

Diophantine Approximation on Manifolds and Fractals: Dynamics, Measure Theory and Schmidt Games (Code: SS 15A), Wolfgang Schmidt, University of Colorado at Boulder, and Lior Fishman, University of North Texas.

Dynamical Systems: Thermodynamic Formalism and Connections with Geometry (Code: SS 10A), Keith Burns, Northwestern University, and Dan Thompson, The Ohio State University.

Dynamics and Arithmetic Geometry (Code: SS 2A), Sujion Ih, University of Colorado at Boulder, and Thomas J. Tucker, University of Rochester.

Elliptic Systems and Their Applications (Code: SS 20A), Wenxiong Chen, Yeshiva University, and Congming Li, University of Colorado at Boulder.

Extremal Graph Theory (Code: SS 3A), Michael Ferrara, University of Colorado Denver, Stephen Hartke, University of Nebraska-Lincoln, and Michael Jacobson, University of Colorado Denver.

Foundations of Computational Mathematics (Code: SS 13A), Susan Margulies, Pennsylvania State University, and Jesus De Loera, University of California, Davis.


Harmonic Analysis of Frames, Wavelets, and Tilings (Code: SS 12A), Veronika Furst, Fort Lewis College, Keri Kornelson, University of Oklahoma, and Eric Weber, Iowa State University.

Noncommutative Geometry and Geometric Analysis (Code: SS 22A), Carla Farsi and Alexander Gorokhovsky, University of Colorado, Boulder.


Number Theory with a Focus on Diophantine Equations and Recurrence Sequences (Code: SS 8A), Patrick Ingram, Colorado State University, and Katherine E. Stange, University of Colorado, Boulder.

Set Theory and Boolean Algebras (Code: SS 17A), Natasha Dobrinen, University of Denver, and Don Monk, University of Colorado, Boulder.

Singular Spaces in Geometry, Topology, and Algebra (Code: SS 11A), Greg Friedman, Texas Christian University, and Laurentiu Maxim, University of Wisconsin, Madison.

Themes in Applied Mathematics: From Data Analysis through Fluid Flows and Biology to Topology (Code: SS 4A), Hanna Makaruk, Los Alamos National Laboratory, and Robert Owczarek, University of New Mexico, and Enfitek, Inc.

Ames, Iowa

Iowa State University

April 27–28, 2013
Saturday - Sunday

Meeting #1090
Central Section

Associate secretary: Georgia Benkart
Announcement issue of Notices: February 2013
Program first available on AMS website: March 14, 2013
Program issue of electronic Notices: April 2013
Issue of Abstracts: Volume 34, Issue 2

Deadlines
For organizers: Expired
For consideration of contributed papers in Special Sessions: January 18, 2013
For abstracts: March 5, 2013

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses
Kevin Costello, Northwestern University, Title to be announced.
Marianne Csonkeyei, University of Chicago, Title to be announced.
Vladimir Markovic, California Institute of Technology, Title to be announced.
Eitan Tadmor, University of Maryland, Title to be announced.

