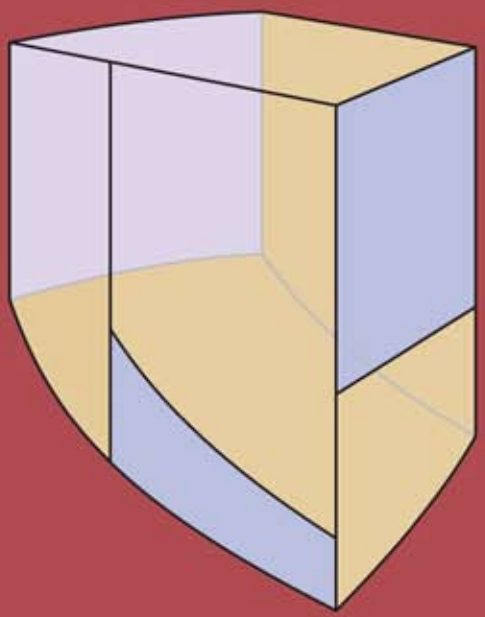
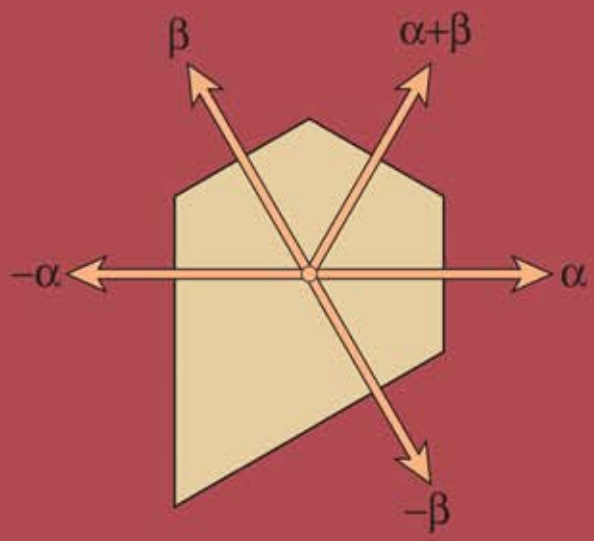
ISSN 0002-9920

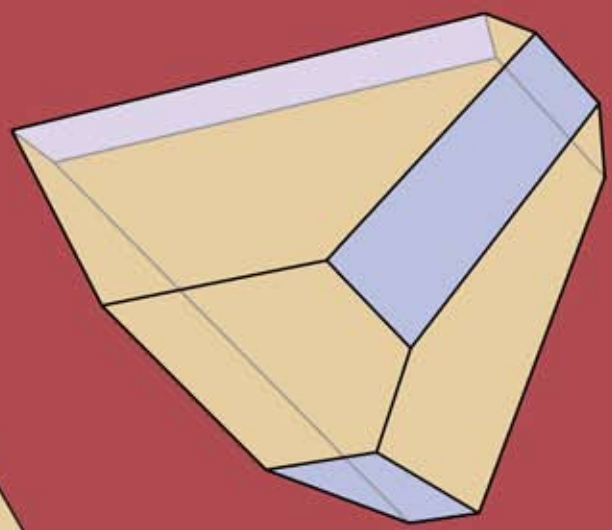
Notices

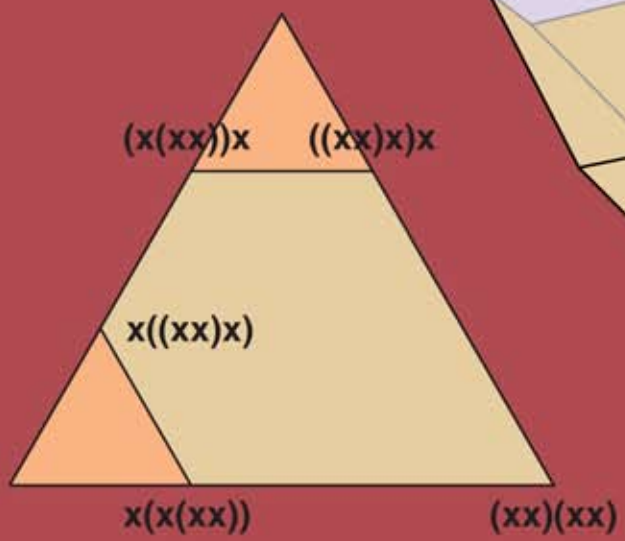
of the American Mathematical Society

December 2007 Volume 54, Number 11









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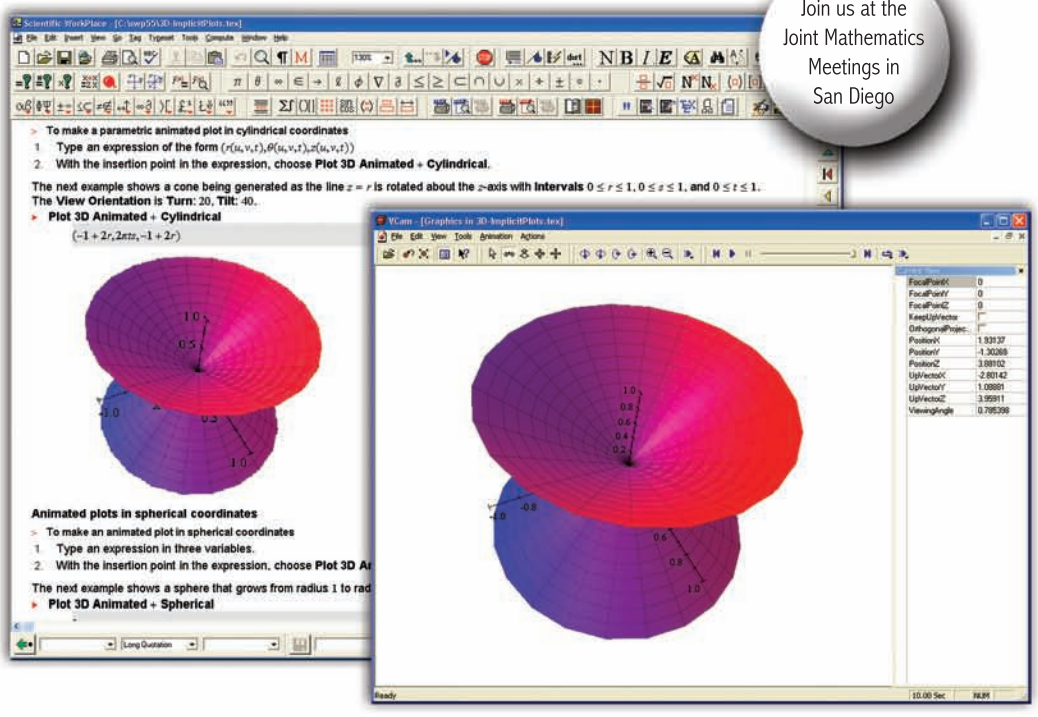

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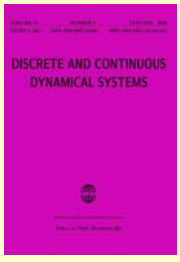

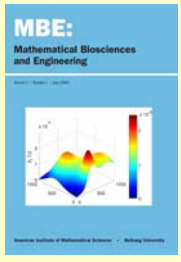

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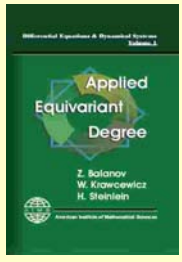

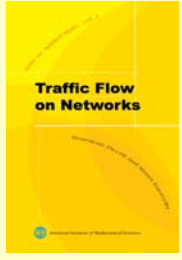

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PROGRESS IN MATHEMATICS, VOL. 264

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2007/XIII, 422 PP./HARDCOVER
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PROGRESS IN MATHEMATICS, VOL. 254

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PROGRESS IN MATHEMATICS, VOL. 256

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MASSIMILIANO BERTI, *Università degli Studi di Napoli 'Federico II', Italia*

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STEVO TODORCEVIC, *Université Paris VII - CNRS, Paris, France and University of Toronto, Canada*

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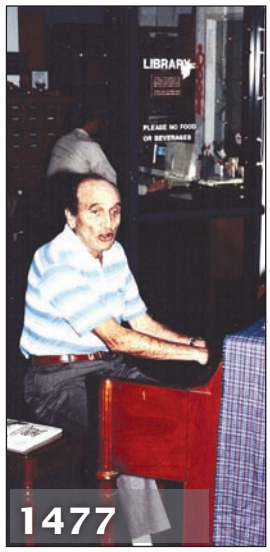
Notices

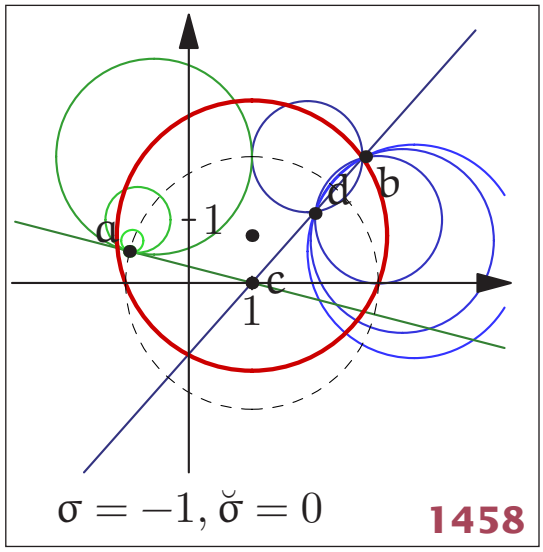
of the American Mathematical Society

December 2007

Communications

Commentary





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Notices

of the American Mathematical Society

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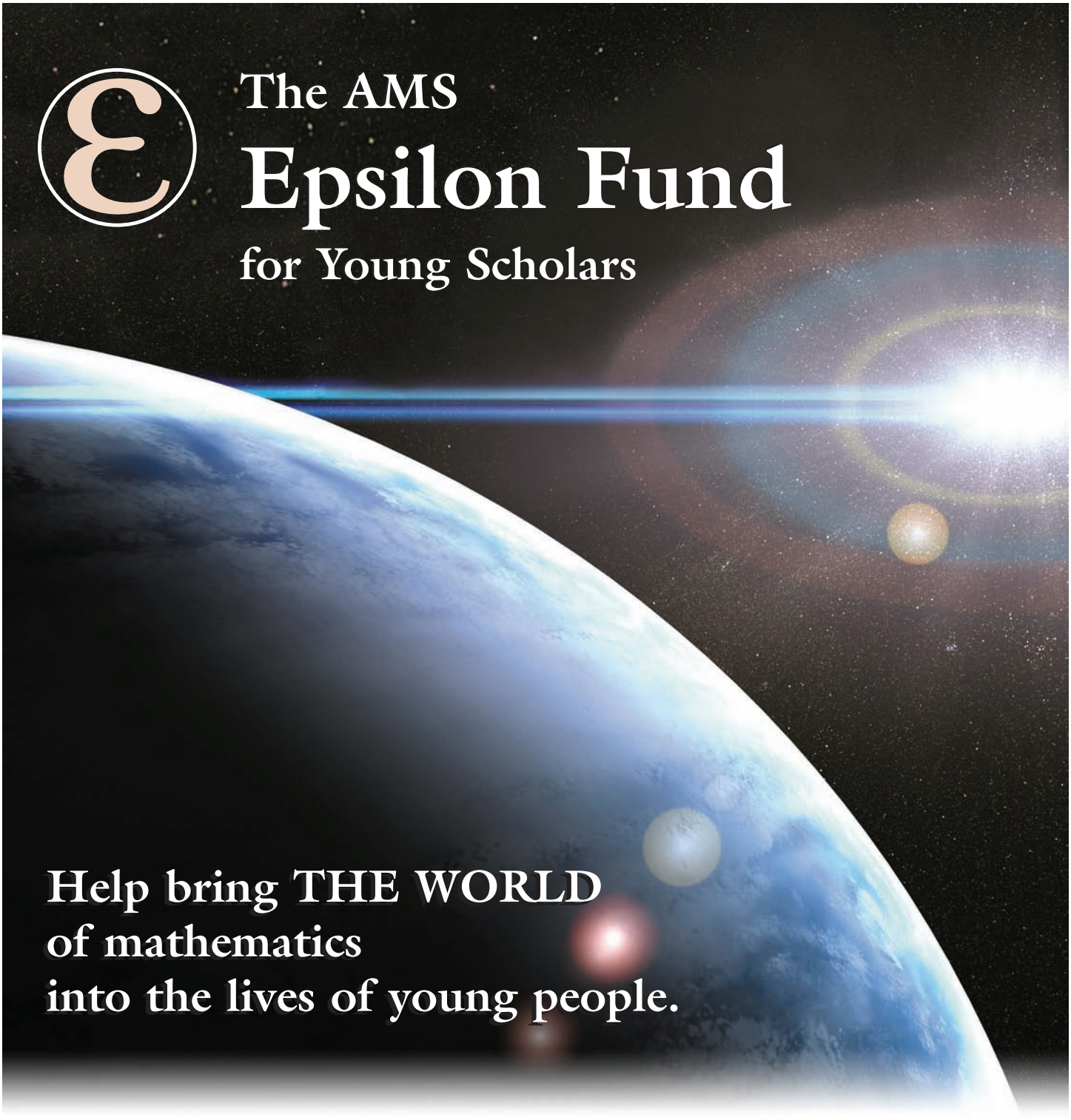

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09/04

Letters to the Editor

Koblitz Article Misleading

I found Koblitz's essay "The uneasy relationship between mathematics and cryptography" (*Notices*, Vol. 54, No. 8) misleading in several ways.

Most importantly, I believe that Koblitz's views regarding the subject are based on several fundamental misconceptions. For example, he seems to view the unfortunate (and rare) cases in which flaws were found in published claimed "proofs" (of security) as indication that proofs are useless (w.r.t. security). In my opinion, these incidences merely reinforce the importance of careful verification of proofs, which constitute our only way of distinguishing facts from conjectures. Furthermore, Koblitz often confuses proofs with what is being proved, and consequently does not distinguish between the inadequacy of the claim (e.g., an unsatisfactory definition of security) and the incorrectness of its proof. Finally, he often uses unsound reasoning (e.g., inferring that last-minute conference submissions indicate a rush to publish minor results).

The foregoing flaws dominate the series of papers by Koblitz and Menezes (see references in Koblitz's essay). For a discussion of the main flaws, the interested reader is referred to my essay `http://eprint.iacr.org/2006/461`. Let me just stress that, in contrary to Koblitz's belief, the fact that this essay does not criticize the papers of Koblitz and Menezes for inadequate references to prior work does not mean that such cases are not numerous. On the contrary. Koblitz's essay suffers from the same problems, and in addition it provides a distorted account of my own essay (e.g., the (legitimate) controversy regarding the "Random Oracle Model" is far from being the focus of my essay and was certainly not the source of my concerns regarding the Koblitz and Menezes papers).

I also wish to correct Koblitz's account of the events related to the publication of his paper with Menezes in the *Journal of Cryptography*. I did not object to the publication of the paper due to my strong disagreement with its contents, but rather due to the nature of this paper which, in my opinion, is not a novel technical contribution of the type sought by the journal. My opinion was that the paper may only be published as a "position paper". Since the authors refused to revise the title of their paper accordingly, the editor-in-chief was forced to write a special preface that explains that their paper is a position paper.

—Oded Goldreich
Weizmann Institute of Science
`oded.goldreich@weizmann.ac.il`

(Received August 27, 2007)

Koblitz Misrepresents Cryptography

In the famous joke, a mathematician would not infer the color of a sheep's right side from its left side. But Neal Koblitz, in his article on "The uneasy relationship between mathematics and cryptography" makes quite a few broad generalizations from a handful of anecdotes.

Koblitz's disparagement of security proofs is particularly misleading. Proofs of security of cryptographic protocols are standard mathematical proofs and in that sense are no more "over-hyped" (to use Koblitz's term) than proofs in calculus. Koblitz gives examples of mistakes in security proofs, but as we know such examples can be found in any area of mathematics. He also criticizes these proofs for relying on unproven conjectures. This is indeed most often the case, as is not surprising in such a young and vibrant field. Eventually we might prove these conjectures (although some seem as hard as the hardest open problems in mathematics) but regardless, it's much better to use a protocol proven secure under a well-defined and widely believed conjecture than a protocol with no analysis at all.

Koblitz points out the obvious truth that in cryptography, as in any mathematical field that models reality, the precise statement of a theorem is crucial to its practical meaning. Indeed, while we all know that the impossibility of angle trisection depends on the precise definition of allowed operations, none of us relies on this theorem to protect our credit card information. Here indeed cryptographers have sometimes misstepped and inadequately modeled the scenarios in which systems could be attacked, leading to systems that regardless of their formal analysis were insecure in practice. But the problem is not inherently with proofs of security but rather with cryptography itself, a notoriously difficult subject which over its long history has seen many great minds miss subtle points and design systems that were eventually broken.

In fact, the only way to systematically improve practical security is to insist on precise modeling, and study these models using mathematical proofs, on the way refining the models and identifying and correcting subtle weaknesses in protocols. Indeed, Koblitz's anecdote on the MQV and HMQV protocols demonstrates precisely how careful definitions and insistence on proofs can direct an incremental process towards more secure protocols.

—Boaz Barak
Princeton University
`boaz@cs.princeton.edu`

(Received August 30, 2007)

Publication of Koblitz's Article Questioned

I was shocked and dismayed that the *AMS Notices* published Neal Koblitz's article ["The uneasy relationship between mathematics and cryptography", September 2007] without, apparently, any editorial oversight. As one who works in the field of "provable security", I vehemently disagree with Koblitz's main argument—more on this below—but this is not my primary complaint. Instead, what I found abhorrent is that the article crosses the line from academic

argument to personal screed, from constructive criticism to belligerent name-calling. I cannot imagine the *Notices* publishing a similarly disparaging article about any other academic discipline.

By another fault of the editors, readers were not given the opportunity to read a companion article containing a countervailing point of view. Without dissecting Koblitz's arguments point-by-point, let me assure readers that proofs in modern cryptography are as meaningful as proofs in any other field. Can a scheme that has been proven secure still succumb to a real-world attack? Yes, but this does not invalidate the proof. (A proof is given with respect to a particular definition; any single definition is not appropriate for all possible environments in which a scheme may be deployed.) Are most results in cryptography conditional? Yes, but this has been shown to be inherent until the *P* vs. *NP* question is settled, and should not hold back research. Do mistakes happen? Occasionally, though rarely. But this surely does not diminish the importance of proofs in the first place.

Frankly, I cannot understand why any mathematician would discourage the use of definitions, proofs, and formal reasoning in any field. (Indeed, these elements have helped cryptography progress from an art to a science.) Koblitz's article clarifies his motivation: sheer elitism. According to Koblitz, cryptographers publish papers of "little originality" and containing "tiny improvements"; when we do publish something of potential interest, it is likely to be wrong. According to Koblitz, cryptographers are simply incapable of writing correct proofs, hence his admonition that anyone other than "trained mathematicians" simply give up on the goal. This is snobbery at its purest.

Publication of Koblitz's article has the potential to cause serious damage: not to the field of cryptography—which will continue to do fine with or without Koblitz's support—but to the future involvement of mathematicians in this field. In the future, the editors should more carefully weight the pros and cons of publishing "contributions" of this nature.

—*Jonathan Katz*
University of Maryland
jkatz@cs.umd.edu

(Received August 30, 2007

Koblitz's Arguments Disingenuous

Addressing Neal Koblitz's disingenuous arguments against theoretical cryptography in his recent article in the *Notices* requires far more elaboration than allowed by the space allocated for this letter (see http://www.ee.technion.ac.il/~hugo/ams-letter). Let me thus focus only on some of Koblitz's unfounded claims against my work on the HMQV protocol that he uses as a way to discredit the entire field of complexity-based cryptography (what he refers to as "provable security") and to deny the significant achievements of this field, in particular its important contributions to the practice of cryptography.

Contrary to what Koblitz claims, the HMQV work represents a prime example of the success of theoretical cryptography, not only in laying rigorous mathematical foundations for cryptography at large, but also in its ability to guide us in the design of truly practical solutions to real-world problems. Indeed, the HMQV key-agreement protocol that resulted from this work not only improved significantly on its predecessor, the MQV protocol, in terms of analysis and security guarantees, but the protocol itself became more practical, improving performance and lowering the dependency on external mechanisms such as trust in certification authorities and key derivation functions.

This double improvement, in both security and performance, is no coincidence. It is the very understanding that one obtains through the process of formally proving (or disproving) a cryptographic protocol that allows us to eliminate safety margins that are often added to cryptographic schemes when there is not enough confidence in the strength of the design. The success of this "proof-driven design" methodology is a testament to the fundamental role of the theory of cryptography in bringing more secure systems to practice.

There is no better way to assess the value of the HMQV protocol than reading the paper itself posted under http://eprint.iacr.org/2005/176. In particular, the introduction and concluding remarks section in the paper, unchanged since the original publication, already contain answers to many of the points raised by Koblitz against our methodology. Also note the preface where I comment on a correction pointed out by Alfred Menezes that, contrary to Koblitz's misleading account, did not change in any essential way the results and value of the work, neither with respect to its provability nor the substantial practical benefits of HMQV.

Let me end by stressing a very important point in understanding the role of theory when designing and analyzing real-world cryptographic systems: By its very nature, there is no (and cannot be) empirical evidence for the security of a design. Indeed, no concrete measurements or simulations can show that attacks against a cryptographic scheme are not feasible. The only way to do so is to develop a formal mathematical model and language in which to reason about such schemes. The area of theoretical cryptography and its applications has been remarkably successful in developing such models. They are certainly not perfect and will be further improved over time, but the foundations laid so far are outstanding. Whoever finds them insufficient should be encouraged to improve upon them or come up with alternatives. Emotional and unfounded attacks against a whole research area and its individuals, as carried by Koblitz, are of no use.

—*Hugo Krawczyk*
IBM T. J. Watson Research Center
hugo@ee.technion.ac.il

(Received September 3, 2007)

Reply to Katz, Goldreich, and Krawczyk

Jonathan Katz misstates what I wrote in my article and attributes to me things I never said, all to justify accusing me of "sheer elitism" and "snobbery at its purest". I never objected to cryptographers making a carefully reasoned, rigorous argument in support of a claim. Indeed, in my papers with Menezes on "provable security" we give detailed explanations of the need for precision in definitions and security analysis, and we describe some of the best examples of early and more recent research along these lines. In my article what I took issue with was all the hype, misleading terminology, and easily misunderstood and misinterpreted "theorems" that one finds in much of the "provable security" literature. It is hard to escape the impression that mathematical jargon and the theorem-proof paradigm are often used to kick dust in the eyes of outsiders.

It is Oded Goldreich, not me, who gives a misleading version of the events surrounding his last-minute effort to prevent publication of my article with Menezes in the *Journal of Cryptology*. Our paper had gone through the refereeing process almost two years before, and had been judged to be of sufficient technical novelty to merit acceptance. Goldreich's essay "On post-modern cryptography" finds fault with our article not on technical, but rather on philosophical grounds. Calling Menezes and me "post-modern [and] reactionary", he is incensed by some of our conclusions—notably, that "our confidence in the random oracle assumption is unshaken" and that cryptography "is as much an art as a science". Whatever Goldreich's reasons might have been for attempting to block our article on the eve of its publication, in the scientific world such conduct by an editorial board member is irregular and improper.

Hugo Krawczyk's letter itself is an illustration of what I find so exasperating in the "provable security" field. In order to advertise his work as "a prime example of the success of theoretical cryptography," Krawczyk minimizes the fact that his published proof was fallacious. If the HMQV protocol had been deployed in its original form as published, not only would the advertised "provable security" guarantee have been false, but in certain settings HMQV could have been breached by a malicious adversary. That's not a minor matter. (See `http://eprint.iacr.org/2005/205` for detailed explanations of the security flaws that have been found in HMQV.) Indeed, if Krawczyk believes that fallacies in proofs are so unimportant, then why bother to give proofs at all?

—Neal Koblitz
University of Washington
`koblitz@math.washington.edu`

(Received September 14, 2007)

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Starting with the Group $SL_2(\mathrm{R})$

Vladimir V. Kisil

The simplest objects with noncommutative multiplication may be 2×2 matrices with real entries. Such matrices *of determinant one* form a closed set under multiplication (since $\det(AB) = \det A \cdot \det B$), the identity matrix is among them, and any such matrix has an inverse (since $\det A \neq 0$). In other words those matrices form a group, the $SL_2(\mathrm{R})$ group [8]—one of the two most important Lie groups in analysis. The other group is the Heisenberg group [3]. By contrast the "$ax + b$"-group, which is often used to build wavelets, is a subgroup of $SL_2(\mathrm{R})$, see the numerator in (1).

The simplest nonlinear transformations of the real line—the linear-fractional or Möbius maps—may also be associated with 2×2 matrices [1, Ch. 13]:

(1)
$$g : x \mapsto g \cdot x = \frac{ax+b}{cx+d}, \text{ where } g = \begin{pmatrix} a & b \\ c & d \end{pmatrix}, x \in \mathbb{R}.$$

An easy calculation shows that the composition of two transforms (1) with different matrices g_1 and g_2 is again a Möbius transform with matrix the product $g_1 g_2$. In other words (1) is a (left) action of $SL_2(\mathrm{R})$.

According to F. Klein's *Erlangen program* (which was influenced by S. Lie) any geometry is dealing with invariant properties under a certain group action. For example, we may ask: *What kinds of geometry are related to the $SL_2(\mathrm{R})$ action* (1)?

The Erlangen program has probably the highest rate $\frac{\text{praised}}{\text{actually used}}$ among mathematical theories, not only due to the big numerator but also due to the undeservedly small denominator. As we shall see below Klein's approach provides some surprising conclusions even for such over-studied objects as circles.

Vladimir V. Kisil is Reader of Analysis at the University of Leeds. He is on leave from Odessa University. His email address is kisilv@maths.leeds.ac.uk.

Dedicated to the memory of Serge Lang.

Make a Guess in Three Attempts

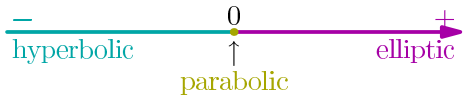
It is easy to see that the $SL_2(\mathrm{R})$ action (1) makes sense also as a map of complex numbers $z = x + \mathrm{i}y$, $\mathrm{i}^2 = -1$. Moreover, if $y > 0$ then $g \cdot z$ has a positive imaginary part as well, i.e., (1) defines a map from the upper half-plane to itself.

However there is no need to be restricted to the traditional route of complex numbers only. Less-known *double* and *dual* numbers [9, Suppl. C] also have the form $z = x + \mathrm{i}y$ but different assumptions on the imaginary unit i: $\mathrm{i}^2 = 0$ or $\mathrm{i}^2 = 1$ correspondingly. Although the arithmetic of dual and double numbers is different from the complex ones, e.g., they have divisors of zero, we are still able to define their transforms by (1) in most cases.

Three possible values -1, 0, and 1 of $\sigma := \mathrm{i}^2$ will be referred to here as *elliptic*, *parabolic*, and *hyperbolic* cases respectively. We repeatedly meet such a division of various mathematical objects into three classes. They are named by the historically first example—the classification of conic sections—however the pattern persistently reproduces itself in many different areas: equations, quadratic forms, metrics, manifolds, operators, etc. We will abbreviate this separation as *EPH-classification*. The *common origin* of this fundamental division can be seen from the simple picture of a coordinate line split by zero into

negative and positive half-axes:

(2)



Connections between different objects admitting the EPH-classification are not limited to this common source. There are many deep results linking, for example, ellipticity of quadratic forms, metrics and operators.