Special Sessions
Algebraic and Geometric Combinatorics (Code: SS 4A), Sung Y. Song, Iowa State University, and Paul Terwilliger, University of Wisconsin-Madison.
Analysis, Dynamics and Geometry In and Around Teichmüller Spaces (Code: SS 17A), Alistair Fletcher, Northern Illinois University, Vladimir Markovic, California Institute of Technology, and Dragomir Saric, Queens College CUNY.
Commutative Algebra and its Environments (Code: SS 6A), Olgu Celikbas and Greg Piepmeyer, University of Missouri, Columbia.
Commutative Ring Theory (Code: SS 8A), Michael Axtell, University of St. Thomas, and Joe Stickles, Millikin University.
Computational Advances on Special Functions and Tropical Geometry (Code: SS 14A), Lubjana Beskaj, Oakland University, and Emma Previato, Boston University.
Control Theory and Qualitative Analysis of Partial Differential Equations (Code: SS 16A), George Avalos, University of Nebraska-Lincoln, and Scott Hansen, Iowa State University.
Discrete Methods and Models in Mathematical Biology (Code: SS 18A), Dora Matache, University of Nebraska-Omaha, and Stephen J. Willson, Iowa State University.
Extremal Combinatorics (Code: SS 7A), Steve Butler and Ryan Martin, Iowa State University.
Generalizations of Nonnegative Matrices and Their Sign Patterns (Code: SS 3A), Minerva Catral, Xavier University, Shaun Fallat, University of Regina, and Pauline van den Driessche, University of Victoria.
Geometric Elliptic and Parabolic Partial Differential Equations (Code: SS 13A), Brett Kotschwar, Arizona State University, and Xuan Hien Nguyen, Iowa State University.
Logic and Algebraic Logic (Code: SS 9A), Jeremy Alm, Illinois College, and Andrew Ylvisaker, Iowa State University.
Multi-Dimensional Dynamical Systems (Code: SS 15A), Jayadev Athreya, University of Illinois at Chicago, Jonathan Chaika, University of Chicago, and Joseph Rosenblatt, University of Illinois at Urbana-Champaign.
Numerical Analysis and Scientific Computing (Code: SS 20A), Haifang Liu, Songting Luo, James Rossmanith, and Jue Yan, Iowa State University.
Numerical Methods for Geometric Partial Differential Equations (Code: SS 22A), Gerard Awanou, University of Illinois at Chicago, and Nicolae Tofulea, Purdue University.
Operator Algebras and Topological Dynamics (Code: SS 1A), Benton L. Duncan, North Dakota State University, and Justin R. Peters, Iowa State University.
Partial Differential Equations (Code: SS 12A), Gary Lieberman and Paul Sacks, Iowa State University, and Mahamadi Warma, University of Puerto Rico at Rio Piedras.
Probabilistic and Multiscale Modeling Approaches in Cell and Systems Biology (Code: SS 19A), Jasmine Foo, University of Minnesota, and Anastasios Matzavinov, Iowa State University.
Quasigroups, Loops, and Nonassociative Division Algebras (Code: SS 21A), C. E. Ealy Jr., Western Michigan University, Annegret Paul, Western Michigan University, Benjamin Phillips, University of Michigan Dearborn, J. D. Phillips, Northern Michigan University, and Petr Vojtechovsky, University of Denver.
Ring Theory and Noncommutative Algebra (Code: SS 24A), Victor Camillo, University of Iowa, and Miodrag C. Iovanov, University of Bucharest and University of Iowa.
Stochastic Processes with Applications to Physics and Control (Code: SS 10A), Jim Evans and Arka Ghosh, Iowa State University, Jon Peterson, Purdue University, and Alexander Roitershtein, Iowa State University.
Topology of 3-Manifolds (Code: SS 23A), Marion Campisi and Alexander Zupan, University of Texas at Austin.
Zero Forcing, Maximum Nullity/Minimum Rank, and Colin de Verdiere Graph Parameters (Code: SS 2A), Leslie Hogben, Iowa State University and American Institute of Mathematics, and Bryan Shader, University of Wyoming.

Alba Iulia, Romania
June 27–30, 2013
Thursday – Sunday

Meeting #1091
First Joint International Meeting of the AMS and the Romanian Mathematical Society, in partnership with the “Simion Stoilow” Institute of Mathematics of the Romanian Academy.
Associate secretary: Steven H. Weintraub
Announcement issue of Notices: January 2013
Program first available on AMS website: Not applicable
Program issue of electronic Notices: Not applicable
Issue of Abstracts: Not applicable
Meetings & Conferences

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses
Viorel Barbu, Universitatea Cuza, Title to be announced.
Sergiu Klainerman, Princeton University, Title to be announced.
George Lusztig, Massachusetts Institute of Technology, Title to be announced.
Sergiu Klainerman, Princeton University, Title to be announced.
Dan Timotin, Institute of Mathematics of the Romanian Academy of Sciences, Title to be announced.
Srinivasa Varadhan, New York University, Title to be announced.

Louisville, Kentucky
University of Louisville
October 5–6, 2013
Saturday – Sunday
Meeting #1092
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: June 2013
Program first available on AMS website: August 22, 2013
Program issue of electronic Notices: October 2013
Issue of Abstracts: Volume 33, Issue 3

Deadlines
For organizers: March 5, 2013
For consideration of contributed papers in Special Sessions: June 18, 2013
For abstracts: August 13, 2013

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, Title to be announced.
Suzanne Lenhart, University of Tennessee, Title to be announced.
Ralph McKenzie, Vanderbilt University, Title to be announced.
Victor Moll, Tulane University, Title to be announced.

Special Sessions
Set Theory and Its Applications (Code: SS 1A), Paul Larson, Miami University, Justin Moore, Cornell University, and Grigor Sargsyan, Rutgers University.

Philadelphia, Pennsylvania
Temple University
October 12–13, 2013
Saturday – Sunday
Meeting #1093
Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of Notices: June 2013
Program first available on AMS website: To be announced
Program issue of electronic Notices: October 2013
Issue of Abstracts: Volume 33, Issue 3

Deadlines
For organizers: March 12, 2013
For consideration of contributed papers in Special Sessions: June 25, 2013
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 Brosnan, University of Maryland, Title to be announced.
Xiaojung Huang, Rutgers University, Title to be announced.
Barry Mazur, Harvard University, Title to be announced (Erdoes Memorial Lecture).
Robert Strain, University of Pennsylvania, Title to be announced.

Special Sessions
Contact and Symplectic Topology (Code: SS 5A), Joshua M. Sabloff, Haverford College, and Lisa Traynor, Bryn Mawr College.
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.
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.

St. Louis, Missouri
Washington University

October 18–20, 2013
Friday – Sunday

Meeting #1094
Central Section
Associate secretary: Georgia 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 33, Issue 4

Deadlines
For organizers: March 20, 2013
For consideration of contributed papers in Special Sessions: July 2, 2013
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
Algebraic and Combinatorial Invariants of Knots (Code: SS 1A), Heather Dye, McKendree University, Allison Henrich, Seattle University, and Louis Kauffman, University of Illinois.
Computability Across Mathematics (Code: SS 2A), Wesley Calvert, Southern Illinois University, and Johanna Franklin, University of Connecticut.

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 33, Issue 4

Deadlines
For organizers: April 2, 2013
For consideration of contributed papers in Special Sessions: July 15, 2013
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, California Institute of Technology, Title to be announced.

Baltimore, Maryland
Baltimore Convention Center, Hilton Baltimore, and Baltimore Marriott Inner Harbor Hotel at Camden Y

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 Benkart
Announcement issue of Notices: October 2013
Program first available on AMS website: November 1, 2013
Meetings & Conferences

Knoxville, Tennessee

University of Tennessee, Knoxville

March 21–23, 2014

Friday - Sunday
Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: April 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lubbock, Texas

Texas Tech University

April 11–13, 2014

Friday - Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: September 18, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Tel Aviv, Israel

Bar-Ilan University, Ramat-Gan and Tel-Aviv University, Ramat-Aviv

June 16–19, 2014

Monday – Thursday
The 2nd Joint International Meeting between the AMS and the Israel Mathematical Union.
Associate secretary: Michel L. Lapidus
Announcement issue of Notices: To be announced
Program first available on AMS website: To be announced
Program issue of electronic Notices: To be announced
Issue of Abstracts: To be announced

Deadlines
For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated.
For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

AMS 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.

Special Sessions

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.

Albuquerque, New Mexico

University of New Mexico

April 5–6, 2014

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: April 2014
Issue of Abstracts: To be announced

Deadlines
For organizers: September 5, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: February 11, 2014

The scientific information listed below may be dated.
For the latest information, see www.ams.org/amsmtgs/sectional.html.

AMS 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.