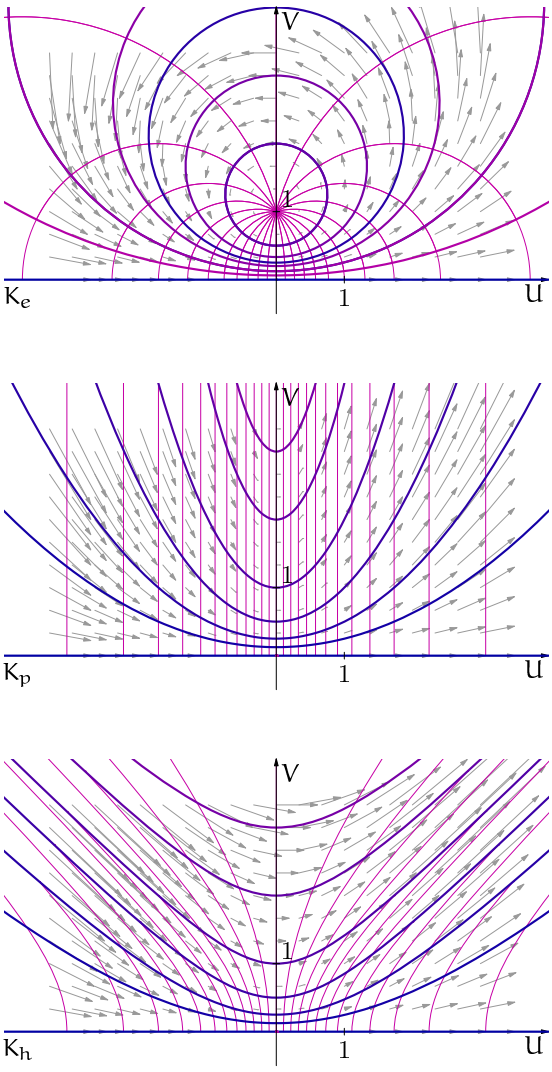


Figure 1. Action of the K subgroup. The corresponding orbits are circles, parabolas, and hyperbolas.

To understand the action (1) in all EPH cases we use the Iwasawa decomposition [8] of $SL_2(\mathrm{R}) = ANK$ into *three* one-dimensional subgroups A, N, K:

(3)
$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} = \begin{pmatrix} \alpha & 0 \\ 0 & \alpha^{-1} \end{pmatrix} \begin{pmatrix} 1 & \nu \\ 0 & 1 \end{pmatrix} \begin{pmatrix} \cos\phi & -\sin\phi \\ \sin\phi & \cos\phi \end{pmatrix}.$$

Subgroups A and N act in (1) irrespective of the value of σ: A makes a dilation by α^2, i.e., $z \mapsto \alpha^2 z$, and N shifts points to left by ν, i.e. $z \mapsto z + \nu$.

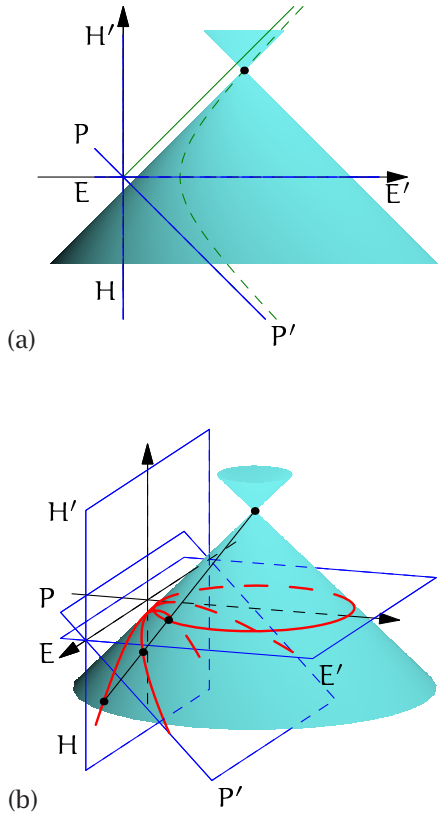


Figure 2. K-orbits as conic sections: circles are sections by the plane EE'; parabolas are sections by PP'; hyperbolas are sections by HH'. Points on the same generator of the cone correspond to the same value of ϕ.

By contrast, the action of the third matrix from the subgroup K sharply depends on σ, see Figure 1. In the elliptic, parabolic and hyperbolic cases K-orbits are circles, parabolas and (equilateral) hyperbolas correspondingly. Thin traversal lines in Figure 1 join points of orbits for the same values of ϕ and grey arrows represent "local velocities"—vector fields of derived representations.

Definition 1. The common name *cycle* [9] is used to denote circles, parabolas, and hyperbolas (as well as straight lines as their limits) in the respective EPH case.

It is well known that any cycle is a *conic section* and an interesting observation is that corresponding K-orbits are in fact sections of the same two-sided right-angle cone, see Figure 2. Moreover, each straight line generating the cone, see Figure 2(b), crosses corresponding EPH K-orbits at points with the same value of the parameter ϕ

from (3). In other words, all three types of orbits are generated by the rotations of this generator along the cone.

K-orbits are K-invariant in a trivial way. Moreover since actions of both A and N for any σ are extremely "shape-preserving" we find natural invariant objects of the Möbius map:

Theorem 2. *Cycles from Definition 1 are invariant under the action* (1)*.*

Proof. We will show that for a given $g \in SL_2(\mathrm{R})$ and a cycle C its image gC is again a cycle. Figure 3 gives an illustration with C as a circle, but our reasoning works in all EPH cases.

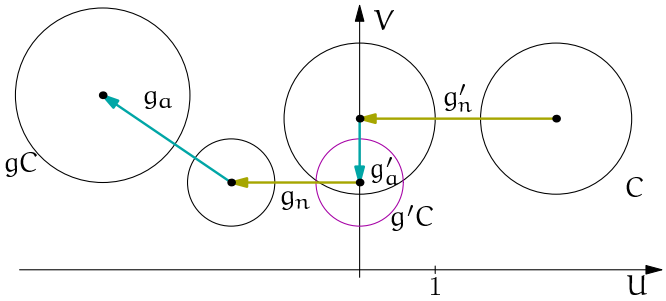


Figure 3. Decomposition of an arbitrary Möbius transformation g into a product $g = g_a g_n g_k g'_a g'_n$.

For a fixed C there is always a unique pair of transformations g'_n from the subgroup N and $g'_a \in A$ such that the cycle $g'_a g'_n C$ is exactly a K-orbit. We make a decomposition of $g(g'_a g'_n)^{-1}$ into a product as in (3):

$$g(g'_a g'_n)^{-1} = g_a g_n g_k.$$

Since $g'_a g'_n C$ is a K-orbit we have $g_k(g'_a g'_n C) = g'_a g'_n C$, then:

$$\begin{aligned} gC &= g(g'_a g'_n)^{-1} g'_a g'_n C = g_a g_n g_k g'_a g'_n C \\ &= g_a g_n g_k (g'_a g'_n C) = g_a g_n g'_a g'_n C. \end{aligned}$$

Since the subgroups A and N obviously preserve the shape of any cycle this finishes our proof. □

According to Erlangen ideology we should now study invariant properties of cycles.

Invariance of FSCc

Figure 2 suggests that we may get a unified treatment of cycles in each EPH case by consideration of higher-dimensional spaces. The standard mathematical method is to declare objects under investigation (cycles in our case, functions in functional analysis, etc.) to be simply points of some bigger space. This space should be equipped with an appropriate structure to hold externally information that was previously inner properties of our objects.

A generic cycle is the set of points $(u, v) \in \mathbb{R}^2$ defined for all values of σ by the equation

$$k(u^2 - \sigma v^2) - 2lu - 2nv + m = 0. \tag{4}$$

This equation (and the corresponding cycle) is defined by a point (k, l, n, m) from a projective space $\mathbb{P}^3$, since for a scaling factor $\lambda \neq 0$ the point $(\lambda k, \lambda l, \lambda n, \lambda m)$ defines the same equation (4). We call $\mathbb{P}^3$ the *cycle space* and refer to the initial $\mathbb{R}^2$ as the *point space*.

In order to get a connection with the Möbius action (1) we arrange the numbers (k, l, n, m) into the matrix

$$C^s_{\check\sigma} = \begin{pmatrix} l + \check\imath s n & -m \\ k & -l + \check\imath s n \end{pmatrix}, \tag{5}$$

with a new imaginary unit $\check\imath$ and an additional parameter s usually equal to ± 1. The values of $\check\sigma := \check\imath^2$ are -1, 0, or 1 independently of the value of σ. The matrix (5) is the cornerstone of the (extended) Fillmore–Springer–Cnops construction (FSCc) [2] and closely related to the technique recently used by A. A. Kirillov to study the Apollonian gasket [4].

The significance of FSCc in the Erlangen framework is provided by the following result:

Theorem 3. *The image $\tilde C^s_{\check\sigma}$ of a cycle $C^s_{\check\sigma}$ under transformation* (1) *with $g \in SL_2(\mathrm{R})$ is given by similarity of the matrix* (5)*:*

$$\tilde C^s_{\check\sigma} = g C^s_{\check\sigma} g^{-1}. \tag{6}$$

In other words FSCc (5) intertwines *Möbius action* (1) *on cycles with a linear map* (6)*.*

There are several ways to prove (6): either by a brute-force calculation (fortunately performed by a CAS) [7] or through the related orthogonality of cycles [2]; see the end of the next section.

The important observation here is that FSCc (5) uses an imaginary unit $\check\imath$ which is not related to i defining the appearance of cycles on plane. In other words any EPH type of geometry in the cycle space $\mathbb{P}^3$ allows one to draw cycles in the point space $\mathbb{R}^2$ as circles, parabolas, or hyperbolas. We may think of points of $\mathbb{P}^3$ as ideal cycles while their depictions on $\mathbb{R}^2$ are only their shadows on the wall of Plato's cave.

Figure 4(a) shows the same cycles drawn in different EPH styles. Points $c_{e,p,h} = (\frac{l}{k}, -\sigma\frac{n}{k})$ are their respective e/p/h-centers. They are related to each other through several identities:

$$c_e = \bar c_h, \quad c_p = \frac{1}{2}(c_e + c_h). \tag{7}$$

Figure 4(b) presents two cycles drawn as parabolas; they have the same focal length $\frac{n}{2k}$ and thus their e-centers are on the same level. In other words *concentric* parabolas are obtained by a vertical shift, not scaling as an analogy with circles or hyperbolas may suggest.

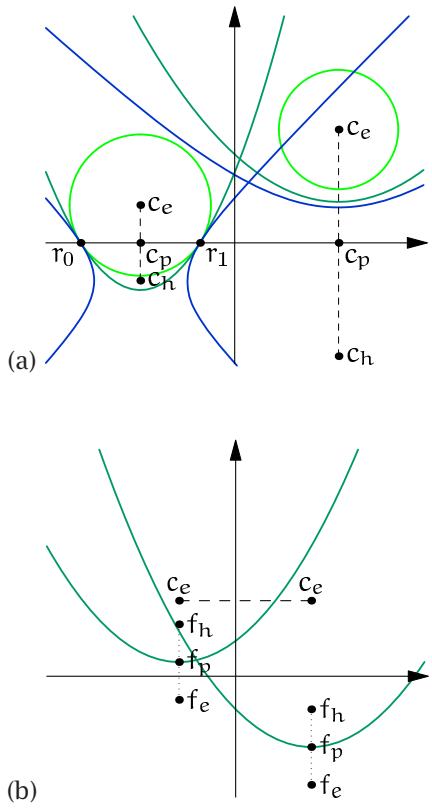


Figure 4. (a) Different EPH implementations of the same cycles defined by quadruples of numbers.
(b) Centers and foci of two parabolas with the same focal length.

Figure 4(b) also presents points, called e/p/h-foci:

$$f_{e,p,h} = \left(\frac{l}{k}, -\frac{\det C^s_{\breve\sigma}}{2nk}\right), \tag{8}$$

which are independent of the sign of s. If a cycle is depicted as a parabola then h-focus, p-focus, e-focus are correspondingly geometrical focus of the parabola, its vertex, and the point on the directrix nearest to the vertex.

As we will see, cf. Theorems 5 and 7, all three centers and three foci are useful attributes of a cycle even if it is drawn as a circle.

Invariants: Algebraic and Geometric

We use known algebraic invariants of matrices to build appropriate geometric invariants of cycles. It is yet another demonstration that any division of mathematics into subjects is only illusive.

For 2×2 matrices (and thus cycles) there are only two essentially different invariants under similarity (6) (and thus under Möbius action (1)): the *trace* and the *determinant*. The latter was already used in (8) to define a cycle's foci. However due to the projective nature of the cycle space $\mathbb{P}^3$ the absolute values of trace or determinant are irrelevant, unless they are zero.

Alternatively we may have a special arrangement for normalization of quadruples (k, l, n, m). For example, if $k \neq 0$ we may normalize the quadruple to $(1, \frac{l}{k}, \frac{n}{k}, \frac{m}{k})$ with the cycle's center highlighted. Moreover in this case $\det C^s_{\breve\sigma}$ is equal to the square of cycle's radius, cf. the next to last section below. Another normalization $\det C^s_{\breve\sigma} = 1$ is used in [4] to get a nice condition for touching circles.

We still get important characterizations even with non-normalized cycles, e.g., invariant classes (for different $\breve\sigma$) of cycles are defined by the condition $\det C^s_{\breve\sigma} = 0$. Such a class is parameterized by two real numbers and as such is easily attached to a certain point of $\mathbb{R}^2$. For example, the cycle $C^s_{\breve\sigma}$ with $\det C^s_{\breve\sigma} = 0$, $\breve\sigma = -1$ drawn elliptically represents a point $(\frac{l}{k}, \frac{n}{k})$, i.e., an (elliptic) zero-radius circle. The same condition with $\breve\sigma = 1$ in hyperbolic drawing produces a null-cone originating at a point $(\frac{l}{k}, \frac{n}{k})$:

$$(u - \frac{l}{k})^2 - (v - \frac{n}{k})^2 = 0,$$

i.e., a zero-radius cycle in the hyperbolic metric.

In general for every notion there are nine possibilities: three EPH cases in the cycle space times three EPH realizations in point space. The nine cases for "zero radius" cycles are shown in Figure 5. For example, p-zero-radius cycles in any implementation touch the real axis.

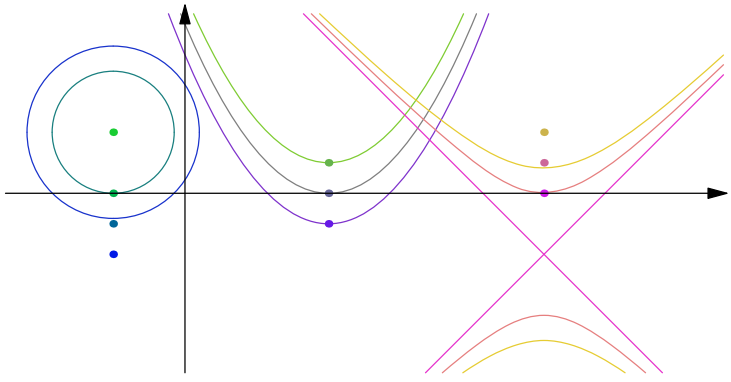


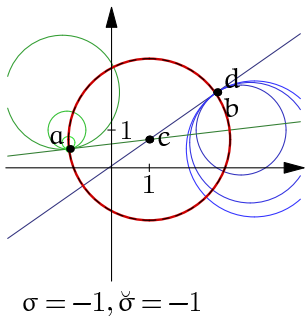
Figure 5. Different i-implementations of the same $\breve\sigma$-zero-radius cycles and corresponding foci.

This "touching" property is a manifestation of the *boundary effect* in the upper-half plane geometry [7, Rem. 3.4]. The famous question on hearing the shape of a drum has a sister:

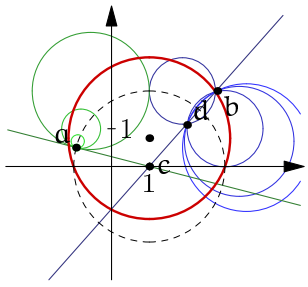
Can we see/feel the boundary from inside a domain?

Both orthogonality relations described below are "boundary aware" as well. It is not surprising after all since the $SL_2(\mathrm{R})$ action on the upper-half plane

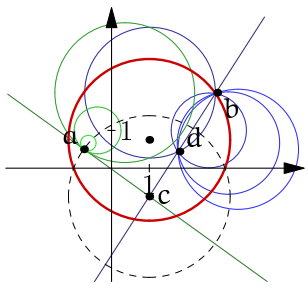
was obtained as an extension of its action (1) on the boundary.



$\sigma = -1, \breve{\sigma} = -1$



$\sigma = -1, \breve{\sigma} = 0$



$\sigma = -1, \breve{\sigma} = 1$

Figure 6. Orthogonality of the first kind in the elliptic point space. Each picture presents two groups (green and blue) of cycles that are orthogonal to the red cycle $C^s_{\breve{\sigma}}$. Point b belongs to $C^s_{\breve{\sigma}}$ and the family of blue cycles passing through b is orthogonal to $C^s_{\breve{\sigma}}$. They all also intersect in the point d, which is the inverse of b in $C^s_{\breve{\sigma}}$. Any orthogonality is reduced to the usual orthogonality with a new ("ghost") cycle (shown by the dashed line), which may or may not coincide with $C^s_{\breve{\sigma}}$. For any point a on the "ghost" cycle the orthogonality is reduced to the local notion in the terms of tangent lines at the intersection point. Consequently such a point a is always the inverse of itself.

According to the categorical viewpoint internal properties of objects are of minor importance in comparison to their relations with other objects from the same class. As an illustration we may put the proof of Theorem 3 sketched at the end of the next section. Thus from now on we will look for invariant relations between two or more cycles.

Joint Invariants: Orthogonality

The most expected relation between cycles is based on the following Möbius invariant "inner product" built from the trace of the product of two cycles as matrices:

$$\left\langle C^s_{\breve{\sigma}}, \tilde{C}^s_{\breve{\sigma}} \right\rangle = tr(C^s_{\breve{\sigma}} \tilde{C}^s_{\breve{\sigma}}). \tag{9}$$

By the way, an inner product of this type is used, for example, in the GNS construction to make a Hilbert space out of C^*-algebras. The next standard move is given by the following definition.

Definition 4. Two cycles are called *$\breve{\sigma}$-orthogonal* if $\left\langle C^s_{\breve{\sigma}}, \tilde{C}^s_{\breve{\sigma}} \right\rangle = 0$.

For the case of $\breve{\sigma}\sigma = 1$, i.e., when geometries of the cycle and point spaces are both either elliptic or hyperbolic, such an orthogonality is the standard one, defined in terms of angles between tangent lines in the intersection points of two cycles. However in the remaining seven $(= 9 - 2)$ cases the innocent-looking Definition 4 brings unexpected relations.

Elliptic (in the point space) realizations of Definition 4, i.e., $\sigma = -1$ are shown in Figure 6. The first picture corresponds to the elliptic cycle space, e.g., $\breve{\sigma} = -1$. The orthogonality between the red circle and any circle from the blue or green families is given in the usual Euclidean sense. The central (parabolic in the cycle space) and the last (hyperbolic) pictures show the non-local nature of the orthogonality. There are analogous pictures in parabolic and hyperbolic point spaces as well [7].

This orthogonality may still be expressed in the traditional sense if we associate to the red circle the corresponding "ghost" circle, which is shown by the dashed line in Figure 6. To describe the ghost cycle we need the *Heaviside function* $\chi(\sigma)$:

$$\chi(t) = \begin{cases} 1, & t \geq 0; \\ -1, & t < 0. \end{cases} \tag{10}$$

Theorem 5. *A cycle is $\breve{\sigma}$-orthogonal to the cycle $C^s_{\breve{\sigma}}$ if it is orthogonal in the usual sense to the σ-realization of the "ghost" cycle $\hat{C}^s_{\breve{\sigma}}$, which is defined by the following two conditions:*

(i) *The $\chi(\sigma)$-center of $\hat{C}^s_{\breve{\sigma}}$ coincides with the $\breve{\sigma}$-center of $C^s_{\breve{\sigma}}$.*

(ii) *The cycles $\hat{C}^s_{\breve{\sigma}}$ and $C^s_{\breve{\sigma}}$ have the same roots, moreover* $\det \hat{C}^1_{\sigma} = \det C^{\chi(\breve{\sigma})}_{\sigma}$.

The above connection between various centers of cycles illustrates their meaningfulness within our approach.

One can easily check the following orthogonality properties of the zero-radius cycles defined in the previous section:

(i) Since $\langle C^s_\sigma, C^s_{\breve\sigma}\rangle = \det C^s_\sigma$ zero-radius cycles are self-orthogonal (isotropic) ones.

(ii) A cycle C^s_σ is σ-orthogonal to a zero-radius cycle $Z^s_{\breve\sigma}$ if and only if C^s_σ passes through the σ-center of $Z^s_{\breve\sigma}$.

Sketch of proof of Theorem 3. The validity of Theorem 3 for a zero-radius cycle

$$Z^s_{\breve\sigma} = \begin{pmatrix} z & -z\bar z \\ 1 & -\bar z \end{pmatrix} = \frac{1}{2}\begin{pmatrix} z & z \\ 1 & 1 \end{pmatrix}\begin{pmatrix} 1 & -\bar z \\ 1 & -\bar z \end{pmatrix}$$

with center $z = x + \mathrm{i}y$ is straightforward. This implies the result for a generic cycle with the help of Möbius invariance of the product (9) (and thus the orthogonality) and the above relation (ii) between the orthogonality and the incidence. See [2] for details. □

Higher Order Joint Invariants: s-Orthogonality

With appetite already whetted one may wish to build more joint invariants. Indeed for any homogeneous polynomial $p(x_1, x_2, \dots, x_n)$ of several non-commuting variables one may define an invariant joint disposition of n cycles ${}^jC^s_{\breve\sigma}$ by the condition:

$$tr\, p({}^1C^s_{\breve\sigma}, {}^2C^s_{\breve\sigma}, \dots, {}^nC^s_{\breve\sigma}) = 0.$$

However it is preferable to keep some geometrical meaning for constructed notions.

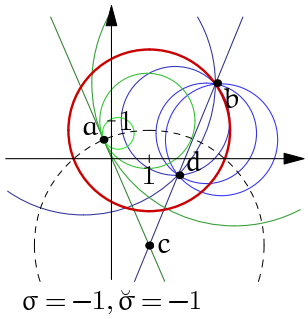
An interesting observation is that in the matrix similarity of cycles (6) one may replace the element $g \in SL_2(\mathrm{R})$ by an arbitrary matrix corresponding to another cycle. More precisely the product $C^s_{\breve\sigma}\tilde C^s_{\breve\sigma}C^s_{\breve\sigma}$ is again the matrix of the form (5) and thus may be associated to a cycle. This cycle may be considered as the reflection of $\tilde C^s_{\breve\sigma}$ in $C^s_{\breve\sigma}$.

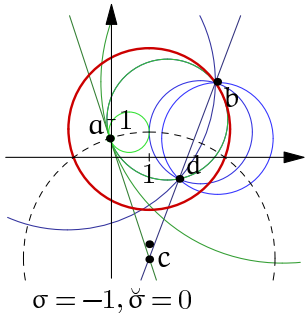
Definition 6. A cycle $C^s_{\breve\sigma}$ is s-orthogonal *to* a cycle $\tilde C^s_{\breve\sigma}$ if the reflection of $\tilde C^s_{\breve\sigma}$ in $C^s_{\breve\sigma}$ is orthogonal (in the sense of Definition 4) to the real line. Analytically this is defined by:

$$tr(C^s_{\breve\sigma}\tilde C^s_{\breve\sigma}C^s_{\breve\sigma}R^s_{\breve\sigma}) = 0. \tag{11}$$

Due to invariance of all components in the above definition s-orthogonality is a Möbius invariant condition. Clearly this is not a symmetric relation: if $C^s_{\breve\sigma}$ is s-orthogonal to $\tilde C^s_{\breve\sigma}$ then $\tilde C^s_{\breve\sigma}$ is not necessarily s-orthogonal to $C^s_{\breve\sigma}$.

Figure 7 illustrates s-orthogonality in the elliptic point space. By contrast with Figure 6 it is not a local notion at the intersection points of cycles for all $\breve\sigma$. However it may be again clarified in terms of the appropriate s-ghost cycle, cf. Theorem 5.





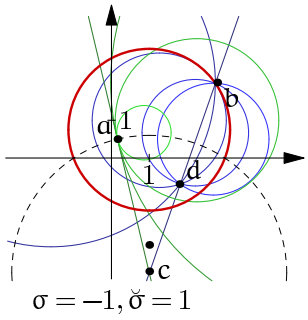


Figure 7. Orthogonality of the second kind for circles. To highlight both similarities and distinctions with the ordinary orthogonality we use the same notation as that in Figure 6.

Theorem 7. *A cycle is s-orthogonal to a cycle $C^s_{\breve\sigma}$ if it is orthogonal in the traditional sense to its* s-ghost cycle $\tilde C^{\breve\sigma}_{\breve\sigma} = C^{\chi(\sigma)}_{\breve\sigma}\mathbb{R}^{\breve\sigma}_{\breve\sigma}C^{\chi(\sigma)}_{\breve\sigma}$, *which is the reflection of the real line in $C^{\chi(\sigma)}_{\breve\sigma}$ and χ is the* Heaviside function (10). *Moreover*

(i) *The $\chi(\sigma)$-Center of $\tilde C^{\breve\sigma}_{\breve\sigma}$ coincides with the $\breve\sigma$-focus of $C^s_{\breve\sigma}$, consequently all lines s-orthogonal to $C^s_{\breve\sigma}$ are passing through the respective focus.*

(ii) *The cycles $C^s_{\breve\sigma}$ and $\tilde C^{\breve\sigma}_{\breve\sigma}$ have the same roots.*

Note the above intriguing interplay between a cycle's centers and foci. Although s-orthogonality

may look exotic it will naturally appear again at the end of the next section.

Of course, it is possible to define other interesting higher-order joint invariants of two or even more cycles.

Distance, Length, and Perpendicularity

Geometry in the plain meaning of this word deals with *distances* and *lengths*. Can we obtain them from cycles?

We mentioned already that for circles normalized by the condition $k = 1$ the value $\det C^s_{\breve{\sigma}} = \langle C^s_{\breve{\sigma}}, C^s_{\breve{\sigma}} \rangle$ produces the square of the traditional circle radius. Thus we may keep it as the definition of the *radius* for any cycle. But then we need to accept that in the parabolic case the radius is the (Euclidean) distance between (real) roots of the parabola, see Figure 8(a).

Having radii of circles already defined we may use them for other measurements in several different ways. For example, the following variational definition may be used:

Definition 8. The *distance* between two points is the extremum of diameters of all cycles passing through both points, see Figure 8(b).

If $\breve{\sigma} = \sigma$ this definition gives in all EPH cases the following expression, see Figure 8(b):

$$d_{e,p,h}(u,v)^2 = (u+\mathrm{i}v)(u-\mathrm{i}v) = u^2 - \sigma v^2. \tag{12}$$

The parabolic distance $d_p^2 = u^2$ algebraically sits between d_e and d_h according to the general principle (2) and is widely accepted [9]. However one may be unsatisfied by its degeneracy.

An alternative measurement is motivated by the fact that a circle is the set of equidistant points from its center. However the choice of "center" is now rich: it may be any point from among three centers (7) or three foci (8).

Definition 9. The *length* of a directed interval $\overrightarrow{AB}$ is the radius of the cycle with its *center* (denoted by $l_c(\overrightarrow{AB})$) or *focus* (denoted by $l_f(\overrightarrow{AB})$) at the point A that passes through B.

This definition is less common and has some unusual properties like non-symmetry: $l_f(\overrightarrow{AB}) \neq l_f(\overrightarrow{BA})$. However it comfortably fits the Erlangen program due to its $SL_2(\mathrm{R})$-*conformal invariance*:

Theorem 10 ([7]). *Let l denote either the EPH distances* (12) *or any length from Definition 9. Then for fixed y, $y' \in \mathbb{R}^\sigma$ the limit:*

$$\lim_{t\to 0} \frac{l(g\cdot y, g\cdot(y+ty'))}{l(y, y+ty')}, \text{ where } g \in SL_2(\mathrm{R}),$$

exists and its value depends only on y and g and is independent of y'.

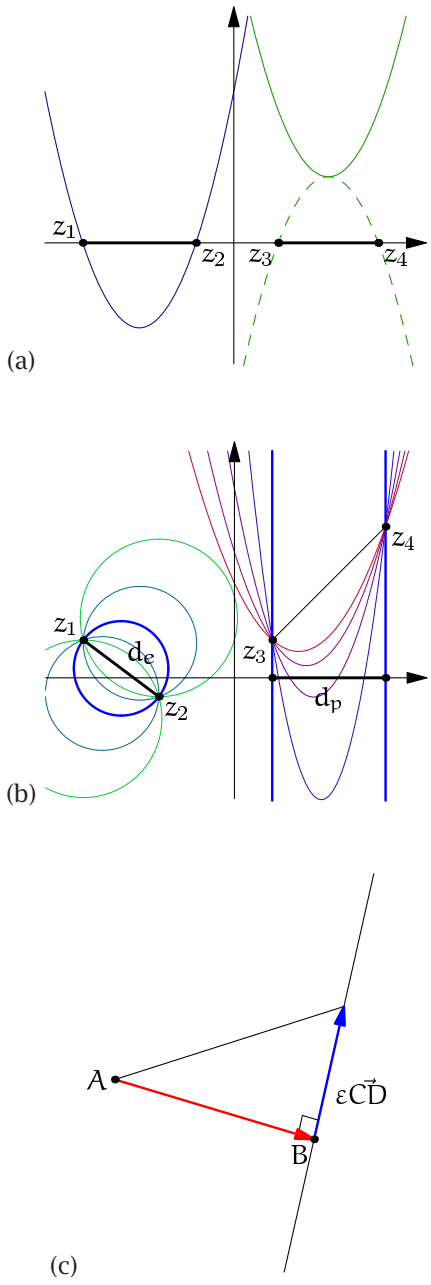


Figure 8. (a) The square of the parabolic diameter is the square of the distance between roots if they are real (z_1 and z_2), otherwise the negative square of the distance between the adjoint roots (z_3 and z_4). (b) Distance as extremum of diameters in elliptic (z_1 and z_2) and parabolic (z_3 and z_4) cases. (c) Perpendicular as the shortest route to a line.

We return from distances to angles recalling that in Euclidean space a perpendicular provides the shortest length from a point to a line, see Figure 8(c).

Definition 11. Let l be a length or distance. We say that a vector $\overrightarrow{AB}$ is *l-perpendicular* to a vector $\overrightarrow{CD}$ if the function $l(\overrightarrow{AB} + \varepsilon\overrightarrow{CD})$ of ε has a local extremum at $\varepsilon = 0$.

A pleasant surprise is that l_f-perpendicularity obtained through the length from focus (Definition 9) coincides with s-orthogonality already defined in the preceding section, as follows from Theorem 7(i).

All these notions are waiting to be generalized to higher dimensions, and Clifford algebras provide a suitable language for this [7].

Erlangen Program at Large

As we already mentioned the division of mathematics into areas is only apparent. Therefore it is unnatural to limit the Erlangen program only to "geometry". We may continue to look for $SL_2(\mathrm{R})$ invariant objects in other related fields. For example, transform (1) generates unitary representations on certain L_2 spaces, cf. (1):

$$g : f(x) \mapsto \frac{1}{(cx+d)^m} f\left(\frac{ax+b}{cx+d}\right). \tag{13}$$

For $m = 1, 2, \ldots$ the invariant subspaces of L_2 are Hardy and (weighted) Bergman spaces of complex analytic functions. All the main objects of *complex analysis* (Cauchy and Bergman integrals, Cauchy-Riemann and Laplace equations, Taylor series, etc.) may be obtained in terms of invariants of the *discrete series* representations of $SL_2(\mathrm{R})$ [5, § 3]. Moreover two other series (*principal* and *complimentary* [8]) play the similar roles for hyperbolic and parabolic cases [5, 7].

Moving further we may observe that transform (1) is defined also for an element x in any algebra $\mathfrak{A}$ with a unit $\mathbf{1}$ as soon as $(cx+d\mathbf{1}) \in \mathfrak{A}$ has an inverse. If $\mathfrak{A}$ is equipped with a topology, e.g., is a Banach algebra, then we may study a *functional calculus* for the element x [6] in this way. It is defined as an intertwining operator between the representation (13) in a space of analytic functions and a similar representation in a left $\mathfrak{A}$-module.

In the spirit of the Erlangen program such a functional calculus is still a geometry, since it is dealing with invariant properties under a group action. However even for a simplest non-normal operator, e.g., a Jordan block of the length k, the space obtained is not like a space of points but is rather a space of k-th *jets* [6]. Such non-point behavior is often attributed to *noncommutative geometry*, and the Erlangen program provides an important input on this fashionable topic [5].

Of course, there is no reason to limit the Erlangen program to $SL_2(\mathrm{R})$ only, other groups may be more suitable in different situations. However $SL_2(\mathrm{R})$ still possesses a big unexplored potential and is a good object to start with.

Note: Graphics for this article were created by the author with the help of Open Source Software:

MetaPost (`http://www.tug.org/metapost.html`), Asymptote (`http://asymptote.sourceforge.net/`), and GiNaC (`http://www.ginac.de/`).

References

[1] Alan F. Beardon, *Algebra and Geometry*, Cambridge University Press, Cambridge, 2005. MR **2153234 (2006a:**00001)

[2] Jan Cnops, *An Introduction to Dirac Operators on Manifolds*, Progress in Mathematical Physics, vol. 24, Birkhäuser Boston Inc., Boston, MA, 2002. MR 1917405

[3] Roger Howe, On the role of the Heisenberg group in harmonic analysis, *Bull. Amer. Math. Soc. (N.S.)* **3** (1980), no. 2, 821–843. MR **81h:**22010

[4] A. A. Kirillov, A tale on two fractals, 2007. (To appear).

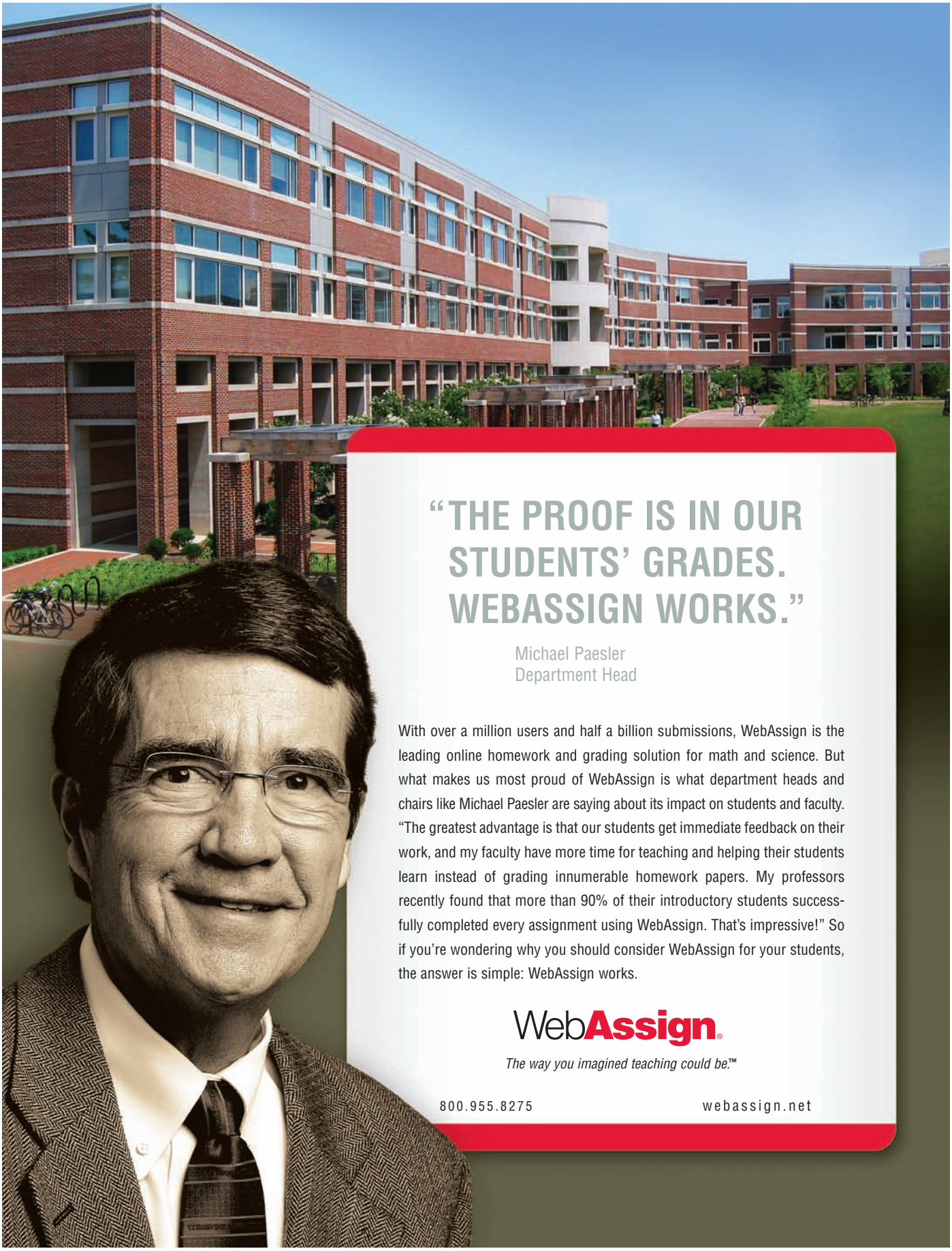
[5] Vladimir V. Kisil, Meeting Descartes and Klein somewhere in a noncommutative space, *Highlights of Mathematical Physics*, 2002. 165–189, American Mathematical Society. `http://arXiv.org/abs/math-ph/0112059`. MR **2005b:**43015

[6] ———, Spectrum as the support of functional calculus, *Functional Analysis and Its Applications*, 2004, pp. 133–141. `http://arXiv.org/abs/math.FA/0208249`. MR MR2098877

[7] ———, Erlangen program at large–1: Geometry of invariants (2005). `http://arXiv.org/abs/math.CV/0512416`. preprint LEEDS–MATH–PURE–2005–28.

[8] Serge Lang, $\mathrm{SL}_2(\mathbf{R})$, *Graduate Texts in Mathematics*, vol. 105, Springer-Verlag, New York, 1985. Reprint of the 1975 edition. MR **803508 (86j:**22018)

[9] I. M. Yaglom, *A Simple Non-Euclidean Geometry and Its Physical Basis*, Springer-Verlag, New York, 1979. An elementary account of Galilean geometry and the Galilean principle of relativity, Heidelberg Science Library, translated from the Russian by Abe Shenitzer, with the editorial assistance of Basil Gordon. MR **520230 (80c:**51007)



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Book Review

The Triumph of Numbers:
How Counting Shaped Modern Life
and
Karl Pearson:
The Scientific Life in a Statistical Age

Reviewed by Brian Blank

The Triumph of Numbers: How Counting Shaped Modern Life
I. Bernard Cohen
W. W. Norton, 2006
US$14.95, 224 pages, ISBN: 978-0393328707

Karl Pearson: The Scientific Life in a Statistical Age
Theodore M. Porter
Princeton University Press, 2005
US$23.95, 352 pages, ISBN: 978-0691126357

"We live in a world of numbers." So begins *The Triumph of Numbers*, the posthumously published book of the eminent historian of science, I. Bernard Cohen. The numbers he refers to are wages, taxes, consumer prices, financial records, economic reports, demographic data, sports statistics, and the like. When did this numerical deluge begin? Too long ago for us to know! Even before the formation of the first civilizations, several Neolithic communities scattered about the Mediterranean left behind stones and ostraca bearing numerical archives of trade, personal services, interest rates, and gambling debts. As civilizations emerged, societies and governments increasingly relied on numbers to manage the ever greater complexities of daily life. Archeologists have unearthed thousands of Sumerian tablets bearing records of commercial transactions that took place more than 5,000 years ago. It is not surprising that numbers are found so frequently in prehistoric artifacts: these numerical symbols predate writing precisely because they played a crucial part in the development of writing. As the historian Will Durant once remarked, "The berated bourgeoisie may take consolation in the thought that literature originated in bills of lading."

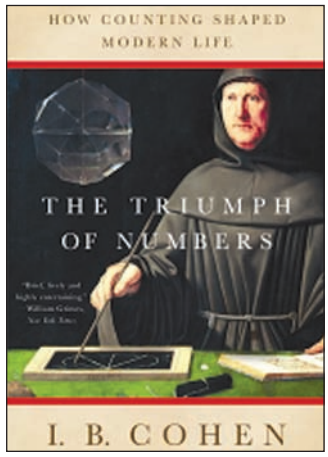
Cohen begins his study of numbers with the Narmer Macehead, which dates from the thirty-first century B.C.E. and is now housed in Oxford's Ashmolean Museum. It has much to excite different sorts of historians. The writing it bears is among the earliest yet found. The king it depicts is one of the earliest named historical persons, the pharaoh Narmer. The event it commemorates is thought to have taken place shortly after the unification of Upper and Lower Egypt and the establishment of the first Egyptian dynasty. All very important to some, but to a historian like Cohen the relic contains another lesson that should not be overlooked: the census figures that are carved in relief on the macehead—120,000 (adult men), 400,000 (cattle), and 1,422,000 (small animals)—show that the ancient Egyptians were able to write very large numbers. Such capabilities were essential for the construction of the Great Pyramid at Giza, which was erected according to a meticulous design requiring some 2,300,000 stone blocks. After discussing the Great Pyramid in thorough numerical detail, Cohen concludes his first chapter by outlining those aspects of the world of numbers that are the focus

Brian Blank is professor of mathematics at Washington University in St. Louis. His email address is brian@math.wustl.edu.

of his investigation: "Our mission from here on is to explicate some of the important and interesting steps whereby the analysis of society, the conduct of government, the regulation of daily life, and the understanding of nature came to be."

The second chapter provides a good illustration of Cohen's plan and execution, his successes and failures. After a capsule treatment of Kepler's third law, Cohen turns to Galileo's study of constantly accelerated motion. Here, as elsewhere, the discussion is aimed at a general reader. Thus, when Galileo is said to have confirmed his formula for free fall by experimenting with a ball rolling down an inclined plane, Cohen assumes that the reader will not notice that the second dynamical problem involves rotational kinetic energy, which is not present in the first. Cohen's survey of the seventeenth century, an era with which he was particularly associated, continues with William Harvey's investigation of the circulation system, Anton Van Leeuwenhoek's estimate of Earth's carrying capacity, Edmond Halley's contributions to insurance annuities, John Graunt's analysis of London's *Bills of Mortality*, and William Petty's advocacy of "Political Arithmetick". It is a tribute to Cohen's narrative skill that he is able to string together such a hodgepodge of case studies so coherently. Moreover, he has enlivened each topic with fascinating, unsuspected details. Thus, even the reader who is well acquainted with elementary mechanics may be surprised to learn Galileo's own description of his discovery: "The distances traversed during successive equal intervals of time by a body falling from rest stand to one another in the same ratio as the odd numbers beginning with unity." Leeuwenhoek's pioneering contributions to microscopy are well known, but how did they lead to an interest in demography? The answer, we discover, is that Leeuwenhoek found it difficult to convey the minuteness of spermatozoa at a time when microscopes were in the hands of only a few scientists. He solved his problem by estimating that the Earth could support a maximum of 13,385,000,000 human beings, a population dwarfed by the number of "little animals in the milt of a cod".

The discourse on John Graunt touches upon two of Cohen's themes: the analysis of society and the conduct of government. Following an episode of plague that struck London in 1603, the government published broadsides called *Bills of Mortality* at regular intervals. By listing the number of deaths per week according to cause, these advisories alerted rich Londoners to any increase of disease that might suggest a precautionary retreat to the shelter of the countryside. Graunt's study of the *Bills*, originally published in 1661 or 1662, is considered to be the first statistical analysis ever undertaken. In addition to calling attention to numerous unsuspected societal regularities, such as the near constant percentage of deaths attributable to suicide, Graunt published credible estimates of London's population and its growth rate. Allowing for plagues, he found that "in eight times eight years the whole People of the City shall double without the access of Foreigners." Graunt, it should be noted, was well aware that a constant doubling time is not indefinitely sustainable. As he quaintly explained, "One couple, viz. Adam and Eve, doubling themselves every 64 years of the 5610 years, which is the age of the World according to the Scriptures, shall produce far more People, than are now in it."



Kepler, Galileo, Harvey, Leeuwenhoek, Halley, Graunt, and Petty—all these essays are packed into a mere twenty-one pages of text. It is inevitable that such brevity results in missed opportunities and incompleteness. Petty's political arithmetic, a statistically based statecraft using algebra for its analysis, is explained in theory, but no application is mentioned. It might have interested the reader to learn that Petty advised the government to combat the plague on economic rather than humanitarian grounds. Funds devoted to fighting the plague, Petty argued, would be profitably invested: the money used to save adult lives would preserve the far greater sums that had already been expended in rearing those individuals to maturity. We are familiar with similar public policy reasoning in modern life, but other suggested uses of political arithmetic now seem startling. As Theodore Porter relates in his study of social statistics [9], "Petty proposed that all Irishmen, save a few cowherds, should be forceably transported to England, for since the value of an English life far surpassed that of an Irish one, the wealth of the kingdom would thereby be greatly augmented."

The last six of Cohen's nine chapters are largely concerned with social and medical statistics. One chapter is devoted to the Belgian sociologist and statistician Adolphe Quetelet (1796–1874), who has been receiving his due in recent years [9], [12], [13]. Less well known is the Parisian lawyer and amateur statistician André-Michel Guerry (1802–1866), who is the subject of Cohen's shortest chapter. Simultaneously but independently, both men analyzed the records of criminal activity that the French government began to publish in 1827. Both were astonished by the regularity with which lawbreaking occurred. Guerry found it difficult to reconcile the constant crime rate with "the infinite number of circumstances that can cause the commission of a crime." Quetelet, believing that the puzzling data could be explained only by a societal component of criminality, concluded that

"Society prepares the crime and the guilty person is merely the instrument by which it is executed." There were many other unsuspected patterns for Guerry and Quetelet to pry from the data. Contrary to expectation, regions with the most educated inhabitants had the highest incidences of crime. One curious correlation noticed by Guerry when he scrutinized suicide records was paraphrased by an astounded English contemporary in this way: "The method by which a person destroys himself is almost as accurately and invariably defined by his age as the seasons are by the sun."

By contrasting nineteenth-century France with seventeenth-century London, we recognize the dawning of a new age of numerical information, an era characterized not only by the assiduousness with which nineteenth-century governments collected and disseminated demographic, social, and medical data but also by a heightened awareness that useful information could be gleaned from a careful study of the tables that were pouring forth. Whereas the *Bills of Mortality* waited nearly sixty years for a John Graunt, the *Compte Général…de la Justice Criminelle* was mined almost instantly by Guerry and Quetelet. Nevertheless, as the bandying of statistics grew, so did the number of critics. In *The Triumph of Numbers*, Cohen uses Charles Dickens, depicted as a well-meaning reactionary who "abhorred the introduction of numbers into discussions of human affairs," to represent the opposition to statistics. Other historians are more receptive to the contention of Dickens that statistics were being manipulated to discount the plight of the working poor. According to Michael Cullen [3, pp. 136, 144], to cite one example, "the statisticians were uniformly committed to policies of economic laissez-faire" and, in order to block labor reform, "disguised propaganda as facts." It was in the nineteenth-century, after all, that Saint Thomas Aquinas's long-standing classification of lies into three kinds—namely the jocose, the officious, and the malicious—evolved into the jibe "There are liars, there are outrageous liars, and there are scientific experts," which in turn mutated into the surviving barb "There are three kinds of lies: lies, damned lies, and statistics." (Cohen's assertion that "scholars now assume that this saying was invented by Mark Twain" is misleading: some scholars cite earlier uses [5], [6].)

Statistical applications in healthcare also had to overcome entrenched resistance. Physicians, striving for the ideal of certitude, often regarded probabilistic reasoning as unscientific. Furthermore, when the first attempts to introduce statistics into medical practice were made, the general public was not ready to place its trust in numbers. The deadly scourge of smallpox in the American colonies is a case in point. Before Edward Jenner discovered vaccination in 1796, the only preventive measure against smallpox was deliberate exposure to a mild case with the goal of survival and future immunity. This procedure, known as *variolation*, originated in seventeenth-century China and reached colonial America by the early 1700s. Despite some fervent advocates, the Puritan minister Cotton Mather included, variolation was distrusted by the public. As a result, waves of smallpox epidemics ravaged the colonies; one outbreak in 1736 took Benjamin Franklin's four-year-old son. In 1756 and 1759, Franklin, who bitterly regretted not having inoculated his child, published pamphlets in support of variolation. To "Parents who omit that Operation on the Supposition that they should never forgive themselves if a child died under it," Franklin cautioned, "my Example [shows] that the Regret may be the same either way, and that therefore the safer [option] should be chosen."

Franklin's strategy for convincing parents of the wiser choice was to analyze the relevant mortality statistics. Of course, his tactic now seems obvious, so far has our acceptance of statistical argument come, but it was inventive for its time. At one smallpox hospital Franklin found the death rate from inoculation to be 6 out of 1,601. At the same hospital 1,002 patients out of 3,856 who contracted smallpox "in the common way" died. Cohen does not directly say whether Franklin published or even determined the incidence of smallpox in the population, a statistic that is necessary for deciding the more prudent course. However, Cohen does quote Franklin's claim that the chance in favor of inoculation was as high as *thirty* to *one* (Franklin's emphasis). Given that epidemics in Boston in 1752 and Charleston in 1738 infected, respectively, 37.5 percent and 50 percent of the inhabitants of those cities, we see that Franklin's analysis was on the mark [1], [4]. The question then becomes, Did Franklin's advocacy of variolation have any measurable effect? Cohen is silent on the subject, but the evidence suggests that Franklin's efforts did *not* result in any triumph of numbers. Smallpox continued to decimate America for decades. Four years after Franklin's first pamphlet, Charleston suffered an epidemic that afflicted 75 percent of its citizens. In 1776, during Benedict Arnold's siege of Quebec in the American Revolutionary War, 1,200 of his 3,200 troops suffered from smallpox—the same incidence rate found in Boston a quarter of a century earlier [2].

The Triumph of Numbers concludes with a chapter that is entirely devoted to Florence Nightingale. Her interest in statistics, although fairly well known, is usually covered so perfunctorily in the mathematical literature (and often only for her commentary on Quetelet) that it is good to have Cohen's lengthier discussion. In 1854 Nightingale was dispatched to the Crimea in response to reports that appalling conditions were prevalent in British military hospitals. To convince the authorities that lives were being needlessly lost on a tragic scale,

Nightingale carefully collected hospital records and analyzed the causes of death. In one finding, she determined that the annual mortality rate in British hospitals in Turkey and the Crimea was 1,174 deaths per 10,000 patients, of which 1,023 per 10,000 were the result not of battle wounds but of disease. Her recommendations called for clean water, improved ventilation, proper sewage disposal, and hot water for laundering, measures that sharply reduced hospital mortality within one month of their implementation. This lesson should have been learned once and for all, but Nightingale had to repeat her algorithm of mortality analysis, nagging, and cajolery in order to win sanitary reform in other locales. Realizing that "none but scientific men ever look into the appendices of a Report," she took pains to augment her tabulated data with graphical presentations. To that end she introduced a type of pie chart, which she called a coxcomb, in which the sectors have equal angles but variable radii.

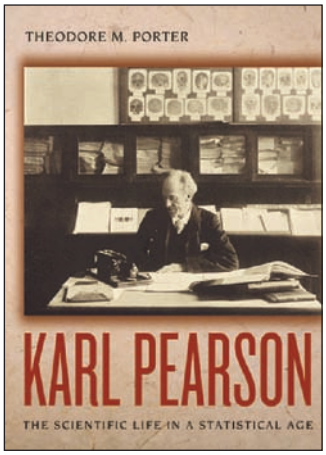
With the story of Florence Nightingale drawing to a close, the reader may sense that a triumph of numbers is near at last. Up until this point, Cohen's case studies have represented the significant steps that are promised in the first chapter but not the triumph that is announced in the title. Thus, when Cohen relates Nightingale's reduction of mortality in India from 69 British troops per 1,000 to 18 per 1,000, it appears that he is finally ready to drive home George Sarton's maxim "Humanity must be protected by the watchful Statistician." Instead, Cohen concludes with a less decisive message sent by Nightingale to Francis Galton in 1891, a letter that thirty years later prompted Karl Pearson to despair, "We are only just beginning to study social problems—medical, educational, commercial—by adequate statistical methods, and that study has at present done very little in influencing legislation." It is a dispiriting note on which to end and an enigmatic one too: why did Cohen bring his story to an abrupt halt a decade short of the twentieth century? A two-page epilogue mentions the punch card that Herman Hollerith invented to process the American census data of 1890, but this brief reference is not a convincing bridge between Florence Nightingale and the digital age. Perhaps a clue to Cohen's seemingly arbitrary close may be found in his *New York Times* obituary, which states that *The Triumph of Numbers* was originally envisioned as *The Fate of Mankind in a World of Numbers* [11]. The *Times* writer goes on to say that the manuscript was mailed the week before its 89-year-old author died. We are left to wonder if Cohen had planned a somewhat different book but wrapped it up when time grew short.

Whatever the case may be, what we do have is a well-written, engaging work that requires few allowances for the adverse conditions under which it was completed. Despite declining health and loss of vision, Cohen was able, for the most part, to bring to his last book the care and scholarship with which he was long associated. The *Numbers in History* section of the first chapter does, however, require some caution. Here Gaspard Monge is said to have invented projective geometry rather than descriptive geometry. Several factoids, apparently repeated from inaccurate secondary sources, are misleading or wrong. Dates are sometimes incorrect (the Narmer Macehead) or inconsistent (the Great Pyramid). Few miscues appear after this section, but several of Cohen's opinions may strike the reader as questionable. Christiaan Huygens, for example, is described as "really comparable with Isaac Newton." Fourier, according to Cohen, is "particularly remembered for his contributions to the mathematical theory of probability." The assertion that Laplace was "the most important mathematician since Isaac Newton" will be considered heretical by readers who see it as a demotion of Euler in the pantheon.

The Triumph of Numbers is neither the capstone of a long, distinguished career nor a technical history of statistical methods. Cohen has written a modest book aimed at the nonspecialist who has never noticed the prevalence of numerical data in modern society or who, having taken such notice, has wondered how society came to be so quantified. Because *The Triumph of Numbers* demands nothing more of its readers than a desire to be entertained and informed, it will reward a wide audience. For the mathematically sophisticated, its greatest value will lie in stimulating an interest in the rise of statistics. To those who wish to delve deeper, the books by Porter [9], [10] and Stigler [12], [13] are especially recommended.