The scientific information listed below may be dated.
For the latest information, see www.ams.org/amsmtgs/internmtgs.html.
Eau Claire, Wisconsin

University of Wisconsin-Eau Claire

September 20–21, 2014

Saturday – Sunday

Central Section

Associate secretary: Georgia Benkart

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: February 20, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: August 5, 2014

Las Vegas, Nevada

University of Nevada, Las Vegas

April 18–19, 2015

Saturday – Sunday

Western Section

Announcement issue of Notices: October 2014
Program issue of electronic Notices: January 2015
Issue of Abstracts: Volume 36, Issue 1

Deadlines

For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

San Francisco State University

October 25–26, 2014

Saturday – Sunday

Western Section

Associate secretary: Michel L. Lapidus

Program first available on AMS website: To be announced
Program issue of electronic Notices: October 2014
Issue of Abstracts: To be announced

Deadlines

For organizers: March 25, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: September 3, 2014

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

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Porto, Portugal

University of Porto

June 11–14, 2015

Thursday – Sunday

First Joint International Meeting between the AMA and the Sociedade Portuguesa de Matemática.

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 consideration of contributed papers in Special Sessions: To be announced
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 consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California
San Diego Convention Center and San Diego Marriott Hotel and Marina

January 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: Matthew Miller
Announcement issue of Notices: October 2016
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 consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia
Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017
Wednesday – Saturday
Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of Notices: October 2016
Program first available on AMS website: To be announced
Program issue of electronic Notices: January 2017
Issue of Abstracts: Volume 38, Issue 1

Deadlines
For organizers: April 1, 2016
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland
Baltimore Convention Center, Hilton Baltimore, and Baltimore Marriott Inner Harbor Hotel at Camden Y

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 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 2, 2018
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
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Name __________________________________________ (please write name as you would like it to appear on your badge)

Mailing Address __________________________________________________________

Telephone __________________________ Fax: __________________________

In case of emergency (for you) at the meeting, call: Day #____________ Evening #____________

Email Address ___________________________________________________________

Affiliation for badge __________________________ Nonmathematician guest badge name: __________________________

I DO NOT want my program and badge to be mailed to me on 12/07/12. (Materials will be mailed to the address listed above unless you check this box.)

Registration Fees

Membership please ✓ that apply. First row is eligible to register as a JMM member.

AMS  ✓ MAA  ✓ ASL  ✓ CMS  ✓ SIAM
ASA  ✓ AWM  ✓ NAM  ✓ YMN

Joint Meetings by Dec 17 at mtg Subtotal

Member AMS, MAA, ASL, CMS, SIAM US$235 US$ 399
Nonmember US$367 US$ 476
Graduate Student (Mem. of AMS or MAA) US$ 52 US$ 62
Graduate Student (Nonmember) US$ 80 US$ 91
Undergraduate Student US$ 52 US$ 62
High School Student US$ 5 US$ 10
Unemployed US$ 52 US$ 62
Temporarily Employed US$191 US$ 220
Developing Countries Special Rate US$ 52 US$ 62
Emeritus Member of AMS or MAA US$ 52 US$ 62
High School Teacher US$ 52 US$ 62
Librarian US$ 52 US$ 62
Press US$ 0 US$ 0
Nonmathematician Guest US$ 15 US$ 15

AMS Short Course: Random Matrices (1/7–1/8)

Member of AMS or MAA US$104 US$ 138
Nonmember US$150 US$ 180
Student, Unemployed, Emeritus US$ 52 US$ 73

MAA Short Course: Conceptual Climate Models (1/7–1/8)

Member of MAA or AMS US$156 US$ 166
Nonmember US$225 US$ 235
Student, Unemployed, Emeritus US$ 78 US$ 88

MAA Minicourses (see listing in text)

I would like to attend: ✓ One Minicourse  ❏ Two Minicourses

Please enroll me in MAA Minicourse(s) #_______ and/or #_______

Price: US$80 for each minicourse.