For readers of the *Notices*, Theodore Porter's newest book, a study of Karl Pearson, also comes to mind as a natural follow-up to *The Triumph of Numbers*. Indeed, the continuation of the timeline is perfect: Pearson began his statistical work the year after the Nightingale letter with which Cohen's history concludes. From that time until the arrival of Ronald Aylmer Fisher decades later, Pearson dominated (in more than one sense) the statistical scene. During its first ten years his biometric school contributed about half of Britain's statistical work. Before these efforts only about 2 percent of papers presented to the Royal Statistical Society dealt with statistical methods [7]. It was largely Pearson who transformed statistics into a branch of mathematical analysis.

The pertinent facts of Karl Pearson's life can be outlined as follows. He was born in 1857; was educated at Cambridge, where he took third wrangler in 1879; was appointed Goldsmid Professor of Applied Mathematics and Mechanics at University College London in 1884; and was selected for the Gresham Lectureship of Geometry in 1891. After being influenced by the economist Francis Ysidro



Edgeworth in 1891 and the biologist Walter Frank Raphael Weldon in 1892, Pearson took up statistics as his vocation in 1892, published his first paper in statistics and coined the term *standard deviation* in 1893, introduced the product-moment correlation formula in 1896, developed the χ^2 test for goodness of fit in 1900, cofounded the journal *Biometrika* in 1901, founded the Biometric Laboratory in 1903, became the first director of Galton's Eugenics Laboratory in 1907, became the first Galton Professor of Eugenics in 1911, founded the *Annals of Eugenics* in 1925, retired in 1933, and died in 1936. His son, Egon Sharpe Pearson (1895–1980), also a leading statistician, became Karl's first biographer in 1936. (For the remainder of this review, "Pearson" will refer to Karl.)

As Stigler has remarked, throughout his adult years Pearson did the work of three men, but before his conversion to statistics it was always in three different fields [12]. In fact, German history, literature, folklore, philosophy, intellectual politics, applied mathematics, physics, and engineering all occupied Pearson to some extent before he turned to biometry, heredity, and other topics that share a statistical theme. Prior to his first paper on statistics, Pearson's publication list numbered one hundred items, nine of which were books (including a fictionalized autobiography and a passion play). Porter describes the Pearson of these years as a "thoroughly restless intellectual." Toward the end of this formative period, Pearson expressed misgivings that he was regarded as a "second-rate mathematician who indulges in extreme views & dabbles in journalism." He confessed to his fiancée, "I look back & round on all the odds & ends of careless & superficial work, which mark my life & make me shudder sometimes at the energy & time frittered away attempting what was not within my powers." Nearly forty years later, a few years after he had been offered the Order of the British Empire, which he refused, and a few years before he was offered a knighthood, which he also refused, Pearson continued to express doubts about his research: "Twenty years hence a curve or a symbol will be called 'Pearson's' & nothing more remembered of the toil of the years."

Pearson was prescient in that *his* name is commemorated primarily by the Pearson correlation coefficient—it is Egon who is remembered when Neyman-Pearson is cited. However, the toil of Karl's years, far from being forgotten, has inspired a vast literature scattered among the journals of diverse fields such as sociology, economics, psychology, genetics, medicine, and epidemiology (in addition to more obvious ones such as statistics and the history of science). For some time now, an expert synthesis has been overdue. Although Egon's memoir [8], written in the year of Karl's death when memories were fresh and documents handy, remains a valuable resource, it is more of a guide to Karl's career in statistics than a proper biography. Furthermore, Egon lacked three important advantages that are available to a modern scholar: the passage of enough time to assess the lasting value of Karl's contributions to science, the objectivity that so polemical a subject as Karl requires in a biographer, and the extensive historical and sociological research that has appeared in the seventy years since Karl's death.

For the connoisseur of biography, the first six chapters of Porter's *Karl Pearson* will prove impressive. Such a reader is bound to marvel at the extent to which Porter immersed himself in Pearson's world, studying the cultural and intellectual currents that Pearson navigated, absorbing the books that influenced Pearson, and travelling down the many dead ends of Pearson's wander years. This part of *Karl Pearson* can be recommended as a self-contained Bildungsroman to both the historian of the Victorian era and the aficionado of biography. The last of these chapters, "Intellectual Love and the Woman Question", presents a particularly intriguing account of Pearson's courtships, all of which were pursued with characteristic eccentricity. In the wooing of Maria Sharpe, for example, Pearson followed his marriage proposal with written confessions of his personality defects. The tactic of admitting hypersensitiveness, self-consciousness, selfish tendencies, and "an almost equally vicious tendency to periods of depression & moroseness" did not disarm Maria immediately, but after nearly a year of anxious deliberation she did accept his offer.

Pearson's marriage in 1890 is the last event in the biographical thread of Porter's book. Excluding a brief epilogue, the final quarter of Porter's study concerns the "statistical impulse" that seized Pearson soon after he wed. How Pearson discovered his vocation after so many false starts is an interesting question. In 1934 Pearson himself asserted that "It was Galton who first freed me from the prejudice that sound mathematics could only be applied to natural phenomena under the category of causation." As Porter has previously observed [9, p. 299], Pearson was either forgetful or disingenuous in this reference to Galton's *Natural Inheritance*. In fact, reporting on Galton's book in 1889, Pearson warned of the "considerable danger in applying the method of exact science to problems in descriptive science." Stigler has suggested that Edgeworth was the pivotal figure in Pearson's turn to statistics [12, p. 305], whereas Porter in his first book concluded that it was only through Weldon that Pearson came to accept Galton's statistical approach [9,

p. 299]. In his new book, Porter attributes Pearson's conversion to "a new vision, one that he acquired not through a single Eureka experience but episodically, over about three years." Porter continues, "Initially his new interest in statistics grew out of an ideal of education, the cultivation of a more effective citizenry." This judgment is reinforced pages later when Porter endorses the widely held view that eugenics motivated and even shaped Pearson's statistical work.

The two chapters that Porter allots to Pearson the statistician concentrate on Pearson's most creative period, the last decade of the nineteenth-century. Because of this narrow focus, very little is said about Pearson's final thirty years, a period of rapid progress in statistics during which Pearson continued to play a prominent though diminishing role. In contrast to the attention lavished on the cultural and social milieux that molded Pearson, the statistical enterprise that Pearson so greatly influenced is largely neglected. William Sealy Gosset, better known by the pseudonym "Student", is mentioned only once, even though he published almost exclusively in Pearson's *Biometrika*. Florence Nightingale David, an assistant of Pearson's who went on to have a distinguished independent career, is not mentioned at all. Pearson's professional disputes were too numerous to receive full coverage, but it is regrettable that Porter does not include a detailed account of Pearson's especially acrimonious and protracted feud with Fisher. Their squabble, which started during World War I, flared up in 1922, and occupied Pearson on multiple fronts in the last few months of his life, is of great interest not only for the many important statistical issues that were raised but also for the nature of the personal combat. "*Wasting your time fitting curves by moments, eh!*" was the opening salvo in one of Pearson's last papers, a public reply to Fisher's attacks on his method of moments and system of frequency curves.

Porter, in a reflexive epilogue concerning methodology and conclusions, confesses that contrary to the general view of scholars he has come to regard Pearson as a figure that is more tragic than malign. Porter's readers may be disinclined to share this assessment, particularly because Porter does not conceal Pearson's offensive beliefs and behaviors. Thus, Porter characterizes the personal insults that Pearson liberally inserted into *Biometrika* as "pointless and petulant" and describes Pearson's writings as "uncourtly", "unattractive", and "disturbing". Porter also exposes Pearson's smug racism and deeply held eugenic sentiments. Here, however, his analysis would have had even greater effect had he quoted Pearson more extensively. Consider, for example, the ideal of education and the cultivation of a more effective citizenry, the key factors Porter cites in Pearson's conversion to statistics. These seem to be benevolent motivations when Porter refers to them, but Pearson's own words reveal a more sinister intent: "It is cruel to the individual, it serves no social purpose, to drag a man of only moderate intellectual power from the hand-working to the brain-working group," "Intelligence can be aided and trained, but no training or education can create it. You must breed it," and "From a bad stock can come only bad offspring, and if a member of such a stock is, owing to special training and education, an exception to his family, his offspring will still be born with the old taint."

Though fairness may be in danger when a historical figure is judged by the ethos of a later era, the declaration of Pearson-trained statistician George Udny Yule that "Votes for women is for me nearly as loathworthy as eugenics" demonstrates the abhorrence of eugenics among even those of Pearson's contemporaries who do not seem enlightened by present-day standards. If nothing else, Pearson's biometric interests remind us that anthropometry and craniometry were flourishing at the end of the nineteeth-century. The cephalic index would soon be joined by other contentious numerical measures such as IQ, the general intelligence factor *g*, and Pearson's own *coefficient of racial likeness*. Cohen did not have to confront such argumentative quantities in his book because of his choice of time frame. Will future historians who update his story be able to speak of a *triumph* of numbers?

Because Porter's *Karl Pearson* is neither a conventional biography nor a thorough account of Pearson's career in statistics, it will seem to fall between two stools. If a classifying label is needed, then *microhistory*, the term Porter uses in his epilogue, is apt. Many readers of the *Notices* will regret that Porter did not write a different sort of book, but no reader of *Karl Pearson* will have cause to wish for a more successful book of its type. Of course, there is still much work for a Pearson scholar to do. Now that nineteenth-century Pearson has received so outstanding a treatment, we may hope for the arrival of another biographer to chronicle twentieth-century Pearson with equal mastery.

References

[1] NICOLAU BARQUET and PERE DOMINGO, Smallpox: The triumph over the most terrible of the ministers of death, *Annals of Internal Medicine* **127** (1997), 635–642.

[2] ANN M. BECKER, Smallpox in Washington's army: Strategic implications of the disease during the American Revolutionary War, *The Journal of Military History* **68** (2004), 381–430.

[3] MICHAEL JOHN CULLEN, *The Statistical Movement in Early Victorian Britain: The Foundations of Empirical Social Research*, The Harvester Press Limited, John Spiers, 1975.

[4] JOHN DUFFY, *Epidemics in Colonial America*, Louisiana State University Press, 1953.

[5] STEPHEN GORANSON, Lies, statistics: Talleyrand? (or dead end?), American Dialect Society list server, January 26, 2007, http://listserv.linguistlist.org/cgi-bin/wa?A2=ind0701d&L=ads-l&D=0&P=12466.

[6] I. D. HILL, Review of "Quotes, Damned Quotes, and…", *J. Roy. Statist. Soc. Series A* **146** (1983), 431.

[7] DONALD A. MACKENZIE, *Statistics in Britain 1865–1930: The Social Construction of Scientific Knowledge*, Edinburgh University Press, 1981.

[8] EGON PEARSON, *Karl Pearson: An Appreciation of Some Aspects of His Life and Work*, Cambridge University Press, 1938.

[9] THEODORE M. PORTER, *The Rise of Statistical Thinking 1820–1900*, Princeton University Press, 1986.

[10] _____ , *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*, Princeton University Press, 1995.

[11] WOLFGANG SAXON, I. Bernard Cohen, 89, Dies; Pioneer in History of Science, *New York Times*, June 28, 2003.

[12] STEPHEN M. STIGLER, *The History of Statistics: The Measurement of Uncertainty before 1900*, Harvard University Press, 1986.

[13] _____ , *Statistics on the Table: The History of Statistical Concepts and Methods*, Harvard University Press, 1999.

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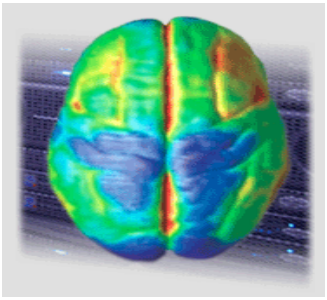

IPAM/CCB Summer School: MATHEMATICS IN BRAIN IMAGING

July 14 – 25, 2008

ORGANIZING COMMITTEE: Paul Thompson (UCLA School of Medicine), **Michael Miller** (Johns Hopkins University), **Russ Poldrack** (UCLA Dept. Psychology), **Tom Nichols** (Oxford University/GlaxoSmithKline), **Keith Worsley** (McGill University), **Jonathan Taylor** (Stanford)

Introduction

This two-week intensive workshop will focus on mathematical techniques applied to brain images to measure, map and model brain structure and function. Topics will range from modeling anatomical structures in MRI scans, and mapping connectivity in diffusion tensor images, to statistical analysis of functional brain images from fMRI, EEG, and MEG. Current applications in radiology and neuroscience will be highlighted, as will new directions in the mathematics of structural and functional image analysis. In the second week on Functional Brain Mapping, a series of lectures on diffusion tensor imaging will discuss mathematics and tools for registration, segmentation, fiber tracking and connectivity modeling in tensor and "beyond-tensor" (high-angular resolution) diffusion images, using metrics on Riemannian manifolds. Software implementing a wide range of algorithms will be demonstrated; tutorial notes will be provided. Talks will interest newcomers as well as experts in the field. Morning lectures on the principles behind the methods; afternoon lectures will go in-depth into applications.

Program Schedule

- Week 1: Computational Anatomy, July 14 – 18, 2008
- Week 2: Functional Brain Mapping, July 21 – 25, 2008

Participation

Additional information about this program including links to register and to apply for funding, can be found on the webpage listed below. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission, and we welcome their applications.

www.ipam.ucla.edu/programs/mbi2008

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Irving Kaplansky 1917–2006

Hyman Bass and T. Y. Lam

I liked the algebraic way of looking at things. I'm additionally fascinated when the algebraic method is applied to infinite objects.
—*Irving Kaplansky*

Introduction

On June 25, 2006, mathematics lost one of its leading algebraists, Irving Kaplansky. He passed away at age eighty-nine after a long illness, at the home of his son, Steven. Eight months earlier he was still doing mathematics (Diophantine equations). Steven's question, "What are you working on, Dad?" brought only, "It would take too long to explain." From a generous teacher and elegant expositor who inspired generations of students and young researchers, this utterance offers perhaps a hint of the weary burdens of his final illness.

"Kap", as Kaplansky became universally known among friends and colleagues, was not only a brilliant research mathematician and teacher, but also an accomplished musician, a distinguished institutional leader, and a devoted husband and father. The remembrances and tributes that follow are from some of the many colleagues, students, friends, and family who Kap influenced and inspired. We hope that they adequately convey the awesome breadth of Kap's life and work—as a mathematician, teacher, writer, administrator, musician, and father—that we celebrate here.

Hyman Bass is professor of mathematics and mathematics education at the University of Michigan. His email address is hybass@umich.edu.

T. Y. Lam is professor of mathematics at the University of California, Berkeley. His email address is lam@math.berkeley.edu.

All photos in this article, except where otherwise noted, are courtesy of Alex Kaplansky.

Hyman Bass

Some Biographical Vignettes of Kap

Mathematicians are conventionally measured by the depth and creativity of their contributions to research. On these grounds alone Kaplansky is a towering figure. But another, perhaps comparably important, way to contribute to the advancement of mathematics lies in the building of human capacity, in the formation of productive young researchers, through teaching, mentoring, and written exposition. In this regard, Kaplansky, with an astonishing fifty-five doctoral students (among whom I count myself), and 627 mathematical descendants, has had a singular impact on our field.

Kap was born March 22, 1917, in Toronto, the youngest of four children, shortly after his parents had emigrated to Canada from Poland. His father, having studied to be a rabbi in Poland, worked in Toronto as a tailor. His mother, with little schooling, was enterprising and built up a business, "Health Bread Bakeries", that supported (and employed) the whole family.

Family photo, approximately 1921. Irving Kaplansky (second from left, see red arrow) and his parents and siblings.

Kap showed an early and evolving talent for music, as he himself recounts [1]:

> At age four, I was taken to a Yiddish musical, Die Goldene Kala (The Golden Bride). It was a revelation to me that there could be this kind of entertainment with music. When I came home I sat down and played the show's hit song. So I was rushed off to piano lessons. After 11 years I realized there was no point in continuing; I was not going to be a pianist of any distinction.…I enjoy playing piano to this day.…God intended me to be the perfect accompanist—or better, the perfect rehearsal pianist. I play loud, I play in tune, but I don't play very well.

First Putnam Fellow, Harvard, around 1940.

Indeed, Kap became a popular accompanist and performer through much of his career. At one point, to demonstrate the virtues of a structure he discovered common to his favorite songs, he says, "I tried to show that you could [use it to] make a passable song out of such an unpromising source of thematic material as the first 14 digits of π." The resulting "Song about π" was later given lyrics by Enid Rieser and is often performed by Kap's daughter, Lucy, herself a popular folk singer-songwriter [3]. Some more personal family vignettes of Kap can be found below in Lucy's reminiscences of her father.

As a senior at the University of Toronto in 1938, Kap won the very first Putnam Competition, as did the Toronto team. This won him a fellowship to Harvard, where he earned his Ph.D. in 1941, under the direction of Saunders Mac Lane. He stayed on as a Benjamin Peirce Instructor till 1944, when Mac Lane brought him to the Applied Mathematics Group at Columbia University in 1944–45, which was doing work to support the war effort. Kap recounts, "So that year was spent largely on ordinary differential equations. I had a taste of real life and found that mathematics could actually be used for something."

From there Kap moved to the University of Chicago in the fall of 1945, where he remained till his retirement in 1984, having chaired the department during 1962–67. A year after Kap's arrival, Marshall Stone came to Chicago to direct and build up the mathematics department, ushering in what some have called "the Stone Age". Stone made four gigantic appointments—Saunders Mac Lane, Antoni Zygmund, André Weil, and Shiing-Shen Chern—followed by waves of talented young faculty and graduate students. Among the younger colleagues who greatly influenced Kap were Irving Segal, Paul Halmos, and Ed Spanier.

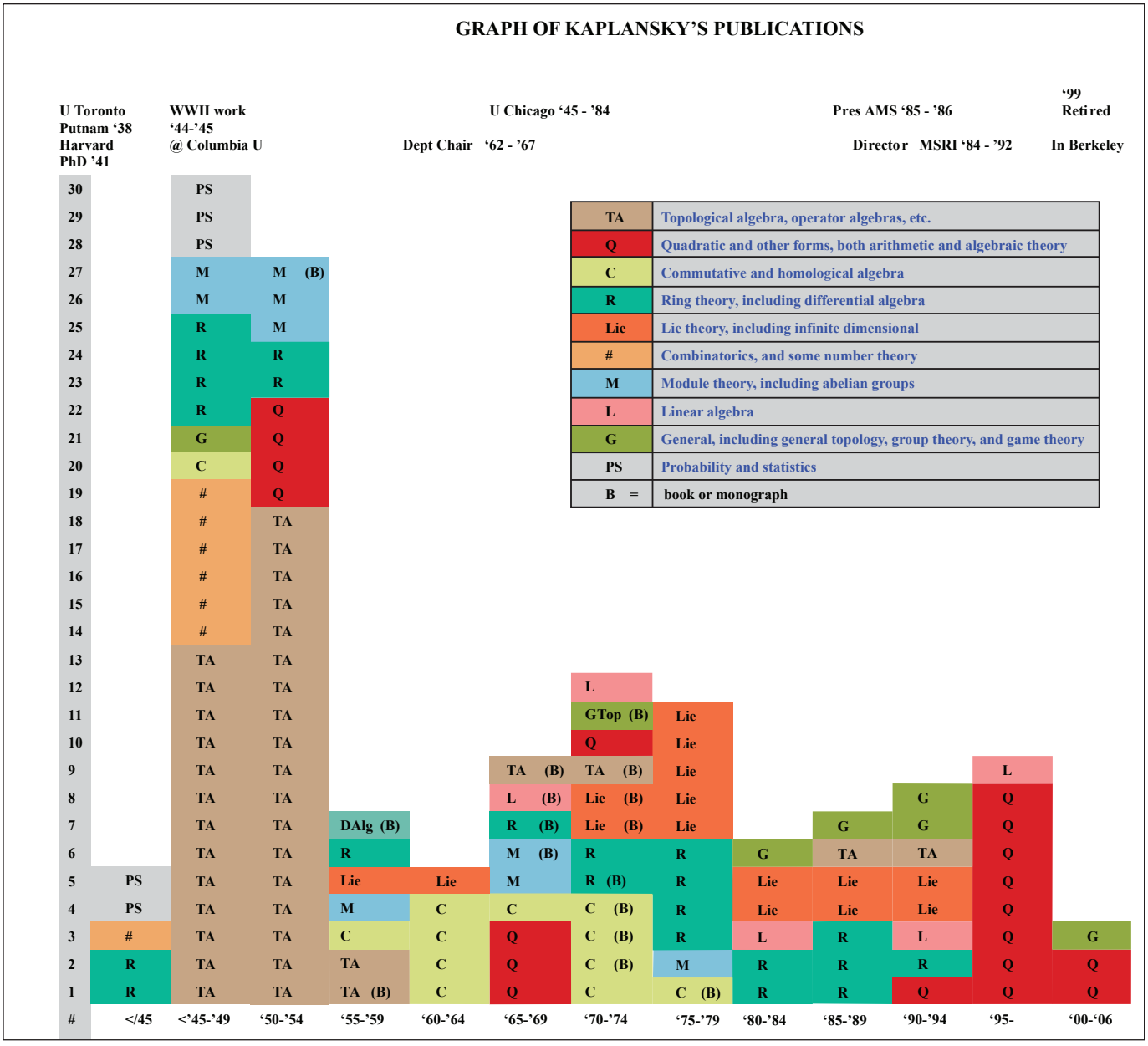
Kap's life style, outside his family and music, was rigorous and austere. He scheduled classes and meetings at (defiantly) early hours of the morning. Daily swimming was a lifelong practice; he loved the Lake Michigan shoreline. Lunch was lean in time as well as substance. With students he was generous and indulgent in mathematical conversation, but entertained little else.

After Chicago, Kap, succeeding Shiing-Shen Chern, became the second director of the Mathematical Sciences Research Institute (MSRI) in Berkeley, 1984–1992. Also in 1984, Kap was elected president of the AMS. So we see here a career trajectory from a precocious college student to a dedicated, well established and prolific researcher, to a leader of some of the premier institutions of the profession. Along the way, Kap was honored by election to the National Academy of Sciences and to the American Academy of Arts and Sciences, and he was named an honorary member of the London Mathematical Society. In 1989 the AMS awarded him the Steele Prize, Career Award.

To understand Kap's mathematical accomplishments, it is important to speak of his students as well as his publications, to distinguish and compare what these two records tell us. Kap's mathematical work is distributed across several different areas of mathematics. For purposes of surveying them, I have somewhat arbitrarily grouped them as follows, the major areas in bold font:

- **TA: Topological algebra, including operator algebras, *-algebras, locally compact rings, etc.**
- **Q: Quadratic and higher forms, both abstract and arithmetic aspects**
- **C: Commutative and homological algebra**
- R: Ring theory (noncommutative)
- **Lie: Lie theory—groups and algebras, including infinite dimensional and characteristic p**
- #: Combinatorics and number theory
- M: Module theory, including abelian groups
- L: Linear algebra
- G Miscellaneous, including general topology, group theory, game theory
- PS: Probability and statistics

In the following chronological chart I have color-coded Kap's journal articles, books, and monographs according to which of these areas they belong. The data are taken from MathSciNet. Not included are the numerous contributions to the Problem sections of the *American Mathematical Monthly*; Kap remained throughout a virtuoso problem solver and contributor.



Several remarkable things stand out from this chart.

• As a fresh Ph.D during the years of WWII, Kap published, beyond his dissertation (on maximal fields with valuation), a small but interesting mix of papers on combinatorics and on probability and statistics, perhaps in part influenced by his applied work at Columbia.

• Then, in the decade 1945–54 there is an extraordinary outpouring of publications, predominantly in what we are calling topological algebra. In fact, in the four years 1948–52, Kap published thirty-two papers! Some of this may have been backlog from the war years, but it is an astonishing ensemble of cutting-edge work in this area. Kap's general inclination was to algebraically axiomatize the various structures of concern to functional analysts, in the program launched earlier by Murray and von Neumann. Dick Kadison [2] writes in some detail about this phase of Kap's work.

• Kap's work in pure noncommutative ring theory is a persistent, but relatively modest theme in his work. One of his most influential papers, on "Rings with polynomial identity", opened an important branch of noncommutative algebra. Here he proves the fundamental result that a primitive algebra with polynomial identity is finite dimensional over its center.

• Lie theory, in its many aspects, is another important strand. This includes work on the classification of simple Lie algebras in characteristic p, lecture notes on the solution of Hilbert's Fifth Problem, and work, partly in collaboration with the physicist Peter Freund, on graded Lie algebras,

Kaplansky had 55 students (1950-1978) and 627 descendents

16					Richard Tarsy '69			MSRI
15					Robert Kibler '69			
14					E. Graham Evans, Jr. '69			
13					Richard Wagner '68			
12					Richard Shaker '68			
11			Gunther Lumer '59		Howard Gorman '68			
10			Hyman Bass '59		Susanna Epp '68			
9		Jacob Feldman[1] '54	Joseph Rotman '59		Mahlon Michael Day '67			
8		Fred Wright, Jr. '53	Eben Matlis '58	Jacob Towber '64	Alphonse Buccino '67	Charles Hanna '74		
7		Oscar Litoff '53	Donald Ornstein '57	Ronald Hamelink '64	Diana Taylor '66	Daniel Anderson '74		
6		William Darsow '53	Hazleton Mirkilmozrw '57	Fred Richman '63	Wolmer Vasconcelos '66	Jacob Matijevic '73		
5		H. Arlen Brown[2] '52	Edward Posner '57	Kolumum Nagarajan '62	Dean Heller '66	Adrian Wadsworth '72		
4		Isidor Fleisher '52	George Kolettis, Jr. '57	Robert MacRae '61	Hwa Tsang '65	Peter Kohn '72		
3		Alex Rosenberg '51	Sterling Berberian '55	Edward Davis '61	Gerson Levin '65	Judith Sally '71	Harry Hutchins '78	
2		Flora Dinkines '51	Harold Widom '55	John Eagon '61	Yung-yung Kuo '65	Bruce Prekowitz '71	Michael Modica '75	
1		Chester Feldman '50	Malcolm Goldman '55	Steven Chase '60	Samuel Gedwiser '65	Stephen McAdam '70	Warren Nichols '75	
#	<'50	'50-'54	'55-'59	'60-'64	'65-'69	'70-'74	'75-'79	≥ '80

[1] Kap was actually the second advisor, the first being Irving Segal. Feldman had 36 descendants.

[2] Kap was actually the second advisor, the first being Paul Halmos. Brown had 74 descendants.

super-symmetry, and related classification problems. Peter Freund writes vividly below about their collaboration.

• Quadratic (and higher) forms: This subject, from the beginning to the end of Kap's career, was dear to his heart. This interest was first inspired by his attending L. E. Dickson's lectures in number theory and quadratic forms at Chicago in the 1940s. It was rekindled during the years of his retirement, when he turned to the arithmetic theory of such forms, partly in collaboration with William Jagy. A charming account of a significant piece of this work can be found in the contribution of Manjul Bhargava below.

• In the eyes of many mathematicians today, commutative and homological algebra is the field with which they now most associate Kaplansky's name. Yet we see that its (yellow) color occupies remarkably little of the chart of publications. How can we explain this paradox? Well, for one thing, Kap's publications in this area include several books and monographs (lecture notes), and these contain a number of new results and methods that were not elsewhere published. This also reflects the fact that Kap was generating mathematics in this rapidly evolving field more through instruction than through papers written in solitude. And so what he was producing mathematically was significantly embodied in the work of the students who were learning from him.