(For more than 2 minicourses call or email the MMSB.) $________

Graduate School Fair

Graduate Program Table US$ 70 US$ 70

(includes table, posterboard & electricity) $________

Employment Center Please go to http://ams.org/profession/employment-services/employment-center to register.
For further information, contact Steve Ferrucci at emp-info@ams.org.

Events with Tickets

Graduate Student/First Time Attendee Reception (1/9) (no charge)

MER/IME Banquet (1/10) US$ 65 #  ❏ Chicken  #  ❏ Fish
#  ❏ Kosher  #  ❏ Vegan

NAM Banquet (1/11) US$ 62 #  ❏ Chicken  #  ❏ Fish
#  ❏ Kosher  #  ❏ Vegan

AMS 125th Anniversary Gala (1/12) US$ 62 #_______

(Additional fees may apply for Kosher meals.) $________

Payment

Registration & Event Total (total from column on left) $________
Hotel Deposit (only if paying by check) $________

Total Amount To Be Paid $________

(Note: A US$5 processing fee will be charged for each returned check or invalid credit card. Debit cards cannot be accepted.)

Method of Payment

☐ Check. Make checks payable to the AMS. Checks drawn on foreign banks must be in equivalent foreign currency at current exchange rates. For all check payments, please keep a copy of this form for your records.

☐ Credit Card. All major credit cards accepted. For your security, we do not accept credit card numbers by postal mail, email or fax. If the MMSB receives your registration form by fax or postal mail, we will contact you at the phone number provided on this form. For questions, contact the MMSB at mmsb@ams.org.

Signature: __________________________

☐ Purchase Order # _________ (please enclose copy)

Other Information

Mathematical Reviews field of interest #_______

How did you hear about this meeting? Check one:

Colleague(s)  ☐ Internet  ☐ Notices  ☐ Focus  ☐ Other #_______

This is my first Joint Mathematics Meetings.

I am a mathematics department chair.

For planning purposes for the MAA Two-year College Reception, please check if you are a faculty member at a two-year college.

I would like to receive promotions for future JMM meetings.

Please do not include my name on any promotional mailing lists.

Please ☐ this box if you have a disability requiring special services.

Mailing Address/Contact:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887
Fax: 401-455-4004. Email: mmsb@ams.org
Telephone: 401-455-4143 or 1-800-321-4267 x4143 or x4144

Deadlines

To be eligible for the complimentary room drawing:

For housing reservations, badges/programs mailed: Nov. 5, 2012
For housing changes/cancellations through MMSB: Nov. 19, 2012
For advance registration for the Joint Meetings, short courses, minicourses, and tickets: Dec. 10, 2012
For 50% refund on advance registration, minicourses & short courses, cancel by: Dec. 17, 2012
For 50% refund on banquet, cancel by: Dec. 27, 2012*
For 50% refund on advance registration, minicourses & short courses, cancel by: Jan. 04, 2013*

*no refunds issued after this date
### 2013 Joint Mathematics Meetings Hotel Reservations – San Diego, CA

(See the hotel page in the announcement or on the web for detailed information on each hotel.) To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc. in the column on the left and by circling the requested room type and rate. If the rate or the hotel requested is no longer available, you will be assigned a room at the next available comparable rate. Please call the MMSB for details on suite configurations, sizes, availability, etc. All reservations, including suite reservations, must be made through the MMSB to receive the JMM rates. Reservations made directly with the hotels before December 19 may be changed to a higher rate. All rates are subject to a 12.5% sales/occupancy tax. **Guarantee requirements:** First night deposit by check (add to payment on reverse of form) or a credit card guarantee.

- **Deposit enclosed (see front of form)**
- **Hold with my credit card. For your security, we do not accept credit card numbers by postal mail, email or fax.** If the MMSB receives your registration form by postal mail or fax, we will contact you at the phone number provided on the reverse of this form.

<table>
<thead>
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<th>Order of choice</th>
<th>Hotel</th>
<th>Single</th>
<th>Double 1 bed</th>
<th>Double 2 beds</th>
<th>Triple 2 beds</th>
<th>Triple 2 beds w/cot or queen w/ cot</th>
<th>Quad 2 beds</th>
<th>Quad 2 beds w/cot</th>
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<td>US$ 147</td>
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<td>US$ 167*</td>
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<td>(all suites)</td>
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<td>Residence Inn by Marriott Gaslamp District (2-bedroom suites, each bedroom has 1 queen bed; living room has a single sofa sleeper.) Limited quantity.</td>
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<td>US$239</td>
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**Special Housing Requests:**
- I have disabilities as defined by the ADA that require a sleeping room that is accessible to the physically challenged. My needs are: ____________________________

- Other requests: ____________________________

- I am a member of a hotel frequent-travel club and would like to receive appropriate credit. The hotel chain and card number are: ____________________________

**Only email confirmations will be sent by the hotels, if an email address is provided.**

If you are not making a reservation, please check one of the following:
- I plan to make a reservation at a later date.
- I will be making my own reservations at a hotel not listed. Name of hotel: ____________________________
- I live in the area or will be staying privately with family or friends.
- I plan to share a room with ____________________________, who is making the reservations.
Meetings and Conferences of the AMS

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Southeastern Section: Robert J. Daverman, Department of Mathematics, University of Tennessee, Knoxville, TN 37996-6900, e-mail: daverman@math.utk.edu; telephone: 865-974-6900.

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:

2013
January 9–12 San Diego, California p. 1614
Annual Meeting

March 1–3 Oxford, Mississippi p. 1614
April 6–7 Chestnut Hill, Massachusetts p. 1617
April 13–14 Boulder, Colorado p. 1617
April 27–28 Ames, Iowa p. 1618
June 27–30 Alba Iulia, Romania p. 1619
October 5–6 Louisville, Kentucky p. 1620
October 12–13 Philadelphia, Pennsylvania p. 1620
October 18–20 St. Louis, Missouri p. 1621
November 2–3 Riverside, California p. 1621

2014
January 15–18 Baltimore, Maryland p. 1621
Annual Meeting

March 21–23 Knoxville, Tennessee p. 1622
April 5–6 Albuquerque, New Mexico p. 1622
April 11–13 Lubbock, Texas p. 1622
June 16–19 Tel Aviv, Israel p. 1622
September 20–21 Eau Claire, Wisconsin p. 1623
October 25–26 San Francisco, California p. 1623

2015
January 10–13 San Antonio, Texas p. 1623
Annual Meeting
June 11–14 Porto, Portugal p. 1623

2016
January 6–9 Seattle, Washington p. 1624

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Annual Meeting

2018
January 10–13 San Diego, California p. 1624
Annual Meeting

2019
January 16–19 Baltimore, Maryland p. 1624
Annual Meeting

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 111 in the January 2012 issue of the Notices for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of \LaTeX{} is necessary to submit an electronic form, although those who use \LaTeX{} may submit abstracts with such coding, and all math displays and similarly coded material (such as accent marks in text) must be typeset in \LaTeX{}. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to absinfo@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.)

July 22–26, 2013: Samuel Eilenberg Centenary Conference (E100), Warsaw, Poland.
NEW TITLES IN MATHEMATICS from CAMBRIDGE UNIVERSITY PRESS!

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Mark Colyvan
Cambridge Introductions to Philosophy

Introduction to the Network Approximation Method for Materials Modeling
Leonid Berlyand, Alexander G. Kolpakov, and Alexei Novikov
Encyclopedia of Mathematics and its Applications

Topics in Structural Graph Theory
Edited by Lowell W. Beineke and Robin J. Wilson
Edited in consultation with Ortrud R. Oellermann
Encyclopedia of Mathematics and its Applications
$95.00: Hb: 978-0-521-80231-4: 344 pp.

Appalachian Set Theory 2006–2012
Edited by James Cummings and Ernest Schimmerling
London Mathematical Society Lecture Note Series
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