• We can see this phenomenon in the preceding chart of Kap's Ph.D. students, again color-coded by the areas of their dissertations.

The first thing to notice in comparing these two charts is that the "relative masses" of topological algebra and commutative algebra have been approximately reversed, of course with a time shift. In topological algebra, Kap was a pioneer and a major, intensely productive, conceptual developer of the field. In commutative and homological algebra, in contrast, the field was already in rapid motion, into which Kap boldly ventured as more of an apprentice, guiding a flock of similarly uninitiated graduate students and postdocs with him.

Homological algebra was spawned from algebraic topology. In the hands of Eilenberg, Mac Lane, Grothendieck, and others it evolved into a new branch of algebra, embracing category theory and other new constructs. Meanwhile, the Grothendieck-Serre reformulation of algebraic geometry demanded that its foundations in commutative algebra be deepened and expanded.

A basic new concept of homological algebra was that of global homological dimension, a new ring-theoretic invariant. This turned out to be uninteresting for the most investigated rings, finite dimensional (noncommutative) algebras. On the other hand, a landmark discovery (of Auslander-Buchsbaum and Serre) was that, for a commutative noetherian local ring A, the global dimension of A is finite if and only if A is regular (the algebraic expression of the geometric notion of nonsingularity). This equivalence, and Serre's homological formulation of intersection multiplicities, firmly established homological algebra as a fundamental tool of commutative algebra.

However, these developments were known mainly on a Cambridge (MA)–Paris–axis. It was in this context that Kap offered a Chicago graduate course introducing these new ideas, methods, and results, then still very much in motion. Use of these methods led to the general proof (by Auslander-Buchsbaum) of unique factorization for all regular local rings. Kap's course, and its sequels, lifted a whole generation of young researchers (myself included) into this field. This played out for Kap over the next two decades, with many students and several books to show for it.

In mathematical style, Kap was a problem solver of great virtuosity. For course goals he sought problems, and theorems of great pedigree, and probed them deeply. His main focus was on proofs (pathways), more than on theorems (destinations). He sought geodesics, and the most economic (high mileage) means to get there. Proof analysis led to double-edged kinds of generalization/axiomatization:

– A given proof yields more than claimed. The given hypotheses deliver more than the stated theorem promises.

– The hypotheses can be weakened. We can get the same results more cheaply, and so more generally.

The strength of this disposition was perhaps sometimes over-zealous, pushing toward "premature maturation" of the mathematics. But it was an effective mode of instruction, yielding powerful conceptual command of the territory covered.

As the record above indicates, and the testimonials below will affirm, Kap was a gifted teacher, mentor, and writer. Here are a few of the things he himself has said in reflection on this.

> *I like the challenge of organizing my thoughts and trying to present them in a clear and useful and interesting way. On the other hand, to see the faces light up, as they occasionally do, to even get them excited so that maybe they can do a little mathematical experimentation themselves—that's possible, on a limited scale, even in a calculus class.*

> Advice to students: *"Look at the first case, the easiest case that you don't understand completely. Do examples, a million examples, 'well chosen' examples, or 'lucky' ones. If the problem is worthwhile, give it a good try—months, maybe years if necessary. Aim for the less obvious, things that others have not likely proved already."*

> And: "*Spend some time every day learning something new that is disjoint from the problem on which you are currently working (remember that the disjointness may be temporary). And read the masters."*

> *When a great mathematician has mastered a subject to his satisfaction and is presenting it, that mastery comes through unmistakably, so you have an excellent chance of understanding quickly the main ideas.* [He cites as examples, Weil, Serre, Milnor, Atiyah.]

> *…the thing that bedevils the mathematical profession—the difficulty we have in telling the world outside mathematics what it is that mathematicians do. And for shame, for shame, right within mathematics itself, we don't tell each other properly.*

And here is a sampling of how Kap was seen by others, including some of his students:

"He was not only a fantastic mathematician but a marvelous lecturer, and he had a remarkable talent for getting the best out of students."

—Richard G. Swan

"I knew Kaplansky in his later years, and also through some of his books. Cheerful, gracious, and elegant are some of the words that come to mind when I think of him."

—Roger Howe

"The mathematical community in India is shocked to have news of the demise of Professor Irving Kaplansky. We all feel very sad at this irreparable loss. Professor Kaplansky was a source of inspiration for mathematicians around the world. He will no doubt live for all time through his mathematical contributions. We will miss his personal wit, charm and warm personality."

—I. B. S. Passi, President,
Indian Mathematical Society

"I did know about the work of Emmy Noether and it may have influenced my choice of area, algebra, although I think the teaching of Irving Kaplansky was what really inspired me."

—Vera Pless

Kaplansky's books "have one feature in common. The content is refreshing and the style of exposition is friendly, informal (but at the same time mathematically rigorous) and lucid. The author gets to the main points quickly and directly, and selects excellent examples to illustrate on the way."

—Man Keung Siu

"I learnt from his books in my youth, and would not have survived without them. Even today, I ask my students to read them, to learn the 'tricks' of the trade."

—Ravi Rao

"Kaplansky was one of my personal heroes: during my student years, I discovered his little volume on abelian groups and noticed that algebra too has stories to tell…"

—Birge Huisgen-Zimmermann

Kap as a Thesis Advisor: "I was very young and very immature when I was Kap's student. I'm deeply indebted to Kap for putting up with me and helping me to develop in my own eccentric way. I asked Kap for a thesis problem that didn't require any background and, surprisingly, he found one with enough meat in it to allow me to get a feeling for doing research.

"It wasn't until I had my own thesis students that I realized how hard it must have been to accommodate my special needs and help me develop in my way, not in his way."

—Donald Ornstein (Kap Ph.D., 1957)

For me Kap's transition from course instructor to thesis advisor was almost imperceptible, since I had become deeply engrossed in his courses on commutative and homological algebra and questions about projective modules, an exciting territory wide open for exploration, and for which Kap had laid a solid groundwork. He did float a few other problems to me, such as the structure of certain infinite dimensional Lie algebras, whose significance I only later came to appreciate. But I didn't take that bait then. He was a generously available and stimulating advisor, often sharing promising ideas that he had not yet had time to pursue. What I remember most of that time is the brilliance of his courses, and the richness and excitement of the mathematical milieu that he had created among his many students then. This milieu powerfully amplified the many mathematical resources that Kap had to offer. I think that it is fair to say that Kap's students are an important part of his oeuvre. One could hardly have asked for a better teacher and advisor.

Chair, University of Chicago Math Department, 1962–1967.

References

[1] DONALD J. ALBERS, Interview with Irving Kaplansky, *The College Mathematics Journal* **22** (1991), no. 2, pp. 99–117.

[2] RICHARD V. KADISON, Irving Kaplansky's role in mid-twentieth century functional analysis, *Notices* of the AMS (to appear).

[3] IVARS PETERSON, A song about π, MathTrek, *MAA Online*, July 12, 1999.

T. Y. Lam

Kap: A Tale of Two Cities

Through Professor Hyman Bass, Kap was my mathematical grandfather. This and the fact that Kap offered me my first job as an instructor at Chicago were perhaps not statistically independent events. The time was forty years ago, when Kap was finishing his five-year term as Chicago chair. The offer was consummated by a Western Union telegram—the 1960s equivalent of email. Kap didn't ask for my C.V. (I wouldn't have known what that was); nor did he want to know my "teaching philosophy" (I had none). For my annual salary, Kap offered me US$8,000—a princely sum compared to my then T.A. stipend of US$2,000 at Columbia University. I have joked to my colleagues that I'll always remember Kap as the only person through my whole career to have ever quadrupled my salary. But in truth, a ticket to Chicago's famed Eckhart Hall for postdoctoral studies was more than anything a fledgeling algebraist could have dreamed. For this wonderful postdoctoral experience Kap afforded me through his unconditional confidence in a mathematical grandson, I have always remained grateful.

I met Kap for the first time in the fall of 1967 when I reported to work in Hyde Park. By that time, Kap had already taught for twenty-two years at the University of Chicago. Although he was Canadian by birth, Chicago had long been his adopted home and workplace: it is, appropriately, the city where our "tale" begins.

For students interested in abstract algebra, Kaplansky is virtually a household name. In graduate school, I first learned with great delight Kap's marvelous theorem on the decomposition of projective modules, and his surprisingly efficient treatment of homological dimensions, regular local rings, and UFDs. It was to take me forty more years, however, to get a fuller glimpse of the breadth and depth of Kap's total mathematical output. In these days of increasing specializations in mathematics, we can only look back in awe to Kap's trail-blazing work through an amazingly diverse array of research topics, ranging from valuation theory, topological algebra, continuous geometry, operator algebras and functional analysis, to modules and abelian groups, commutative and homological algebra, P.I. rings and general noncommutative rings, infinite-dimensional Lie algebras, Lie superalgebras (supersymmetries), as well as the theory of quadratic forms in both its algebraic and arithmetic flavors. Kap was master of them all. In between the "bigger" works, Kap's publications also sparkled with an assortment of shorter but very elegant notes, in number theory, linear algebra, combinatorics, statistics, and game theory. All of this, still, did not include the many other works recorded in "fourteen loose-leaf notebooks" (referred to in the preface of [1]) that Kap had kept for himself over the years. One cannot help but wonder how many more mathematical gems have remained hidden in those unpublished notebooks!

For me, reading one of Kap's papers has always proved to be a richly rewarding experience. There are no messy formulas or long-winded proofs; instead, the reader is treated to a smooth flow of novel mathematical ideas carefully crafted to perfection by an artisan's hand. Some authors dazzled us with their technical brilliance; Kap won you over by the pure soundness of his mathematical thought. In his publications, Kap was much more given to building new conceptual and structural frameworks, than going down single-mindedly into a path of topical specialization. This style of doing mathematics made him a direct intellectual descendant of Emmy Noether and John von Neumann. As a consequence, many of Kap's mathematical discoveries are of a fundamental nature and a broad appeal. The famous Kaplansky Density Theorem for unit balls and his important inaugural finiteness result in the theory of rings with polynomial identities are only two of the most outstanding examples.

Those of us who have had the privilege of listening to Kap all knew that he was extremely well spoken and had indeed a very special way with words. However, this gift did not always manifest itself when Kap was in social company with Chellie. It was quite clear to all his colleagues who Kap thought was the better orator in the family. Dinner parties the Kaps attended were often replete with Chellie's amusing stories about the Chicago department and its many colorful mathematical personalities, from an austere André Weil down to the more transient, sometimes bungling graduate students over the years. As Chellie recounted such funny stories with her characteristic zest and candor, Kap would listen admiringly on the side —without interruption. Only at the end of a story would he sometimes add a clarifying comment, perhaps prompted by his innate sense of mathematical precision, such as "Oh, that was 1957 summer, not fall."

Kap's extraordinary gift in oral (and written) expression was to find its perfect outlet in his teaching, in which it became Chellie's turn to play a supporting role. In the many lecture courses Kap gave at the University of Chicago in a span of thirty-nine years, he introduced generation after generation of students to higher algebra and analysis. In those courses he taught that were of an experimental nature, Kap often directly inspired his students to new avenues of investigation, and even to original mathematical discoveries at an early stage. (Schanuel's Lemma on projective resolutions, proved by Stephen Schanuel in Kap's fall 1958 Chicago course in homological algebra, was perhaps the best known example.) It was thus no accident that Chicago graduate students flocked to Kap for theses supervision. Over the years, Kap directed doctoral dissertations in almost every one of the mathematical fields in which he himself had worked. Many of Kap's fifty-five Ph.D. students from Chicago are now on the senior faculty at major universities in the U.S. Currently, the Mathematics Genealogy Project listed Kap as having 627 descendants—and counting. This is the *second* highest number of progeny produced by mathematicians in the U.S. who had their own Ph.D. degrees awarded after 1940. We leave it as an exercise for the reader to figure out who took the top honor in that category, with the not-too-useful hint that this mathematician was born a year after Kap.

Books of Irving Kaplansky

Infinite Abelian Groups, 1954, 1969
An Introduction to Differential Algebra, 1957, 1976
Introduction to Galois Theory (in Portuguese), 1958
Rings of Operators, 1968
Fields and Rings, 1969, 1972
Linear Algebra and Geometry. A Second Course, 1969, 1974
Commutative Rings, 1970, 1974
Lie Algebras and Locally Compact Groups, 1971, 1974
Set Theory and Metric Spaces, 1972, 1977
Matters Mathematical (with I. Herstein), 1978
Selected Papers and Other Writings, 1995

While Kap had clearly exerted a tremendous influence on mathematics through his own research work and that of his many Ph.D. students, the books written by him were a class by themselves. The eleven books listed in the sidebar on this page traversed the whole spectrum of mathematical exposition, from the advanced to the elementary, reaching down to the introduction of mathematics to non-majors in the college. *Differential Algebra* typified Kap's broad-mindedness in book writing, as its subject matter was not in one of Kap's specialty fields. On the other hand, *Infinite Abelian Groups* introduced countless readers to the simplicity and beauty of a subject dear to Kap's heart, while *Rings of Operators* served as a capstone for his pioneering work on the use of algebraic methods in operator algebras. *Lie Algebras*, *Commutative Rings*, as well as *Fields and Rings*, all originating from Kap's graduate courses, extended his classroom teaching to the mathematical community at large, and provided a staple for the education of many a graduate student worldwide, at a time when few books covering the same materials at the introductory research level were available. In these books, Kap sometimes experimented with rather audacious approaches to his subject matters. For instance, *Commutative Rings* will probably go down on record as the only text in commutative algebra that totally dispensed with any discussion of primary ideals or artinian rings.

As much as his books are appreciated for their valuable and innovative contents, Kap's great fame as an author derived perhaps even more from his very distinctive writing style. There is one com-

mon characteristic of Kap's books: they were all short—something like 200 pages was the norm. (Even *Selected Papers* [1] had only 257 pages, by his own choice.) Kap wrote mostly in short and simple sentences, but very clearly and with great precision. He never belabored technical issues, and always kept the central ideas in the forefront with an unerring didactic sense. The polished economy of Kap's writing makes it all at once fresh, crisp, and engaging for his readers, while his mastery and insight shone on every page. The occasional witty comments and asides in his books—a famous Kaplansky trademark—are especially a constant source of pleasure for all. In retrospect, Kap was not just a first-rate author; he was truly a superb expositor and a foremost mathematical stylist of his time.

After I moved from Chicago to Berkeley, my contacts with Kap became sadly rather infrequent. So imagine my great surprise and delight, sixteen years later, when word first came out that Kap was to retire from the University of Chicago, in order to succeed Chern as the director of MSRI! In the spring of 1984, the Kaplanskys arrived and established their new abode a few blocks north of the university campus—in Berkeley, California, the second city of our tale.

The math departments at Chicago and Berkeley share much more than the "U.C." designation of the universities to which they belong. There has been a long (though never cantankerous) history of the Berkeley department recruiting its faculty from the Chicago community, starting many years ago with Kelley, Spanier, and Chern. Indeed, when Kap himself joined the U.C.B. faculty in 1984, there were at least as many as sixteen mathematicians there who had previously been, in one way or another, associated with the University of Chicago. It must have given Kap a tinge of "nostalgia" to be reunited, in such an unexpected way, with so many former graduate students, postdocs, and colleagues from his beloved Chicago department. But if anyone had speculated that, by coming West, Kap was to spend his golden years resting on his laurels, he or she could not have been more wrong. In fact, as soon as Kap arrived at Berkeley in 1984, he was to take on, unprecedentedly, two simultaneous tasks of herculean proportions: (a) to head a major mathematics research institute in the U.S., and (b) to preside over the largest mathematical society in the world—the AMS[1].

Other contributors to this memorial article are in a much better position than I to comment on Kap's accomplishments in (a) and (b) above, so I defer to them. In the following, my reminiscences on Kap's Berkeley years are more of a personal nature. From 1984 on, I certainly had more occasions than ever before to interact mathematically with Kap—discussing with him issues in quadratic forms and ring theory. Kap seemed to favor the written mode of communication (over the oral), but his letters were just as concise as his books. I still have in my prized possession an almost comical sample of Kap's terseness, in the form of a covering letter for some math notes he sent me. Written out on a standard-size 8½ by 11 MSRI letterhead, the letter consisted of twelve words: "Dear Lam: I just did a strange piece of ring theory. Kap." It was briefly—but of course unambiguously—dated: "Apr. 11 /97".

Another interaction with Kap in 1998 led to some mathematical output. In preparation for a special volume in honor of Bass's sixty-fifth birthday, I was very much hoping to commission an article from Kap. In his usual self-effacing fashion, Kap protested that he had really nothing to write about. However, after much persuasion on my part (stressing that he must write for Bass), he gave in and wrote up in his impeccable hand a short note in number theory [2]. Glad that my tactics had paid off, I worked all night to set Kap's written note in TEX, and delivered a finished printout to him early the next morning. Kap was surprised; he thanked me profusely, but said that maybe he shouldn't have written his article. It was too late.

One of Kap's best known pieces of advice to young mathematicians was to "spend some time every day learning something new that is disjoint from the problem on which you are currently working,...and read the masters" [3]. Amazingly, even after reaching his seventies, Kap still took his own advice personally and literally. In all the years he was in Berkeley, Kap made it his habit to go to every Monday's Evans-MSRI talk and every Thursday's Math Department Colloquium talk. He even had a favorite seat on the left side of the front row in the colloquium room, which, in deference to him, no local Berkeley folks would try to occupy. In the years 1995–97 when I worked at MSRI, I saw Kap quite frequently at the periodicals table in the library, poring over the *Mathematical Reviews* to keep himself abreast with the latest developments in mathematics. And he read the masters too, e.g., in connection with his work on the integral theory of quadratic forms. Members of MSRI have reported sightings of Kap using a small step-ladder in the library to reach a certain big book on a high shelf, and putting the book back in the same fashion after using it (instead of leaving it stray on a table). That tome was an English translation of *Disquisitiones Arithmeticae*: the fact that even a six-foot-tall Kap needed a step-ladder to access it was perhaps still symbolic of the lofty position of the work of the twenty-year-old Carl Friedrich Gauss.

My two-years' stay at MSRI was rich with other remembrances about Kap. Undoubtedly, a highlight was Kap's eightieth birthday fest in March

[1] *Kaplansky served as AMS president-elect in 1984, and president for the 2-year period 1985–86.*

1997, which was attended by three MSRI directors and six MSRI deputy directors, as well as visiting dignitaries such as Saunders Mac Lane, Tom Lehrer, and Constance Reid. Another most memorable gathering was the holiday party in December 1996, where a relaxed and jovial Kap sang some of his signature songs for us all, accompanying himself on the piano in the MSRI atrium. His energetic, sometimes foot-stomping performance really brought down the house! It saddens me so much to think that, now that Kap is no longer with us, these heart-warming events will never be repeated again.

Twenty years may have been only about a third of Kap's professional life, but I hope that Kap cherished his twenty years in Berkeley with as much fondness as he had cherished his thirty-nine years in Chicago. Those were the two cities (and universities) of his choice, for a long and very distinguished career in mathematics. In Chicago, Kap was a researcher, a chairman, a teacher, a mentor, and an author. In Berkeley, while remaining a steadfast researcher, Kap also became a scientific leader, a senior statesman, and a universal role model. In each of these roles, Kap served his profession with devotion, vigor, wisdom, and unsurpassed insight. His lifetime work has profoundly impacted twentieth century mathematics, and constituted for us an amazingly rich legacy.

On a personal level, Kap—mathematical grandpa and algebraist par excellence—will continue to occupy a special place in my heart. I shall miss his great generosity and easy grace, but thinking of Kap and his towering achievements will always enable me to approach the subject of mathematics with hope and joy.

References

[1] I. KAPLANSKY, *Selected Papers and Other Writings*, Springer-Verlag, Berlin-Heidelberg-New York, 1995.

[2] _____ , A salute to Euler and Dickson on the occasion of Hy's 65th birthday, in *Algebra, K-theory, groups, and education* (T. Y. Lam, A. Magid, eds.), Contemp. Math. **243** (1999), pp. 79–81, Amer. Math. Soc., Providence, R.I.

[3] _____ , Response to Steele Prize citation (Career Award), *Notices of the Amer. Math. Soc.* **36** (1989), p. 836.

Richard Kadison

Letter from Richard Kadison to Section 11 (Mathematics) of the National Academy of Sciences

(Addressed to the Chair, Paul Rabinovich, July 1, 2006)

Dear Paul,

Just about ten minutes ago, I sat down to my email; I had looked at it at about 9:30 a.m.—before the sad news about Kap arrived. So, I saw the message appended below (you have it as well) only a few minutes ago. I was shocked by the news. "Sad" really doesn't begin to describe my feelings; Kap was almost as close, where I'm concerned, as a beloved parent. Of all my graduate school teachers (Stone, Zygmund, Chern, Spanier, Halmos, Segal, Weil, Graves, Hestenes, Mac Lane, Albert, etc.), and I revered each and every one of them, Kap was my favorite. A half-hour-to-hour conversation with him about mathematics generated so much excitement that I spent the rest of the day walking on a cloud. Irv was immensely popular with the graduate students; he was always ready to talk math with us and make good and useful suggestions for our work, but he was also somewhat "scary" for many of the students. His "social" behavior was even more peculiar than the "standard" behavior of dedicated mathematicians. Most of us have an exaggerated sense of the "futility" of small talk; Irv's view of that had to be described as "excessive". For example, if you met him in the hallway and stopped for a conversation with him, when the conversation was clearly over, he just walked on, turned and walked away, whatever—absolutely no decompression stage (or phrases, e.g., the currently popular, and almost always, fatuous "have a nice day"—recently inflated to "have a great day"). Handshakes? Forget it! As fast and smart and creative as he was, and all that (genuine, not affected) no-nonsense behavior of his, we loved ("worshipped" might be more accurate) him. Chatting with him in his office, after a few years, he asked me a nice question that had occurred to him, a fine blend of algebra and analysis (nilpotents of index 2 and approximation). I thought about it for fifteen minutes or so that evening and didn't see how to get started. Being busy with other things I dropped it and didn't get back to it until I met and talked to him a day or two later. He asked me if I had thought about the problem. I said that I had, but hadn't been able to get started on it, and then asked him if he really thought it

Richard Kadison is the Gustave C. Kuemmerle Professor of Mathematics at the University of Pennsylvania. His email address is kadison@math.upenn.edu.

Kap and Chellie Kaplansky on their wedding day, 1951.

was true. His response was, "When God whispers a theorem in your ear, you should listen." Now, of course I understood his "cute" way of giving me some valuable mathematical advice, but I chose to misinterpret it. When I reported this to the other graduate students, I told them the story and added that Kaplansky had finally revealed himself, and as many of us had suspected, he was God. In those very early years (end of the 1940s), Irv lived an austere life. He rented a single room in a house near the U. of Chicago campus, paid $5 a week for it, if I remember correctly, and saved almost all the rest of his salary. The word was that he was (relatively) wealthy in those days. (Of course, that could mean anything from someone with a bank balance of $100 and up and no debts, in those days and our society.) Chellie (Rochelle), Irv's wife of fifty-five years was tremendous fun, great sense of humor. I had the impression that she could wrap him around her little finger, he knew it, and he enjoyed it. She entered the picture in 1951. Some years later (about five), George Mackey was having dinner with Karen and me at our apartment in Cambridge (we were visiting MIT that year). The conversation turned to Irv. (Kap and George were great friends.) When the subject of Kap's purported wealth came up, George told of a conversation he and Chellie had had some little time back. He said that he had asked Chellie if she didn't feel that she was lucky to have married a wealthy man—to which she replied, with a (feigned) surprised smile, "Oh, that—it was only about $30,000 and I went thru that in no time!" George paused after reporting that, assumed a troubled, somber look and said, "Fair, sent a chill down my spine!" It probably helps to know that, in those days, George was still a bachelor, and lived a frugal, austere existence—completely by choice. Both Kap and Mackey were perfectly willing to spend their money when the occasion warranted it. I've had many fine meals with each of them. Kap did not eat lunch with us during our graduate student days, we took too long with it. I remember a bunch of us walking down the stairs of Eckhart Hall on our way over to lunch at the Commons. Irv came bouncing past us, evidently on the same mission. The Commons is a few hundred meters from Eckhart. We sauntered over arriving in time to see Kap emerging from the Commons, lunch over. Chellie probably slowed him down over the years. In my first years at Chicago, Irv had no discernible social life. He liked swimming in Lake Michigan during the summer and did so early each morning. Then, in 1949 he had a few quarters off and went out for a stay at UCLA. The rumors flew back to Chicago, Kap had bought himself a convertible, now drank liquor, socially, and smoked. One day it was said that the "new" Kaplansky had returned. A day later, I happened on my dear pal and fellow graduate student, Arnold Shapiro. He told me that he had just talked with Irv a few hours ago. I asked, "The new Kaplansky?" Arnold's reply was, "What new Kaplansky? It's just the old Kaplansky—with a smile on his face." Shortly after that, a few of us finished our Ph.D. requirements. As tradition had it, we invited one and all to a party. Walking around with a tray and two drinks ("highballs") on it, one primarily scotch and the other bourbon, I offered one of those drinks to Irv. His question for me was, "Which is the perfume and which is the hair tonic?" That, apparently, was the "new" Kaplansky. Of course, I could tell you so many more stories about Irv, many of them that have some mathematical significance. They are all memories I treasure. Kap is one of the very few people I've known well most of my working life of whom I can say that I have nothing but enjoyable memories.

—Kindest,
Dick

Peter G. O. Freund

Irving Kaplansky and Supersymmetry[2]

I arrived in Chicago some two decades after Irving Kaplansky, and I met Kap, as we all called him, shortly after my arrival here. We became friends later, in 1975, while collaborating on a paper on supersymmetry. Lie superalgebras, graded counterparts of ordinary Lie algebras, play a central role in string theory and other unified theories. A classification of the simple ones was of essence. I took some initial steps, but the real work started when Yitz Herstein put me in touch with Kap. At first, communication was not easy. We couldn't quite make out each other's reasoning, much as we agreed on results. It didn't take long however,

Peter G. O. Freund is professor emeritus in the department of physics at the University of Chicago. His email address is freund@theory.uchicago.edu.

[2]*Based on remarks at the Irving Kaplansky Memorial at MSRI, Berkeley, CA, February 23, 2007.*

to get used to the other's way of looking at things. Mathematicians and physicists think in similar ways after all, all that was needed was a dictionary. This was during the early phase of the rapprochement between mathematics and theoretical physics. After the glorious first half of the twentieth century—when the likes of Poincaré, Hilbert, Weyl, von Neumann, Élie Cartan, Emmy Noether, and others made major contributions to the then-new physical theories of general relativity and quantum mechanics, while physicists like Jordan, Dirac, Casimir, and Feynman made major contributions to mathematics—physics entered a period best described as phenomenological. During this period, some advanced complex function theory aside, very little modern mathematics was drawn on. To give you an idea, when in his celebrated "Eightfold Way" paper, Murray Gell-Mann wrote down a basis of the three-dimensional representation of the $su(3)$ Lie algebra, this was heralded by physicists as a great mathematical feat. "Imagine, he found a 3×3 generalization of the famous 2×2 Pauli matrices," is what most people said. To get there, Murray had consulted with Block and Serre!

It was in the fields of supersymmetry and gauge theory that the initial steps in modern mathematical physics were taken. This convergence of the paths of mathematics and of theoretical physics is typical of times when major new physical theories—gauge theory and string theory in this case—are being born. The earliest example of such a convergence is the creation of calculus at the birth of Newton's mechanics and of his theory of gravitation. Weyl's spectacular work on group theory under the impact of the newborn quantum mechanics is another such example.

A few words about our joint paper [1] are in order here. In it we found all the infinite families of simple Lie superalgebras, as well as 17-, 31- and 40-dimensional exceptional ones. We also discussed real forms and explained why supersymmetry can act on 4-dimensional anti-de Sitter but not on de Sitter space, a result essential for understanding why the remarkable duality discovered by Maldacena [2] in the 1990s, is of the AdS/CFT and not of the dS/CFT type. We were convinced that we had found all simple Lie superalgebras (as we actually had), but we lacked a proof of this fact. The proof came from the powerful independent work of Victor Kac [3]. Amusingly, in his beautiful proof, Kac somehow overlooked one of the exceptional superalgebras, namely the 31-dimensional superalgebra $G(3)$, whose Bose (even) sector consists of the ordinary Lie algebra $g_2 + sl(2)$, the only simple Lie superalgebra to have an exceptional ordinary Lie algebra as one of the two constituents of its Bose sector. I said "amusingly" above because, as I learned from Kap, in the classification of ordinary simple Lie algebras, in his extremely important early work, Killing had found almost all of them, but he "somehow overlooked one," namely the exceptional 52-dimensional simple Lie algebra F_4, which remained to be discovered later by Élie Cartan. Apparently, $G(3)$ is the exceptional Lie superalgebra which carries on that curse of the ordinary exceptional Lie algebra F_4.

I mentioned the almost total lack of contact between theoretical physicists and mathematicians, when this work got going. It went so deep that in 1975 most physicists, if asked to name a great modern mathematician, would come up with Hermann Weyl, or John von Neumann, both long dead. Mathematicians had it a bit easier, for if they read the newspapers, they could at least keep track of the Nobel Prizes, whereas newspaper editors rarely treated Fields Medal awards as "news fit to print."

I recall that while standing by the state-of-the-art Xerox machine to produce some ten copies of our paper in about…half an hour's time, I asked Kap, "Who would you say, is the greatest mathematician alive?" He immediately took me to task: my question was ill-defined, did I mean algebraist, or topologist, or number-theorist, or geometer, or differential geometer, or algebraic geometer, etc.…I replied that I did not ask for a rigorous answer, but just a "gut-feeling" kind of answer. "Oh, in that case the answer is simple: André Weil," he replied, without the slightest hesitation, a reply that should not surprise anyone, who has heard today's talks. "You see," Kap went on, "We all taught courses on Lie algebras or Jordan algebras, or whatever we were working on at the time. By contrast, Weil called all the courses he ever taught simply 'mathematics' and he lived up to this title."

Kap went on to tell me about Weil's legendary first colloquium talk in Chicago. This was the first time I heard that very funny story. Weil had been recruited for the Chicago mathematics department by its chairman, Marshall Stone. With Stone sitting in the first row, Weil began his first Chicago colloquium talk with the observation, "There are three types of department chairmen. A bad chairman will only recruit faculty worse than himself, thus leading to the gradual degeneration of his department. A better chairman will settle for faculty roughly of the same caliber as himself, leading to a preservation of the quality of the department. Finally, a good chairman will only hire people better than himself, leading to a constant improvement of his department. I am very pleased to be at Chicago, which has a very good chairman." Stone laughed it off; he did not take offense.

The lack of communication between mathematicians and physicists was to end soon. By 1977, we all knew about Atiyah and Singer, and then the floodgates came down fast, to the point that an extremely close collaboration between mathematicians and physicists got started and, under

the leadership of Ed Witten and others, is ongoing and bearing beautiful fruit to this day. By the way, on Kap's desk I noticed some work of his on Hopf algebras. I asked him about Hopf algebras, and got the reply, "They are of no relevance whatsoever for physics." I took his word on this, was I ever gullible. In the wake of our joint work, Kap and I became good friends. This friendship was fueled also by our shared love of music; he was a fine pianist, and I used to sing. For me, the most marvelous part of my collaboration and friendship with Kap was that for the first time I got to see up-close how a great mathematician thinks.

References

[1] P. G. O. FREUND and I. KAPLANSKY, Simple supersymmetries, *J. Math. Phys.* **17** (1976), 228–31; I. KAPLANSKY, Superalgebras, *Pacific J. Math.* **86** (1980) 93–8.

[2] J. M. MALDACENA, The large *N* limit of superconformal theories and supergravity, *Adv. Theor. Math. Phys.* **2** (1988), 231–52; archive hepth/9711200.

[3] V. G. KAC, Classification of simple superalgebras, *Funct. Anal.* (English) **9** (1975), 263-5; ibid. 10,163 (1976); A sketch of Lie superalgebra theory, *Comm. Math. Phys.* **53** (1977) 31–64.

Calvin C. Moore

Kap Encounters in Chicago and Berkeley

I first "met" Kap mathematically when I was a graduate student at Harvard working in functional analysis and read and studied his striking 1951 papers on C*-algebras in which he defined and explored the properties of what he called CCR and GCR algebras. His algebraic insight into these objects arising in analysis turned out to be of seminal importance and indeed were years ahead of their time. I also read about what was by then called the Kaplansky density theorem for von Neumann algebras dating from 1952 and studied his wonderful 1948 paper on groups with representations of bounded degree and its connection with polynomial identities.

I was eager to meet this algebraist whose work had been so influential in my own studies in a very different field, and I had that opportunity when I had a postdoctoral appointment at Chicago in 1960–61. However, I soon left Chicago for Berkeley, and it was many years before our paths crossed again. When we were planning a full year program at the Mathematical Sciences Research Institute (MSRI) in 1983-84 on the topic of infinite dimensional Lie algebras, Kap's broad and deep insight and understanding in algebra led us to select him as the chair of the program committee. We also recognized that his subtle and effective diplomatic skills would be essential ingredients in making this program the great success that it was.

Almost at the same time, the Board of Trustees of MSRI selected Kap to succeed Shiing-Shen Chern as director of MSRI in 1984. We served together at MSRI, he as director and I continuing as deputy director for a year before I left MSRI for an administrative post in the University of California. It was a wonderful learning and teaching experience for both of us. I learned much from Kap's wisdom and experience, and I in turn tried to convey to him what I knew about MSRI operations. I subsequently watched more from a distance, and it was clear that MSRI grew and prospered under his eight years of excellent leadership as director. He also maintained a lively research program while serving as director and for many years after stepping down. We all miss this generous and wise man of many talents.

Calvin C. Moore is emeritus professor of mathematics at the University of California, Berkeley. His email address is ccmoore@math.berkeley.edu.

Susanna S. Epp and E. Graham Evans Jr.

Kap as Advisor

We are two of the fifty-five students who completed a doctorate with Kaplansky between 1950 and 1978. This is an astonishing number. Indeed during the years 1964–1969, when we were at the University of Chicago, Kap oversaw an average of three completed dissertations a year despite serving as department chair from 1962–1967. His secret, we think, was an extraordinary instinct for productive avenues of research coupled with a generous willingness to spend time working with his students. He also often encouraged students to run a seminar, with beginning students presenting background material and advanced students presenting parts of their theses.

When Evans worked with him, Kap was teaching the commutative algebra course that was published soon afterward by Allyn and Bacon. As with each course he taught, he filled it with new thoughts about the subject. For instance, at one memorable point he experimented to see how much he could deduce if he knew only that $\mathrm{Ext}^1(A,B)$ was zero. He managed to get pretty far, but eventually the proofs became unpleasantly convoluted. So he abruptly announced that henceforth, he would assume the full structure of $\mathrm{Ext}^i(A,B)$, and the next day he resumed lecturing in his usual polished fashion. This episode was atypical in that he first developed and then cut off a line of inquiry. More frequently, after commenting on

Susanna S. Epp is Vincent de Paul Professor of Mathematics at DePaul University. Her email address is sepp@condor.depaul.edu.

E. Graham Evans Jr. is emeritus professor of mathematics at the University of Illinois at Urbana-Champaign. His email address is graham@math.uiuc.edu.

new insights of his own, he would interject questions for students to explore and develop. In his lectures he made the role of non-zero divisors, and hence regular sequences, central in the study of commutative rings. At one point he gave an elegant proof, avoiding the usual filtration argument, that the zero divisors are a finite union of prime ideals in the case of finitely generated modules over a Noetherian ring. Then he asked Evans to try to determine what kinds of non-Noetherian rings would have the property that the zero divisors of finitely generated modules would always be a finite union of primes. One of the ideas in Kap's proof was just what Evans needed to get the work on his thesis started.

The year that Epp worked with Kap, he was not teaching a course but had gone back to a previous and recurring interest in quadratic forms. A quintessential algebraist, he was interested in exploring and expanding classical results into more abstract settings. Just as in his courses he tossed out questions for further investigation, in private sessions with his students he suggested various lines of inquiry beyond his own work. In Epp's case this meant exploring the results Kap had obtained in generalizing and extending H. Brandt's work on composition of quaternary quadratic forms and trying to determine how many of these results could be extended to general Cayley algebras.

Kap typically scheduled an early morning weekly meeting with each student under his direction. For some it was much earlier than they would have preferred, but for him it followed a daily swim. He led our efforts mostly by expressing lively interest in what we had discovered since the week before and following up with question after question. Can you prove a simpler case? Or a more general one? Can you find a counterexample? When one of us arrived disappointed one day, having discovered that a hoped-for conjecture was false, Kap said not to be discouraged, that in the search for truth negative results are as important as positive ones. He also counseled persistence in other ways, commenting that he himself had had papers rejected—a memorable statement because it seemed so improbable. Having made contributions in so many fields and having experienced the benefits of cross-fertilization, he advised being open to exploring new areas. Some of his students may have taken this advice further than he perhaps intended, ultimately working far from their original topic areas at the National Security Agency, at the Jet Propulsion Laboratory, and in K–12 mathematics education, for example.

Kap derived a great deal of pleasure from having generated 627 mathematical descendants, perhaps especially from meeting his mathematical grandchildren and great-grandchildren. When one encountered him at the MSRI bus stop one day and, not knowing what to say, commented on the weather, Kap responded with a smile, "Cut the crap. Let's talk mathematics." They did, and he became one of the many students Kap mentored long after he retired.

Joseph Rotman

Student Memories of Kap

As a graduate student at the University of Chicago, I attended many of Kaplansky's elementary courses: complex variables, group theory, set theory, point-set topology; later, I attended more advanced courses: commutative algebra, Hilbert's fifth problem, abelian groups, homological algebra. Every course, indeed, every lecture, was a delight. Courses were very well organized, as was each lecture. Results were put in perspective, their applications and importance made explicit. Humor and droll asides were frequent. Technical details were usually prepared in advance as lemmas so as not to cloud the main ideas in a proof. Hypotheses were stated clearly, with examples showing why they were necessary. The exposition was so smooth and exciting that I usually left the classroom feeling that I really understood everything. To deal with such arrogance, Kap always assigned challenging problems, which made us feel a bit more humble, but which also added to our understanding. He was a wonderful teacher, both in the short term and for the rest of my mathematical career. His taste was impeccable, his enthusiasm was contagious, and he was the model of the mathematician I would have been happy to be.

Kap was my thesis advisor. I worked in abelian groups (at the same time, he had five other advisees: two in homological algebra and three in functional analysis). He set weekly appointments for me. When I entered his office, he was usually sitting comfortably at his desk, often with his feet up on the desk. He'd greet me with "What's new?" I would then talk and scribble on the blackboard as he listened and asked questions. Once I had axiomatized a proof of his and Mackey's, enabling me to generalize their result. "How did you think of that?" he asked. I replied that that was the way he had taught me to think; he smiled.

Both of us spent a sabbatical year in London at Queen Mary College. Of course, I continued to enjoy his mathematics, but I saw another side of him as well. N. Divinsky was another sabbatical visitor (as was H. Flanders), and I was dubbed Rotmansky to go along with Kaplansky and Divinsky. Kap discovered cricket, and often went to Lord's Cricket Grounds. But Kap really loved Gilbert and Sullivan. He arranged an evening in which we performed Iolanthe. Kap was at the piano, Divinsky

Joseph Rotman is emeritus professor of mathematics at the University of Illinois at Urbana-Champaign. His email address is rotman@math.uiuc.edu.

did the patter songs, Flanders was on the recorder, and I was Strephon.

There are few giants in the world, and now there is one less.

Lance Small

Kap as Teacher and Mentor

I was not a student of Kaplansky—at least, not in the sense we usually mean in mathematics. He was, however, my teacher in a number of courses, undergraduate and graduate, and was chairman of the University of Chicago math department when I was a graduate student. Kap's "style", mathematical as well as personal, shone through everywhere.

Photograph courtesy of Julius Zelmanowitz, MSRI.

Kaplansky at the keyboard.

Nowadays, most math departments offer a "bridge" course for their majors. This course is designed to ease the transition to real, upper-division mathematics from (increasingly) less rigorous calculus courses. Chicago has had such a course for years. In my day, it was Math 261; at present it has the fashionably inflated number 26100. Currently, just as it did several decades ago, the course covers "sets, relations, and functions; partially ordered sets; cardinal numbers; Zorn's lemma, well-ordering, and the axiom of choice; metric spaces; and completeness, compactness, and separability." When I took the course, Kap used notes of Ed Spanier on "Set Theory and Metric Spaces". Spanier never got around to writing these notes up as a book. Kap, however, did! *Set Theory and Metric Spaces* appeared in 1972 and continues in the AMS Chelsea series. Kaplansky's style is as appealing to current students as it was to us decades ago. I have used the book in my classes for many years. One of my recent students enjoyed the book so much that she bought it as a birthday present for her engineer father!

As chairman, Kap maintained a keen interest in graduate students and the graduate program. His sensitivity to grad student-advisor dynamics can be illustrated by the following anecdote. One afternoon at math tea, my advisor, Yitz Herstein, and I got into a "discussion" on how Kap (of Canadian origin like Yitz) pronounced "schedule". I maintained that Kap would pronounce it with an "sk" as Americans do and Yitz, of course, said that Kap would say "shedule", as Canadians and Britons do. So, Yitz and I bet a quarter. When Kap arrived at tea, Yitz and I bounded up to him and told him of our bet. Kap thought for an instant and, then, carefully pronounced "skedule" remarking that faculty shouldn't take money from students and that Yitz "should pay up." However, I only got 15 cents.

Kap's rhetorical flourishes are well known; but, sometimes they had unintended consequences. For my first job, I needed official certification that I had completed the Ph.D. A letter from the chairman would suffice. Kap wrote such a letter concluding "…and, barring catastrophe, he will receive the degree on June 11…." This was deemed insufficient by a departmental administrator at Berkeley who quoted the "barring catastrophe" remark. Kap washed his hands of it and sent me off to the Dean of Students in the Division of Physical Sciences for a "really" official letter.

Even, at the last moment, during my final oral exam, Kap's style was apparent. He asked me where would you find a commutative ring with some property or other. I started to construct the ring when he interrupted: "No, no, in what book would you look for it?" I replied, "Nagata" and was off the hook!

Kap's lessons and advice remain fresh to this day. His books and his expositions are as attractive to the current generation of students as they were to mine.

Manjul Bhargava

Kap Across Generations

I was a graduate student at Princeton in the year 1999. And being a student of algebra, I obviously knew of Professor Kaplansky, though I knew of him more as a "legend" than as a person. His name was one that was attached to a number of great theorems, some going back to the 1940s. At the time I suspect it never occurred to me that he might be an actual person who was still doing great mathematics.

While working on my dissertation, I became interested in a classical problem from number theory relating to quadratic forms. (It was not really a problem in the "Kaplansky style", or so I thought!) The question was: When does a positive-definite integral quadratic form represent all positive integers? (For example, Lagrange's Four Squares Form $a^2+b^2+c^2+d^2$ gives such an expression—i.e.,

Lance Small is professor of mathematics at the University of California, San Diego. His email address is lwsmall@ucsd.edu.

Manjul Bhargava is professor of mathematics at Princeton University. His email address is bhargava@math.princeton.edu.

every positive integer can be written as a sum of four square numbers.) This was a beautiful question of Ramanujan that Professor Conway taught me about and got me hooked on.

After working on the question for some time, I realized that some good headway could be made provided that one could understand the classification of what are known as "regular ternary forms". In particular, I needed to know: How many such regular ternary forms are there? I did some searches on MathSciNet, and soon enough found a 1997 (!) paper by W. Jagy and I. Kaplansky entitled: "There are 913 regular ternary forms".

Here was the exact answer to my question in the very title of a paper written only two years ago! It was quite exciting, and I thought to myself "Surely this is not the same Kaplansky!," but after some research I soon discovered that it was.

I emailed Jagy and Kaplansky later that week, and heard back from both almost immediately. Kap and Will (Jagy) were also both very excited that their recent work had found applications so soon. I mentioned to them that I would be in Berkeley for a few weeks that summer to learn tabla with my teacher, and Kap kindly invited me to visit MSRI while I was there.

Kap asked David Eisenbud, the director of MSRI, to give me an office for the summer, and David generously agreed. That summer turned out to be one of my most productive summers ever. I worked on mathematics during the day and played tabla by night. Rather than working in my private office, I found myself mostly working in Kap's office! We didn't really work together, but rather we worked independently and then shared what we had discovered or learned at various intervals throughout the day. Kap, Will, and I discussed and learned various mathematical topics together in what were some extremely enjoyable sessions. Kap's love, enthusiasm for, and unique view of mathematics were constantly evident and always inspiring!

In addition, I talked to Kap a lot about other things; we shared common interests not only in mathematics but also in music, making it a rather frequent topic of conversation. In the process, I also learned a great deal about Kap's amazingly regular life and his other associated charming idiosyncrasies. He brushed his teeth more often than anyone I've ever known. And no matter how exciting a particular conversation or work session was, if it was time for his daily noon swim, then there was no stopping him from running off to the pool! (The same occurred when it was time for his chosen 5:14 p.m. end-of-the-day bus from MSRI.) I found myself changing my own schedule to match his work schedule better (including waking up rather early!).

The same schedule was adhered to the following few summers, as he always generously invited me back (He would write, "Looking forward to renewing our sessions!," and there were always new and exciting things to discuss; every year I looked forward to it.) Until the very last summer, when I heard the sad and devastating news. I've since always felt that it was unfair that I got to know him only toward the later years of his life. Of course, deep down I know I should be grateful that I got to meet him at all, and to have been one of the lucky ones in my generation to have had the privilege of knowing him. He was so encouraging to me always, as a person, as a musician, and most of all, as a mathematician. I will always cherish the memories of his enthusiasm, brilliance, generosity, and friendship. I will miss him very much.

David Eisenbud

Kap at MSRI

Kap was enormously influential in many fields of mathematics, through his papers, through his books, and perhaps most of all through his Ph.D. students and the many many additional students who, like myself, listened raptly to his courses. I remember well his highly entertaining and beautifully polished lectures from my student days in Chicago —whatever he taught, I signed up for the course, it being such a pleasure to listen to him. From being on the first winning team of the Putnam competition to being president of the AMS and National Academy member, his career was truly remarkable —you can find more information starting from the AMS website, `http://www.ams.org/ams/48-kaplansky.html`.

As the second director of MSRI, Kap served the Institute directly from 1984 through 1992. He greatly developed the reputation and influence of MSRI, building on the start provided by the founders, Chern, Moore, and Singer. My own first experiences at MSRI were under Kaplansky's directorship. As with everything he did, he paid attention to every detail of the operation—he boasted to me once that he personally read and signed every single letter of invitation that the Institute sent out during his eight years in office. He and his wife, Chellie, were also very present and available to the members—literally thousands will remember Kap's musical performances at the Christmas parties. Among the many marks Kap left on MSRI was the start of fundraising activity. For example Kap formed the "International Board of Friends of MSRI", and the connections made through this group are still of the utmost importance to us. Kap's first paper appeared in 1939. After stepping down as MSRI director, at seventy-five, Kap went back to full time research mathematics, and returned to number theory, one of his first loves.

David Eisenbud is professor of mathematics at the University of California, Berkeley. He is former director of MSRI. His email address is `de@msri.org`.

Photograph courtesy of Julius Zelmanowitz, MSRI.

AMS president, 1985–86.

Some of his most recent work, on integral quadratic forms, was published in 2003, when he was eighty-six.

Mathematically, Kap was my brother: he, the first student of MacLane, I, nearly the last. But he was much more an uncle to me who had been down most of the avenues that I later began to explore. He was always generous in advice, counsel, and in giving credit. I saw him nearly every day in my student days at Chicago, and again, nearly every day, over the first eight years I was MSRI director. Interacting with Kap was always a pleasure, crisp, clear, and somehow uplifting. It is one that I shall deeply miss.

John Ewing

Kap and the AMS

For more than forty years, Irving Kaplansky was active in the American Mathematical Society, and for much of that time he was a driving force. He began as associate editor of the *Bulletin* at the age of twenty-eight in 1945—the same year that he joined the faculty of the University of Chicago. Two years later, he became an editor for the *Transactions*, and ten years after that he was an editor for the *Proceedings*. He thus served as editor for the entire complement of AMS journals at the time.

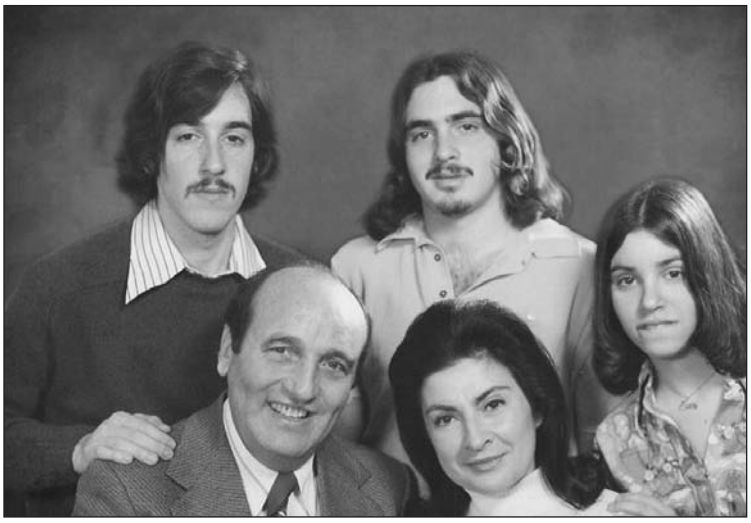
In addition to his role with journals, Kap was active in the Society's governance for many years. He was elected to the Council in 1951 as a young faculty member, and later was elected to the Board of Trustees (as an older one). He was elected vice president in 1974, putting him back on the Council, and finally in 1985–86 was elected president of the AMS. All together, he served a total of ten years on the Council and seven years on the Board—a great many meetings for anyone!

The four years from 1984–87, which included his time as president elect and past president, were particularly eventful for the Society. Kap played a key role in every one of those events. The AMS hosted the 1986 International Congress, which took place in Berkeley; Kap was on the local organizing committee and oversaw many aspects of the Congress. The Society was undergoing some radical changes during this time, including its recovery from a disastrous financial situation earlier in the decade and a restructuring of Mathematical Reviews administration; again, Kap played a key role in reshaping the AMS. And it was during this period that the AMS decided to create a premier journal—the *Journal of the American Mathematical Society*. Kap was the one who championed this idea (which came from the Committee on Publications) and helped bring the journal to life by carefully choosing the first editorial board.

The most remarkable feature about Kap's service to the Society was his style. In every job he undertook—in everything he did—he was forceful and yet graceful, eloquent and yet thoughtful, energetic and yet polite. When he received the AMS Steele Prize, Career Award in 1989, the citation acknowledged that style by honoring him for "his energetic example, his enthusiastic exposition, and his overall generosity." It went on to point out that he "has made striking changes in mathematics and has inspired generations of younger mathematicians."

Kap left his mark on many parts of mathematics, but he especially left his mark on the Society.

John Ewing is executive director of the AMS. His email address is jhe@ams.org.



1972 family photo. Top row, left to right: Steven, Alex, and Lucy. Front: Irving and Chellie Kaplansky.

Lucy Kaplansky

Kap Was My Father

My dad, Irving Kaplansky, was a mathematician, but he was also a teacher, and he taught me many things. When I was a little girl he taught me to play checkers. In our games together he would start with half his checkers, and he'd beat me anyway. But whenever I played checkers with other kids, I demolished them. He got a huge kick out of that.

He taught me math. I would come home from school when I was in grade school and high school and he would re-teach me that day's math lesson. He was always patient and clear, and he made it all make sense. I'd go back to school the next day, and

Singer-songwriter Lucy Kaplansky lives in New York City. Her website is www.lucykaplansky.com

often I was the only one who would understand what was going on in math class.

I ran into a couple of my math teachers from grade school recently and they told me when they found out I was in their classes they were petrified because they knew exactly who my dad was!

My dad taught me to be organized in everything, reliable, and punctual. I think I'm the only musician I know who always shows up on time and actually does what I say I'm going to do.

He taught me that I should love what I do for a living. Throughout my childhood he would sit in his study, classical music always on the radio, doing math. Sometimes he'd look like he was doing nothing, maybe even sleeping, but he'd always say he was "thinking mathematics". He instilled in me one of the central ideas that has informed my life, that making money for money's sake was not important, that doing work you love is everything.

I asked him once why he loved math. He responded simply "it's beautiful."

He taught me that learning was fun. He especially loved learning about history and he was forever reading about and discussing history, all kinds. Because of him, I, too, love to learn about history; because of him I love to learn, period.

And perhaps most of all he taught me to love music. He was a gifted pianist, and there's a story I've heard my whole life that when he was three years old he and his family attended a Yiddish musical in Toronto, and when they got home he sat down at the piano and played the show's main song perfectly, note for note.

From as early as I can remember I would sing while he played the piano. He taught me dozens of songs from the 1930s and 1940s, as well as from Gilbert and Sullivan operettas. I still remember most of these songs.

When I was older and pursued a career as a singer-songwriter, I started performing songs that he had written; one of the most popular was "A Song About Pi". To this day it's one of my most requested songs.

When my dad was already in his eighties, my parents often went on the road with me when I was doing concerts. We'd all get in the car and stay in hotels, and he would sell my CDs for me after the show, sometimes he was even asked for autographs. And if there was a piano on stage he would accompany me on a couple of his songs. He always brought down the house. I'm so grateful we were able to share this. The last time he sat in with me onstage he was 88 years old.

I've heard from so many of my dad's students over the years what a wonderful teacher he was. I know that. He was my teacher.

WHAT IS...

a Cluster Algebra?

Andrei Zelevinsky

Cluster algebras, first introduced in [2], are constructively defined commutative rings equipped with a distinguished set of generators *(cluster variables)* grouped into overlapping subsets *(clusters)* of the same finite cardinality (the *rank* of an algebra in question). Among these algebras one finds coordinate rings of many algebraic varieties that play a prominent role in representation theory, invariant theory, the study of total positivity, etc. For instance, homogeneous coordinate rings of Grassmannians, Schubert varieties, and other related varieties carry a cluster algebra structure (after a minor adjustment). Potential applications of this structure include explicit constructions of the (dual) canonical basis and toric degenerations for these varieties.

Since its inception, the theory of cluster algebras has found a number of exciting connections and applications: quiver representations, preprojective algebras, Calabi-Yau algebras and categories, Teichmüller theory, discrete integrable systems, Poisson geometry... The current state of these developments, including links to papers, working seminars, conferences, etc., is represented at the online Cluster Algebras Portal created and maintained by S. Fomin [1].

Although some of the above connections are rather technical, cluster algebras themselves are defined in an elementary manner not requiring any tools beyond high-school algebra. On the other hand, they have an unusual feature that both generators and algebraic relations among them are not given from the outset but are produced by an iterative process of *seed mutations*.

Andrei Zelevinsky is professor of mathematics at Northeastern University. His email address is andrei@neu.edu.
He thanks Sergey Fomin for helpful suggestions.
The author was partially supported by NSF grant DMS 0500534 and a Humboldt Research Award.

Before discussing the general definition, let us look at cluster algebras of rank two. One associates such an algebra $\mathcal{A}(b,c)$ with any pair (b,c) of positive integers. The cluster variables in $\mathcal{A}(b,c)$ are the elements x_m, for $m \in \mathbb{Z}$, defined recursively by the *exchange relations*

$$x_{m-1}x_{m+1} = \begin{cases} x_m^b + 1 & \text{if } m \text{ is odd;} \\ x_m^c + 1 & \text{if } m \text{ is even.} \end{cases}$$

Iterating these relations, we can express each x_m as a rational function of x_1 and x_2. Thus, $\mathcal{A}(b,c)$ is the subring generated by all the x_m inside the field of rational functions $\mathbb{Q}(x_1,x_2)$. The clusters are the pairs $\{x_m, x_{m+1}\}$ for $m \in \mathbb{Z}$. Starting with the initial cluster $\{x_1,x_2\}$, we can reach any other cluster by a series of exchanges

$$\cdots \leftrightarrow \{x_0,x_1\} \leftrightarrow \{x_1,x_2\} \leftrightarrow \{x_2,x_3\} \leftrightarrow \dots .$$

For an arbitrary rank n, the construction is similar. Each cluster $\mathbf{x} = \{x_1,\dots,x_n\}$ is a collection of algebraically independent elements of some ambient field, and each cluster variable x_k can be exchanged from $\mathbf{x}$ by forming a new cluster $\mathbf{x}' = \mathbf{x} - \{x_k\} \cup \{x_k'\}$. Here x_k and x_k' are related by an exchange relation of the following form: the product $x_k x_k'$ is equal to the sum of two disjoint monomials in the variables from $\mathbf{x} \cap \mathbf{x}' = \mathbf{x} - \{x_k\}$. (For simplicity, we restrict ourselves to the *coefficient-free* case, where both monomials appear with the coefficient 1.) The exponents in these two monomials are encoded by an $n \times n$ integer matrix $B = (b_{ij})$ called the *exchange matrix*; it is usually assumed to be skew-symmetrizable, that is, $d_i b_{ij} = -d_j b_{ji}$ for some positive integers $d_1,\dots,d_n$. The corresponding exchange relations take the form

$$x_k x_k' = \prod_i x_i^{[b_{ik}]_+} + \prod_i x_i^{[-b_{ik}]_+},$$

where we use the notation $[b]_+ = \max(b,0)$.

A pair $(\mathbf{x}, B)$ as above is called a *seed*. To begin the iterative process, we extend, for each index k, the transformation $\mathbf{x} \mapsto \mathbf{x}'$ of clusters to the transformation $(\mathbf{x}, B) \mapsto (\mathbf{x}', B')$ of seeds called the *seed mutation* in direction k. Its key ingredient is the *matrix mutation* $\mu_k : B \mapsto B' = (b'_{ij})$ given by the rule

$$b'_{ij} = \begin{cases} -b_{ij} & \text{if } i = k \text{ or } j = k; \\ b_{ij} + [b_{ik}]_+[b_{kj}]_+ & \\ \quad -[-b_{ik}]_+[-b_{kj}]_+ & \text{otherwise.} \end{cases}$$

The corresponding cluster algebra is then defined as the subring of $\mathbb{Q}(x_1, \ldots, x_n)$ generated by all cluster variables, that is, by the union of all clusters obtained from the initial cluster $\mathbf{x}$ by iterating seed mutations in all directions.

The definition of matrix mutations may look strange at first. (Remarkably, the same rule came up in recent work on Seiberg dualities in string theory.) One of its main consequences—and one of the main reasons for introducing it—is the *Laurent phenomenon*: every cluster variable, which a priori is just a rational function in the elements of a given cluster, is in fact a Laurent polynomial with integer coefficients. For instance, in each rank 2 algebra $\mathcal{A}(b, c)$, every cluster variable x_m is a Laurent polynomial in x_1 and x_2. As a corollary, if we specialize all elements of some cluster to 1 then all cluster variables become integers. This is rather unexpected since, in the process of seed mutations, every cluster variable eventually appears as the denominator of the expression used for producing a new one. The cluster algebra machinery provides a unified explanation of several previously known phenomena of this kind. One example is the *Somos-5* sequence discovered some years ago by M. Somos: its first five terms are equal to 1, and the rest are given by the recurrence relation $x_m x_{m-5} = x_{m-1}x_{m-4} + x_{m-2}x_{m-3}$. The fact that all terms of this sequence are integers can be deduced from the Laurent phenomenon for cluster algebras.

The Laurent polynomial expressions for cluster variables are not yet well understood. S. Fomin and the author conjectured that all coefficients in these Laurent polynomials are *positive*; this is still open in general. The strongest known result in this direction (by P. Caldero and M. Reineke), which establishes the conjecture in many special cases, uses some heavy machinery: it is based on a beautiful geometric interpretation (due to P. Caldero and F. Chapoton) of the coefficients in question as Euler-Poincaré characteristics of certain *quiver Grassmannians*.

A cluster algebra is of *finite type* if it has finitely many seeds. As shown in [3], these algebras are classified by the same Cartan-Killing types (or Dynkin diagrams) as semisimple Lie algebras, finite root systems, and many other important structures. In particular, the rank-two cluster algebra $\mathcal{A}(b, c)$ is of finite type if and only if $bc \le 3$; the reader is invited to check that if $bc = 1$ (respectively 2; 3) then the sequence of cluster variables is periodic with period 5 (respectively 6; 8). These three cases are naturally associated with the root systems A_2, B_2, and G_2.

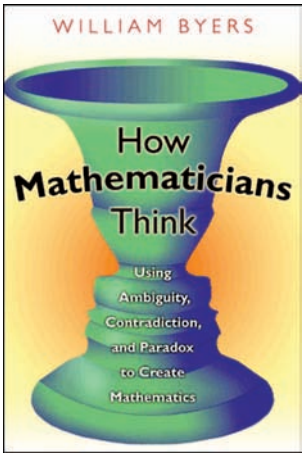
The study of cluster algebras of finite type brings to light new combinatorial and geometric structures associated to root systems. For example, by a result of F. Chapoton, S. Fomin, and the author, the *cluster complex* (the simplicial complex whose vertices are cluster variables and whose maximal simplices are clusters) can be identified with the dual face complex of a simple convex polytope, the *generalized associahedron*. These polytopes include as special cases the Stasheff associahedron (in type A_n), and the Bott-Taubes *cyclohedron* (in type B_n).

We conclude this brief tour of cluster algebras with the following informal question: how can one detect a cluster algebra structure in a commutative ring of interest? A possible strategy is to look for three-term relations satisfied by some naturally arising elements of the ring and try to interpret them as exchange relations. The mutation mechanism will take care of the rest. One recent example (due to S-W. Yang and the author): consider the variety X_n of tridiagonal $(n+1) \times (n+1)$ unimodular complex matrices $U = (u_{ij})$ with $u_{i,i+1} = u_{i+1,i} = 1$ for all i. The top-left-corner principal minors $D_1, \ldots, D_n$ of U satisfy the recurrence relations $D_{k+1} = u_{k+1,k+1}D_k - D_{k-1}$, which feature prominently in the classical theory of orthogonal polynomials. Rewritten in the form $D_k u_{k+1,k+1} = D_{k+1} + D_{k-1}$, these relations acquire distinct "cluster flavor". Indeed, the coordinate ring of X_n can be made into a cluster algebra (of finite type A_n) with the initial cluster $\mathbf{x} = \{D_1, \ldots, D_n\}$, so that the above relations are exactly the exchange relations from $\mathbf{x}$. Other examples of three-term relations leading to cluster algebras include short Plücker relations between Plücker coordinates on Grassmannians, and Ptolemy relations between Penner coordinates on the decorated Teichmüller space of a bordered Riemann surface.

Further Reading

1. S. FOMIN, `http://www.math.lsa.umich.edu/~fomin/cluster.html`.
2. S. FOMIN and A. ZELEVINSKY, Cluster algebras I: Foundations, *J. Amer. Math. Soc.* **15** (2002), 497–529.
3. _____ , Cluster algebras II: Finite type classification, *Invent. Math.* **154** (2003), 63–121.

Book Review



How Mathematicians Think

Reviewed by Reuben Hersh

How Mathematicians Think: Using Ambiguity, Contradiction, and Paradox to Create Mathematics
William Byers
Princeton University Press, 2007
425 pages, US$35.00, ISBN 978-0691127385

This book is a radically new account of mathematical discourse and mathematical thinking. It's addressed to everyone, from a lay reader who hasn't met complex numbers, up to a professional who appreciates Sarkovsky's theorem on cycles of iterated functions, or Goodstein's number-theoretic equivalent of Gödel's theorem for arithmetic with induction. No math preparation is presupposed, and everything is explained with complete clarity, yet deep contemporary issues are faced with no hesitancy. The discussion is free of pretentiousness or grandiosity. Byers straightforwardly explains the issues and clarifies them.

Starting with Imre Lakatos' 1976 *Proofs and Refutations*, some writers have been turning away from the search for a "foundation" for mathematics and instead, seeking to understand and clarify the actual practice of mathematics—*what real mathematicians really do*. Conferences toward this end have been held in Mexico, Belgium, Denmark, Italy, Spain, Sweden, and Hungary. In particular, I would mention books by Bettina Heinz, Carlo Cellucci, and Alexandre Borovik. My own anthology collects essays by mathematicians, philosophers, cognitive scientists, sociologists, a computer scientist, and an anthropologist.

There's not much consensus, but at least one thing has been pretty generally taken for granted: mathematical thinking and discourse is supposed to be *precise*—that is to say, unambiguous. A mathematical statement is supposed to have a single definite meaning. What Byers's book reveals is that ambiguity is always present, from the most elementary to the most advanced level. In teaching school mathematics, it is an unacknowledged source of difficulty. At the level of research, it is often the key to growth and discovery.

Ambiguity can just mean vagueness. But also, it can mean, as Byers puts it, "a single situation or idea that is perceived in two self-consistent but mutually incompatible frames of reference." (p. 28) In fact, he makes a persuasive case that ambiguity is actually what makes mathematical ideas so powerful:

> Normally ambiguity in science and mathematics is seen as something to overcome, something that is due to an error in understanding and is removed by correcting that error. The ambiguity is rarely seen as having value in its own right, and the existence of ambiguity was often the very thing that spurred a particular development of mathematics and science.... The power of ideas reside in their ambiguity. Thus any project that would eliminate ambiguity from mathematics would destroy mathematics. (p. 24)

Familiar examples of ambiguity include: Negating Euclid's parallel postulate. Different sizes of infinite sets. Using logic to prove the limitations

Reuben Hersh is professor of mathematics at the University of New Mexico. His email address is rhersh@gmail.com.

of logic. Infinitely rough curves, self-similar on infinitely many different scales. And on and on.

No surprise that there's ambiguity in "infinite" or "infinity". The philosophically inclined won't be surprised that there's ambiguity in "true" and even in "proof". But even in the simplest, most "elementary" mathematical steps, there is already deep, unacknowledged ambiguity.

An obvious example is: square roots of negative numbers. It takes effort simultaneously to know that "-1 has no square root" (on the real line) and "it has two of them" (in the plane.) The student must switch contexts as needed. Sometimes there is no square root, sometimes there are two. It all depends on what are you are talking about, what are you are trying to do! But a while back, the same effort was required regarding negative numbers. We have forgotten that for D'Alembert or De Morgan, it both made sense and didn't make sense, to contemplate a quantity less than "nothing".

Indeed, "zero" is ambiguous! Unlike D'Alembert or DeMorgan, today we don't say "nothing" when we mean "zero". Zero is *something*—it's a number. Yet, of course, "nothing" is what it means. Zero is a something, and what is stands for, what it means—is "nothing"! This is ambiguous, but we math teachers have buried the ambiguity so deeply, that if we ever have to talk to a student who is troubled by it, we can hardly understand what is her difficulty.

"One" is ambiguous! Frege's famous book, *Grundlagen der Arithmetik*, was motivated by mathematicians' inability to explain coherently what they meant by "one". Frege's answer was: "one" is the "concept" of singletons. But Dedekind and Peano had a different answer: "one" is just an undefined term, in the axioms for the relation of "successor". And still another answer is given in every elementary math classroom—"one" is a slash or a tally mark, which can be repeated to make "two", and repeated again, to make "three". If that's not enough ambiguity, there's still a deeper ambiguity in "one". When we choose to think about all the things that belong to some system (for example, all the counting numbers) and regard that collection as "one" set—when we make a *unity* out of a *multiplicity*—we are committing an ambiguity. An ambiguity, indeed, that is a central feature of mathematical thinking. (Notice how the word "universal", with the sense of "all-embracing", uses the primitive root, "uni", a single slash or tally mark.)

In fact, the relation of "equality" in general is ambiguous, for the entities on the two sides of the equals sign are usually not identical. ("$x = x$" is not usually interesting.) In an interesting equation, the entities on the left and the right are not identical, so the claim that they are "equal" is necessarily ambiguous, subject to different interpretations according to context. Using the simplest example imaginable, Byers elucidates the ambiguity inherent in the notion of equality:

> When we encounter "1+1=2", our first reaction is that the statement is clear and precise. We feel that we understand it completely and that there is nothing further to be said. But is that really true? The numbers "one" and "two" are in fact extremely deep and important ideas…The equation also contains an equal sign. Equality is another very basic idea whose meaning only grows the more you think about it. Then we have the equation itself, which states that the fundamental concepts of unity and duality have a relationship with one another that we represent by "equality"—that there is unity in duality and duality in unity. This deeper structure that is implicit in the equation is typical of a situation of ambiguity. Thus even the most elementary mathematical expressions have a profundity that may not be apparent on the surface level. (p. 27)

A more advanced example of the ambiguity of the equals sign is $1 = .999\ldots$.

> What is the precise meaning of the "=" sign? It surely does not mean that the number 1 is identical to that which is meant by the notation .999…. There is a problem here, and the evidence is that, in my experience, most undergraduate math majors do not believe this statement… they all agreed that .999…was very close to 1. Some even said "infinitely close", but they were not absolutely sure what they meant by this…. This notation stands both for the process of adding this particular infinite sequence of fractions and for the object, the number that is the result of that process…. Now the number 1 is clearly a mathematical object, a number. Thus the equation 1 = .999… is confusing because it seems to say that a process is equal (identical?) to an object. This appears to be a category error. How can a process, a verb, be equal to an object, a noun? Verbs and nouns are "incompatible contexts" and thus the equation is ambiguous…. I hasten to add that this ambiguity is a strength, not a weakness, of our way of writing decimals. To understand infinite decimals means to be able to move freely from one of these points of view to the other. That is, understanding involves the realization that there is "one single idea" that can be expressed as 1 or as 1 = .999… that can be understood as the process of summing an infinite series or an endless process of successive approximation as well as a concrete object, a number. This kind of creative leap is required before one

> can say that one understands a real number as an infinite decimal. (p. 41)

Byers also discusses how students struggle with ideas that are less advanced than $1 = .999\ldots$ For example, here he unravels the ambiguity of the "variable" x as students encounter it in the seventh grade:

> Does the "x" in "$x + 2 = 4$" refer to *any* number or does it refer to the number 2? The answer is, "Both and neither." At the beginning, x could be anything. At the end, x can only be 2. Yet at the end, we are saying that every number x NOT $= 2$ is *not* a solution, so the equation is also about all numbers. Thus at every stage, the x stands for *all* numbers but ALSO for the *specific* number 2. We are required to carry along this ambiguity throughout the entire procedure of solving the equation. It begins with something that could be anything and ends with a specific number that could not be anything else. What an exercise in subtle mental gymnastics this is! How could this way of thinking be called *merely* mechanical? No wonder children have difficulty with algebra. The difficulty is the ambiguity. The resolution of the ambiguity, solving the equation, does not involve eliminating the double context but rather being able to keep the two contexts simultaneously in mind and working within that double context, jumping from one point of view to the other as the situation warrants. (p. 42)

Mathematicians are accustomed to making use of multiple "representations" of "the same" thing. With the precise notion of "isomorphic equivalence", we are able legitimately and smoothly to use different representations simultaneously. The group of permutations on three letters is "the same thing" as the automorphism group of the equilateral triangle, or the group of functions under composition generated by $1/x$ and $1-x$, and so on and so on. And any graph is equivalent to, is virtually "the same", as its adjacency matrix. And any solution of Laplace's partial differential equation is an integral with a Green's function as kernel, and it is simultaneously the minimal solution of a certain variational problem, and it is simultaneously the limit of a sequence of solutions of difference equations, and it is simultaneously the expected value of the outcome of the random motion of a Brownian particle, as well as the equilibrium distribution of heat in a homogeneous medium, and also the potential of a distribution of gravitational mass or electrostatic charge. When we make simultaneous or alternate use of "different" representations or interpretations of "the same" structure, we are using ambiguity in a controlled, algorithmic way—using the multiple-meaningness of the concepts of group, or graph, or solution of a differential equation.

In discussions of the nature of mathematics, the notion of "abstraction" is often mentioned, but rarely clarified or explicated. Byers has a remarkable explanation of abstraction. "Abstraction consists essentially in the creation and utilization of ambiguity." For example, when *functions* are first introduced, either in the classroom or in the history of mathematics, they are active. The function transforms one number into another. Later, when we focus on differential operators, the functions are passive. The operator transforms one function into another. So which is it? Is a function active or passive, verb or noun? "The initial barrier to understanding, that a function can be considered simultaneously as process and object—as a rule that operates on numbers and as an object that is itself operated on by other processes—turns into the insight. That is, it is precisely the ambiguous way in which a function is viewed which is the insight." (p. 48)

Byers doesn't stop with mathematics itself. Not only mathematics, but even more, philosophy of mathematics, is inextricably tied up with ambiguity, paradox, and contradiction. "Do we create math or do we discover it?" "Is it in our minds, or is it out there"? Contradictions, *nicht wahr*?

One deep ambiguity is the double meaning of "exist". Does it mean something is "constructed" from already "constructed" entities, by some clearly understood notion of "construct"? Or does it rather mean something is contradiction-free, is "safe" to "postulate", because it doesn't crash into or interfere with other notions or facts that we don't want disturbed? This is just the stale old argument between intuitionist/constructivists and standard/classical mathematicians. For Byers, the point isn't to choose sides, to decide who is right and who is wrong. Rather, it is to perceive that this ambiguity of "exist" is intrinsic to our mathematical practice, and is fruitful. The clash of viewpoints arising from this ambiguity brings forth interesting mathematics.

Speaking of the often mentioned but rarely analyzed unreflective Platonism of the working mathematician, Byers writes:

> The ambiguity of an unsolved problem is mitigated somewhat by the Platonic attitude of the working mathematician. That is, she feels that it is objectively either true or false and that the job of the mathematician is "merely" to discover which of these a priori conditions applies. Psychologically, this Platonic point of view brings the ambiguity of the situation into enough control so that researchers have confidence the correct solution exists independent of their efforts. It moves the problem from the domain of

> "ambiguity as vagueness" in which anything could happen to the sort of incompatibility that has been discussed in this chapter where there are two conflicting frameworks, true or false.

"Contradictions demand resolution!" you may say. "To rise to the next level in philosophy of mathematics, we must overcome the contradiction, resolve it, not just pooh-pooh it!"

But Byers offers us an insight—this is the way it has to be! Live with it! Life is ambiguous and contradictory. Mathematics is part of life. Insofar as the philosophy of mathematics describes the total mathematical situation—process as well as content—naturally it's also bound to be ambiguous.

Well, that does in fact seem to be the case.

You might say that the work of the mathematician is to drive away ambiguity. "Precision" is what mathematics is all about. "Say what you mean, mean what you say, nothing is there except what is right on the page." Byers pushes us back, to the ambiguous situation that calls for mathematical explication. He makes us see that the ambiguity we insist on banishing is the source, the origin, of the mathematical work. "Logic moves in one direction, the direction of clarity, coherence and structure. Ambiguity moves in the other direction, that of fluidity, openness, and release. Mathematics moves back and forth between these two poles…. It is the interaction between these different aspects that gives mathematics its power." (p. 78) "Mathematical ideas are not right or wrong; they are organizers of mathematical situations. Ideas are not logical. In fact the inclusion should go the other way around—logic is not the absolute standard against which all ideas must be measured. In fact logic itself is an idea." (p. 257)

The normal mathematician—the philosopher's "working mathematician", the ordinary mathematician, the "mathematician in the street"?—may respond with a shrug and a, "So what?" We do our calculations and prove our theorems by following our noses, not by looking right or left to see where we are in the broader conceptual or "philosophic" realm. You don't need to know what is meant by "one" in order to know that one and one is two. But recall the old saying of Socrates, about the unexamined life. Most mathematical life, like most human life in general, is unexamined. Byers pulls away the covering habit and routine, to expose life-giving embarrassments hidden beneath.

You can't quite say that nobody has said this before. But nobody has said it before in this all-encompassing, coherent way, and in this readable, crystal clear style. The examples are well known and familiar, but it's something else to put them all together and say, "This is it! This is exactly what mathematics is all about, this is the very core and nature of mathematical thinking!"

Byers finds far-reaching consequences, beyond mathematics, for our very understanding of what it means to be human.

> Any great quest demands courage. It is a voyage into the unknown with no guaranteed results. What is the nature of this courage? It is the courage to open oneself up to the ambiguity of the specific situation. The whole thing may end up as a vast waste of time, that is, the possibility of failure is inevitably present... Our lives also have this quality of a quest, the attempt to resolve some fundamental but ill-posed question. In working on a mathematical conjecture, life's ambiguities solidify into a concrete problem. That is, the situation of doing research is isomorphic to some extent with the situation we face in our personal lives. This is one reason that working on mathematics is so satisfying. In resolving the mathematical problem we, for a while at least, resolve that large, existential problem that is consciously or unconsciously always with us…. Learners need support when they are encouraged to enter into new unexplored ambiguities. A new learning experience requires the learner to face the unknown, to face failure. Sticking with a true learning situation requires courage and teachers must respect the courage that students exhibit in facing these situations. Teachers should understand and sympathize with students' reluctance to enter into these murky waters. After all, the teacher's role as authority figure is often pleasing insofar as it enables the teacher to escape temporarily from their own ambiguities and vulnerability. Thus the value of learning potentially goes beyond the specific content or technique but in the largest sense is a lesson in life itself. (p. 57)

This book strikes me as profound, unpretentious, and courageous.

References

ALEXANDRE BOROVIK, *Mathematics Under the Microscope*, http://www.maths.manchester.ac.uk/~avb/micromathematics/downloads.

CARLO CELLUCCI, *Filosofia e Matematica*, Laterza, Bari, 2002.

BETTINA HEINZ, *Die Innenwelt der Mathematik*, Springer 2000.

REUBEN HERSH, Ed., *18 Unconventional Essays on the Nature of Mathematics*, Springer, 2005.

_____, *What Is Mathematics, Really?*, Oxford University Press, 1997.

IMRE LAKATOS, *Proofs and Refutations*, Cambridge University Press, 1976.

Emma Lehmer 1906–2007

John Brillhart

Emma Lehmer

Emma Lehmer, née Trotskaya, was born on November 6, 1906, in Samara, a city on the Volga River in Russia. When she was four years old, her family moved to Harbin in Manchuria, where she was tutored at home in basic subjects, music, and languages. When she was fourteen, she finally went to the new public high school in Harbin. During the next four years, she saved enough money to allow her to travel across the Pacific and enroll at the University of California in Berkeley.

Many years later she described her earlier feelings when she was at home as follows: "I expect I was rather insufferable in my intense desire to fly from home into the great unknown."

At Berkeley she had the extraordinary good fortune of being hired as a student assistant to mathematics professor D. N. Lehmer and his son Dick, to help them with some work in number theory. She soon found herself a part of the Lehmer family itself, many of whose members were independent, creative, artistic, and enterprising like herself.

In 1928, when she graduated from UC Berkeley in mathematics, she and Dick were married, thus beginning sixty-three years of devoted marriage that lasted until his death in 1991. She was his helpmate, mother of their two children Laura and Donald, mathematical collaborator in their research, and hostess to the vast number of visitors who came to Berkeley and stayed at the Lehmers' home as guests.

Emma was very informal, cordial, and charming. She especially made a point of greeting Russian visitors in Russian to make them feel at home and inviting them to her house for dinner. She was always modest and self-effacing and seemed completely satisfied in her role of providing a genial social setting on a variety of mathematical occasions. She and her husband had marvelous senses of humor.

In 1969 she and her husband founded the West Coast Number Theory meeting, which has met every year since at locations around the West. It has been of tremendous value as a meeting where young people in particular can come and enjoy a comfortable, friendly, and informal environment where they can find their way into the real world of mathematics. It remains a real tribute to the Lehmers.

From the beginning, Emma was a mathematical researcher and scholar along with her husband. She wrote 56 papers, 17 jointly with her husband, 5 three-way papers with him and a second person, and one jointly with H. S. Vandiver. She was as knowledgable about computing in number theory as her husband, always being there while projects were being discussed and contributing at all levels to their development. Her publications appeared in the primary mathematical journals.

She was also a Russian translator for the AMS for whom she translated Pontryagin's *Topological Groups* and Delone and Faddeev's work on *Irrationalities of the Third Degree* along with Sue Ann Walker.

Her papers deal with cyclotomy, character theory, difference sets, residuacity, and algebraic units. When she was eighty, she discovered that certain units can be gotten from Gaussian periods by translation, a good example of the kind of basic number theory she and her husband had done all their lives.

When she became one hundred, the AMS announced this fact in the December 2006 *Notices*. Part of the announcement said that if people would like to celebrate her birthday with her, they might send her a card, perhaps with flowers on it or a natural scene. Her daughter later said that cards came pouring in from all over the world for the next two months. In all, the number of signatures on the cards was 275. How many of us would draw that kind of response when we reach the age of

John Brillhart is professor emeritus of mathematics at the University of Arizona. His email address is jdb@math.arizona.edu.

one hundred? It was most gratifying to her and to everyone else.

Emma passed away quietly in her sleep at her home in Berkeley on the morning of May 7, 2007.

Publications of Emma Lehmer

[1] A numerical function applied to cyclotomy, *Bull. AMS* **36** (1930), 291–298.
[2] On a resultant connected with Fermat's last theorem, *Bull. AMS* **41** (1935), 864–867.
[3] On the magnitude of the coefficients of the cyclotomic polynomial, *Bull. AMS* **42** (1936), 389–392.
[4] On congruences involving Bernoulli numbers and the quotients of Fermat and Wilson, *Annals of Math.* **39** (1938), 350–360.
[5] (with D. H. Lehmer), On the first case of Fermat's last theorem, *Bull. AMS* **47** (1941), 139–142.
[6] The quintic character of 2 and 3, *Duke Math. J.* **18** (1951), 11–18.
[7] On residue difference sets, *Canad. J. Math.* **5** (1953), 425–432.
[8] (with D. H. Lehmer and H. S. Vandiver), An application of high speed computing to Fermat's last theorem, *Proc. Nat. Acad.* **40** (1954), 25–33.
[9] On cyclotomic numbers of order 16, *Canad. J. Math.* **6** (1954), 449–454.
[10] On the number of solutions of $u^k + D = w^2 (mod\ p)$, *Pacific J. Math.* **5** (1955), 103–118.
[11] Period equations applied to difference sets, *Proc. AMS* **6** (1955), 433–442.
[12] *Number Theory on the SWAC*, Proc. Symp. Appl. Math., AMS, v. 6, McGraw Hill, New York, 1956, 103–108.
[13] On the location of the Gauss sums, *MTAC* **10** (1956), 194–202.
[14] (with H. S. Vandiver), On the computation of the number of solutions of certain trinomial congruences, *J. Assoc. Comp. Mach.* **4** (1957), 505–510.
[15] Criteria for cubic and quartic residuacity, *Mathematika* **5** (1958), 20–29.
[16] On Euler's criterion, *J. Austral. Math. Soc.* **1** (1959/61), 64–70.
[17] (with D. H. Lehmer), On the cubes of Kloosterman sums, *Acta Arith.* **6** (1960), 15–22.
[18] On Jacobi functions, *Pacific J. Math.* **10** (1960), 887–893.
[19] (with D. H. Lehmer), On runs of residues, *Proc. AMS* **13** (1962), 102–106.
[20] (with D. H. Lehmer and W. H. Mills), Pairs of consecutive power residues, *Canad. J. Math.* **15** (1963), 172–177.
[21] (with D. H. Lehmer, W. H. Mills, and J. L. Selfridge), Machine proof of a theorem on cubic residues, *Math. Comp.* **16** (1962), 407–415.
[22] (with D. H. Lehmer), *Heuristics, Anyone?*, Studies Math. Anal. and Related Topics, Stanford U. Press, 1962, 202–210.
[23] On the infinitude of Fibonacci pseudo-primes, *Fib. Quart.* **2** (1964), 229–230.
[24] (with J. Brillhart and D. H. Lehmer), Bounds for pairs of consecutive seventh and higher power residues, *Math. Comp.* **18** (1964), 397–407.
[25] Artiads characterized, *J. Math. Anal. Appl.* **15** (1966), 118–131.
[26] On the quadratic character of the Fibonacci root, *Fib. Quart.* **5** (1967), 135–138.
[27] (with D. H. Lehmer), The cyclotomy of Kloosterman sums, *Acta Arith.* **12** (1967), 385–407.
[28] On the divisors of the discriminant of the period equation, *Amer. J. Math.* **90** (1968), 375–379.
[29] (with D. H. Lehmer), The cyclotomy of hyper-Kloosterman sums, *Acta Arith.* **14** (1968), 89–111.
[30] (with D. H. Lehmer and D. Shanks), Integer sequences having prescribed quadratic character, *Math. Comp.* **24** (1970), 433–451.
[31] On the quadratic character of some quadratic surds, *J. für Math.* **250** (1971), 42–48.
[32] On some special quartic reciprocity laws, *Acta Arith.* **21** (1972), 367–377.
[33] Power characters of quadratic units, *Proc. 1972 Number Theory Conf.*, Boulder Colo., 128–132.
[34] On the cubic character of quadratic units, *J. Number Th.* **5** (1973), 385–389.
[35] On the quartic character of quadratic units, *J. für Math.* **268/269** (1974), 294–301.
[36] A family of supplementary difference sets, *Bull. Austral. Math. Soc.* **11** (1974), 1–4.
[37] An outcropping of combinatorics in number theory, *Proc. Fifth S-E Conf. on Comb., Graph Theory, and Computing*, Boca Raton, 1974, 75–92.
[38] (with D. H. Lehmer), A new factorization technique using quadratic forms, *Math. Comp.* **28** (1974), 625–635.
[39] Existence criteria for supplementary difference sets, *J. Austral. Math. Soc. Ser. A* **21** (1976), 438–446.
[40] *Generalizations of Gauss' Lemma, Number Theory and Algebra*, Academic Press, New York, 1977, 187–194.
[41] Rational reciprocity laws, *Amer. Math. Monthly* **85** (1978), 467–472.
[42] (with D. H. Lehmer), Picturesque exponential sums I, *Amer. Math. Monthly* **86** (1979), 725–733.
[43] (with D. H. Lehmer), Picturesque exponential sums II, *J. für Math.* **318** (1980), 1–19.
[44] (with D. H. Lehmer), Cyclotomy with nonsquarefree moduli, *Lecture Notes in Math.*, Springer-Verlag **899** (1981), 276–300.
[45] (with D. H. Lehmer), Multiple sums of cyclotomic numbers, *Util. Math.* **23** (1983), 223–239.
[46] Patterns of power residues, *J. Number Th.* **17** (1983), 37–46.
[47] (with D. H. Lehmer), Properties of polynomials having Fibonacci numbers for coefficients, *Fib. Quart.* **21** (1983), 62–64.
[48] (with D. H. Lehmer), Cyclotomy with short periods, *Math. Comp.* **41** (1983), 743–758.
[49] (with D. H. Lehmer), The sextic period polynomial, *Pacific J. Math.* **111** (1984), 341–355.
[50] On special primes, *Pacific J. Math.* **118** (1985), 471–478.
[51] On square-separable primes, *Amer. Math. Monthly* **92** (1985), 719–720.
[52] Cyclotomy of order twice a prime, *Rocky Mountain J.* **15** (1985), 481–489.
[53] (with D. H. Lehmer), Cyclotomic resultants, *Math. Comp.* **48** (1987), 211–216.
[54] Connection between Gaussian periods and cyclic units, *Math. Comp.* **50** (1988), 535–541.
[55] An indeterminate in number theory, *J. Austral. Math. Soc. Ser. A* **46** (1989), 469–472.
[56] (with D. H. Lehmer), The Lehmer Project, *Math. Comp.* **61** (1993), 313–317.

Remembering Philip Rabinowitz

Philip J. Davis and Aviezri S. Fraenkel

The applied mathematician and numerical analyst Philip (Phil, Pinchas, Pinny) Rabinowitz was born in Philadelphia on August 14, 1926, and passed away on July 21, 2006, in Jerusalem. Philip Davis recounts reminiscences from his early scientific career; while Aviezri Fraenkel relates some of his activities at the Weizmann Institute of Science, where he began work in 1955, as well as snapshots from earlier periods.

Philip J. Davis

I had a long and fruitful friendship and collaboration with Phil (Pinny) Rabinowitz that began in the fall of 1952 at the National Bureau of Standards (NBS: now NIST) in Washington, D.C. When I began my employment there in the late summer of 1952, Phil was already there.

Phil (I never called him Pinny) grew up in Philadelphia. He got his Ph.D. degree from the University of Pennsylvania in 1951 under the supervision of Walter Gottschalk with a thesis titled *Normal Coverings and Uniform Spaces*. Of course, this topic in topology was irrelevant to the work of the bureau, and Phil was immediately pulled into numerical analysis, computation, programming, and running mathematical models of importance to members of other portions of the bureau and of the U.S. government.

At that time, the Bureau of Standards had one of the very few electronic digital computers in the world. It came on line in 1950 and was known as the SEAC (Standards Electronic Automatic Computer). Within a very short period of time Phil became an expert programmer on SEAC.

If I remember correctly, some of the features of SEAC were as follows: It had 128 memory cells, and one programmed it in what was called "the four address system". A line of code went typically as follows: take the number in cell 28, combine it with the number in cell 37 according to standard operation S, store the result in cell 6 and go to cell 18 to pick up the next instruction. Computations were in fixed-point arithmetic so that scalings had to be introduced to keep the numbers in bounds. The lines of code were first set out in pencil on standard coding sheets; these were transferred to punch cards or teletype tape, thence to magnetic wire from which they were inserted in SEAC.

In retrospect SEAC would be called a first generation computer. Though many numerical strategies (algorithms) had been worked out for a wide variety of mathematical problems in pre-electronic days, the new computers expanded the algorithmic possibilities tremendously. But it was important to work out by trial and error (and occasionally by theory) which of these strategies were optimal vis-a-vis the limitations of time, storage, money, and the difficulties inherent within the algorithm itself such as complexity, divergence, instability, ill-posedness, etc.

The 1950s were a transitional age computationally speaking. Until about 1955 or so, the electronic computers were still grinding out tables of Special Mathematical Functions and publishing them in bound volumes. Later, this was seen as largely unnecessary; special software would be incorporated into scientific computational packages and would produce values of special functions on call and as needed.

One of Phil's first publications (1954) was a *Table of Coulomb Wave Functions* done jointly with Milton Abramowitz (head of the Bureau of Standards Computation Laboratory) and Carl-Erik Fröberg, a numerical analyst from Lund, Sweden.

Shortly after I arrived in Washington, Phil worked on a project that teamed up Kenneth Cole of the National Institutes of Health and Henry Antosiewicz of NBS. Cole was a biomathematician who studied the Hodgkin-Huxley equations

Philip J. Davis is emeritus professor of applied mathematics at Brown University. His email address is Philip_Davis@Brown.edu.

Aviezri S. Fraenkel is professor of computer science and applied mathematics at the Weizmann Institute of Science. His email address is aviezri.fraenkel@weizmann.ac.il.

of impulse transmission down a nerve fiber. If I remember correctly the H-H model consisted of a system of ordinary nonlinear differential equations. Antosiewicz was an expert in that field. This very successful work was reported as "Automatic Computation of Nerve Excitation" and appeared in the Vol. 3, September 1955 issue of the *Journal of the Society for Industrial and Applied Mathematics* (SIAM).

Some incidental gossip: SIAM was founded around 1952 essentially by Ed Block who was a Ph.D. classmate of mine and who for many years was its managing director. In 1963, Alan Hodgkin and Andrew Huxley won the Nobel Prize in physiology for their work on nerve excitation, and it seems likely to me that the work of Cole, Antosiewicz, and Rabinowitz contributed a bit towards this award. Many years later, around 1988, my wife Hadassah and I met Hodgkin and his American wife socially in Cambridge, England. I told Hodgkin this NBS story, but I do not now remember what his reaction was.

In Washington, my friendship with Phil grew, and Hadassah and I grew to know Phil's family: his wife Terry and his children. One of his sons was born in Washington, and we were invited to the brit. There we met Phil's father and his mother. His father was a major chassidic rabbi in Philadelphia and "held court" there with many followers.

Some years later, on one of my professional trips to Philadelphia, I was able to meet Phil's sister, Margola. I believe she had or was getting a degree in philosophy from the University of Pennsylvania. She showed me around tourist Philadelphia and later we took in a summer theatre production of "Amphitryon 38" (Giradoux/S.N. Behrman) with Kitty Carlyle Hart in one of the roles. In the course of our wandering, Margola told me quite a bit about how it was growing up in a chassidic court in Philadelphia in the late 1940s. I was so amazed and intrigued by what I heard that I told her she ought to do a book of reminiscences. Perhaps she has.

In one of my first jobs at the NBS and as part of an extensive project, I was confronted with the necessity of doing some approximate integrations in the complex plane very accurately. I worked on this with Phil.[1] I thought a good strategy would be to use a very subtle and accurate scheme derived in the early 1800s by the great Carl Friedrich Gauss. Prior to 1954, the Gaussian integration rules were available only up to $n = 16$ points. The values had been calculated on desk calculators—an extremely laborious task—by Lowan, Davids, and Levenson. It was also the case that the Gaussian rules were

Photograph courtesy of the authors.

View of SEAC, circa 1952.

out of favor in the days of paper-and-pencil scientific computation, as the numbers involved were helter-skelter irrational decimals, impossible to remember and difficult to enter on a keyboard without error.

It was my plan to carry the computation beyond $n = 16$. I suggested to Phil that we attempt the Gaussian computation on the SEAC. He was game. I anticipated that it would be desirable to work in double-precision arithmetic to about 30 decimal places, and Phil, who was much more skillful at SEAC coding than I, agreed to write the code that would effectuate the double precision.

But first I had to devise a numerical strategy. The n abscissas of the Gaussian integration rules are the roots of the Legendre polynomials of degree n. The weights corresponding to the abscissas can be obtained from the abscissas by a number of relatively simple formulas. I proposed to get the Legendre polynomials pointwise by means of the known three-term recursion relation. I would get their roots by using Newton's iterative method, starting from good approximate values. These starting values would be provided by a beautiful asymptotic formula that had been worked out in the 1930s by the Hungarian-American mathematician Gabor Szegö.

I didn't know whether this strategy would work. It might fail for three or four different reasons. I was willing to try, and if it worked, good; if it didn't—well, something is always learned by failure. We could give the failure some publicity, and other mathematicians would avoid the pitfalls and might then be able to suggest more successful strategies.

I wrote the code and Phil wrote the double-precision part. I tried to anticipate what scaling would be necessary. I reread my code and checked it for bugs. Phil checked it for bugs. I (or Phil) punched up the code on teletype tape and checked that out. The tape was converted automatically to a wire, and the wire cartridge was inserted in the SEAC. We manually set $n = 20$, crossed our fingers, held our breath, and pushed the button to run the program.

[1] *P. Davis and P. Rabinowitz, "Some SEAC computations of subsonic fluid flows by Bergman's method of integral operators" (1953), in M. Z. v. Krzywoblocki,* Bergman's Linear Integral Operator Method in the Theory of Compressible Fluid Flow, *Springer, Vienna, 1960.*

Photograph courtesy of the authors.

P. J. Davis (left) and P. Rabinowitz (right) laying out an algorithmic strategy. Circa 1955.

The SEAC computed and computed and computed and computed. Our tension mounted. Finally, the computer started to output the Gaussian abscissas and weights. Numbers purporting to be such started to spew out at the teletype printer. The numbers had the right look and smell about them. We punched in $n = 24$ and again pushed the "run" button. Again, success. And ditto for even higher values of n.

The staff of the NBS computing lab declared us "Heroes of the SEAC", a title awarded in those days to programmers whose programs ran on the first try—a rare event—and for some while we had to go around wearing our "medals," which were drawn freehand in crayon on the back of used teletype paper. (The word "hero" was in parody of the practice in the Soviet Union of declaring persons "Heroes of the Soviet Union" for this and that accomplishment.)

This was the first electronic digital computation of the Gaussian integration rules. In the years since, alternative strategies have been proposed, simplified, and sharpened (by Gautschi, Golub, and others). And though all the theoretical questions that kept us guessing in 1955 have been decided positively, there are many problems as yet unsolved surrounding the Gauss idea.

Phil and I also worked together—in an experimental fashion—on the numerical solution of elliptic partial differential equations using expansions in orthogonal functions, and published a number of papers on that topic.

For Phil and me, our success and our continued interest in approximate integration led to numerous papers and to a book on the topic which, over the years, has been widely used and referenced. Our *Methods of Numerical Integration*, Academic Press, has gone through three editions.

Sometime in the mid-1950s Phil decided to "make aliya" to Israel. An opportunity opened up for him at the Weizmann Instuitute of Science in Rehovot, in connection with the WEIZAC computer (1954) and the GOLEM (1964). He was hired by Chaim Pekeris who headed up the applied math group at the Weizmann Institute. Although we were now separated, our interest in producing a book on numerical integration persisted. We worked together on the book in several places; in Providence, where Phil and his family spent two semesters at Brown in 1965–66, and from February to May 1970 in Rehovot where my wife and two of our children, Ernie and Joey, spent three months. Again, in 1972, I was by myself in Rehovot for about a month, staying in the San Martin Guest House of the Weizmann Institute.

With the publication of the third edition of *Methods of Numerical Integration* in 1975, my interest in the subject slackened, though I believe that Phil published papers in the topic from time to time. He also did a book *A First Course in Numerical Analysis* with Anthony Ralston which has gone through several editions.

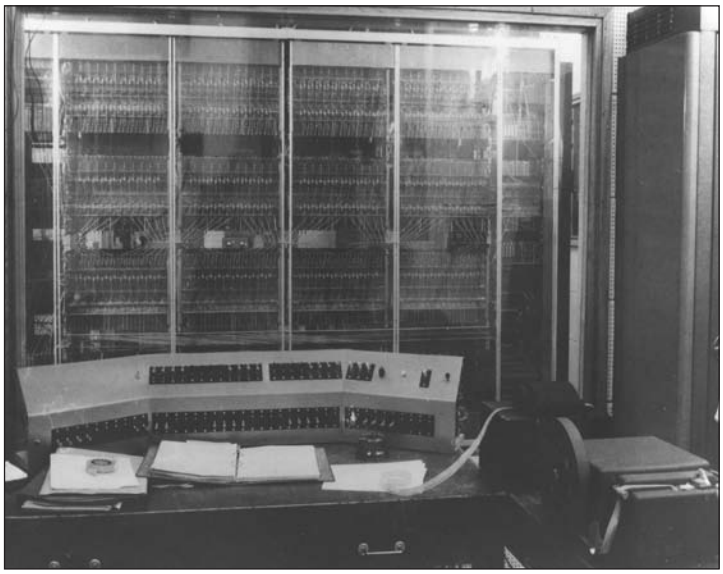
In between and in the years that followed, I would see Phil from time to time at conferences in different parts of the world. In 1969 we were at a conference at the University of Lancaster. The first moon landing occurred during the conference on July 20 and the sessions were suspended while—all agog—we all watched on the TV. The last day of the conference occurred on Tisha b'Av. Phil prepared to leave the conference early and return to London. I asked him why. He replied that sundown occurred earlier in London than in Lancaster and so he would be able to break his fast sooner. An example of his humor.

Aviezri S. Fraenkel[2]

Pinny (I never called him Phil) grew up in Philadelphia in a chassidic-zionist family. Since there was no Jewish day school there at the time, he studied Jewish subjects with a private tutor who came to his house for a few hours on a daily basis. While in high school, and later at the University of Pennsylvania, he attended Talmud lessons given in various synagogues in Philadelphia. He continued these studies until his deathbed.

At the university he studied medicine, but at the end of the first year he did not take a test that took place on Saturday, in order not to desecrate the sanctity of the Sabbath, so he switched to math. He got his first, second, and third degree from the University of Pennsylvania during 1946–1951. There was an important interlude: during 1948–9, Pinny was chosen to go to the new Servomechanism Laboratory at MIT, where he joined the Whirlwind Computer Project numerical analysis group. There he acquired his first experience in writing programs for a digital computer, interacting with

[2] *A shorter version of this part, in Hebrew, appeared recently in a Weizmann Institute publication.*



The front of WEIZAC.

Photograph reproduced with permission of the Weizmann Institute of Science.

people such as Alan Perlis (numerical solutions of integral equations), J. W. Carr (2-register method for floating point computations), Charles Adams (programming languages), Alex Orden and Edgar Reich (solution of linear equations). In Boston he also met Terry, whom he married shortly after getting his Ph.D. in 1951. During 1951–55 he worked at the Computation Laboratory, National Bureau of Standards, Washington, DC.

In 1954, the first digital computer in Israel was constructed under the leadership of Jerry Estrin, who was a member of the team that had just finished constructing John von Neumann's first "stored program" computer at the Institute for Advanced Study, Princeton. Jerry later went to the Engineering Department at the University of California, Los Angeles. The initiator of WEIZAC's construction was the late Chaim L. Pekeris, head of the Applied Mathematics Department at the Weizmann Institute. The WEIZAC project was recently recognized by the Institute for Electrical and Electronics Engineers as a Milestone in the History of Computing. The unveiling of the plaque took place at the Institute on December 5, 2006. On that occasion the team members who constructed the machine received the WEIZAC Medal. Pinny and some others got it posthumously.

Major operation times of WEIZAC were, addition: 50 microsecs; multiplication: 750 microsecs on the average; division: 850 microsecs. It had one of the first ferrite core memories with 4,096 words; memory access time: 10 microsecs. A unique feature of the machine was its word length: 40 bits. Input/output was via punched paper tape.

Pekeris invited Pinny to head the software development, which Pinny began in 1955, after relocating in Israel. Pinny wrote the first utility programs and built up the scientific software library, in the form of subroutines, which constituted the basic infrastructure for numerical solutions of mathematical problems. In addition he gave programming courses at various levels to many people who later became the leading programmers in Israel. In addition to Institute scientists, key personnel from government, defense, and industry participated. Pinny was the pioneer who triggered the large potential of software and high-tech industries in Israel.

Pinny taught numerical analysis at the Hebrew University, Jerusalem, and Tel Aviv and Bar Ilan Universities, in addition to the Weizmann Institute, and helped various colleges to establish computer science programs. In 1968 he received the annual prize of the Israeli Information Processing Society, the Israeli parallel of the U.S.-based Association for Computing Machinery. He traveled extensively, collaborating with mathematicians all over the continents. A conference "Numerical Integration", the core of his scientific interests, was dedicated to his sixtieth birthday. The meeting took place in Halifax, Nova Scotia, in August, 1986.

He helped the defense establishment in writing their first programs. During the tense days preceding the 6-day war, he wrote new programs and backup programs at the Institute, as fallback protection in case the defense department's main computer should become incapacitated.

Among his students were applied mathematician Nira Dyn of Tel Aviv University and computer scientist Mira Balaban of Ben Gurion University. In 1991 Nira organized an international conference on numerical analysis at Tel Aviv University, to mark Pinny's retirement. Mira is interested in artificial intelligence, especially computer music. She wrote her Ph.D. thesis on this topic, under the joint supervision of Pinny and Eli Shamir of Hebrew University. This enabled Pinny to fuse his loves for science and art.

Pinny was a passionate connoisseur of the fine arts, especially paintings, and a frequent visitor at modern art galleries. A large collection of modern paintings decorated every free inch of the walls of his home. He had a sharp eye for recognizing young talents, whose creations he purchased before they became famous, thus encouraging budding talents. As a token of thanks, some of them, such as Menashe Kadishman, dedicated some of their creations to him. He loved music ardently, especially that of Jean Sibelius.

He also encouraged and guided young mathematical talents. David Harel began concentrating on topology for his M.Sc. degree at Tel Aviv University. After one year he decided to leave his studies and become a programmer. Pinny advised

Image courtesy of the authors.

The cover page of the proceedings, "Numerical Integration", NATO Series, *Math and Physical Sciences*, Vol. 203, 1987.

him to meet Amir Pnueli. As a result, David wrote his M.Sc. degree in computer science under Amir. Both later got the Israel Prize in computer science. Amir is also a Turing Prize laureate.

In June 1956 Shaula and I got married. Weeks before, Pinny secretly began hoarding the colored "holes" of the punched paper tape. When we paraded to the podium where the marriage ceremony took place, Pinny tossed the confetti on our heads.

During the hot and humid summers of Rehovot, home of the Weizmann Institute, Pinny usually went abroad working with colleagues. During later years, when he reduced his travel, he purchased a house in Efrat, near Jerusalem, where his daughter lives, and the climate is cooler and drier. There he and Terry spent the summers. During winter they lived in Rehovot. Over the years, those winters became shorter and the summers got longer. During the last winter of his illness he also stayed in Efrat.

Pinny's personality reflected a harmonious fusion of Judaic values, love for the land of Israel, science, and the fine arts. May his memory be blessed.

How to Write Your First Paper

Steven G. Krantz

This article is the third in an occasional series intended for graduate students. The series is coordinated by Associate Editor Lisa Traynor.

In today's world, most any math department wants each of its faculty to have a scholarly profile. If you wish to establish yourself in the profession, if you want to make your reputation, if you want to achieve tenure status, then you must publish. While it is okay to publish a "Letter to the Editor" in the *Notices*, or a recreational problem in the *American Mathematical Monthly*, the hard fact of the matter is that the publishing that really counts is that of a research article in a peer-reviewed mathematics journal. The purpose of this article is to tell you how to perform that task.

I have published more than 150 articles myself. So I guess that I know how to do it. I have never written an article and then been unable to publish it. The notion—that one reads about in stories or sees in popular movies—of a forlorn scholar languishing away because he/she cannot get his/her ideas in print is mostly nonsense. You cannot succeed at anything in life unless you understand what it is that you are trying to achieve. Once you understand what mathematical research is about, and how the publication process works, then you should be able to get your work into print. We shall lay out all the essential moves here.

Blood and Guts

First, you need to become involved in an ongoing research area of current interest. If you are lucky, you will have had a good and effective thesis advisor who will have given you a problem that is *not* a dead end. Then whatever you achieved in your thesis will have opened new doors, and suggested new questions, and you will certainly have interesting and productive things to think about. If, sadly, this is not the case, then you will have to do the job yourself. Go to one or more conferences, listen carefully to the best talks, and find out what people are thinking about. Pick two or three good papers and work through them in detail. *Talk to people.* Go to seminars in your own department. Get involved in some Internet chat groups. Immerse yourself in a field. In the best of all possible worlds, this should be a field that fascinates you, that gives you the proverbial "fire in the guts". Eventually you will find a problem that you cannot let go, that you must solve or else.

So solve it. Make sure it is right. Give a seminar on your result. Discuss it with some friends. When you are confident that you have a winner, then it is time to write it up. Again, it is essential that you understand what it is that you are trying to achieve.

You cannot write a good math paper by just picking up a pencil and starting to write. Some planning is definitely in order. Will this be a 10-page paper that simply states a theorem and proves it, or will this be a 50-page *magnum opus* that redefines a field and sets it in a new direction? If you are a beginner in the field, and if you are an ordinary mortal like most of us, then most likely your first paper will be of the first type. But we shall give here some advice for both types of work.

Begin by writing an outline of the paper. This could be as simple as

- Introduction
- Background
- Thanks

Steven G. Krantz is deputy director of the American Institute of Mathematics. His email address is skrantz@aimath.org.

- Definitions
- Statement of Main Results
- Indication of Methodology
- Details of Proof
- Concluding Remarks

At least now you will have an idea of what are the main ingredients of this new work. You can probably make an estimate of the length of the paper. And you can begin to write.

Some of us write directly on the computer (in TEX), without working from a paper draft written by hand. If you are doing serious, deep mathematics then you will certainly have to do some of your calculations by hand. You may also have to draft some of your theorems and your arguments by hand. That is just the way the human intellect works. You can hardly perform a delicate estimation of singular integrals on the fly at the keyboard. Some people will write out every word by hand before going to the computer. Others will combine the two media.

Think about what attributes make a paper readable. I have certainly seen papers which begin

Notation is as in my last paper.

Theorem: Let $\epsilon > 0$. …

This is okay if all you want to do is plant your flag. Back in the 1960s, there were many journals that Dutch theoretical computer scientist Edsger Dijkstra would have called "write only", and they would have published something like this. Today journals are more demanding, and in any event you should set a higher standard for yourself. Write a paper that you yourself would want to read. Make it accessible. Bear in mind that the referee for your paper will be a busy person who has no patience for a tract that he cannot fathom. Lay out the material so that it is rapidly apparent what your main result is, what the background for that result is, and how you are going to go about proving it. If the proof is long and complicated, then break it up into digestible pieces. Tell the reader what is going to happen *before* it happens. Tell the reader what has just happened before you go on to the next step. At the end of a long argument, summarize it.

Write a nice conclusion for your paper. A mathematical article that ends

and so $S \subseteq T$. □

has a certain *joie de vivre* to it, but leaves the reader hanging. Why not have a nice section of Concluding Remarks, telling the reader what you have accomplished and where things might go from here? Leave the reader with a forward-looking view of things; make him/her feel as though this is a field that he/she might want to get involved in.

I promised to say something about longer papers, and I shall do so now. It is difficult to publish a long paper. If you write a 50-page paper, even if it is extremely good, you are going to have trouble getting it into print. Many journals have strict page limits, and the limit is usually about 15 or 20 pages. Many journals make it clear that, if they are going to publish your 50-page polemic, then it had better glow in the dark.[1] As a general strategy, it is best to break your ideas up into smaller pieces. Publish three 20-page papers rather than one 50-page paper. If you are into self-abuse and seek the defeatist situation of having a paper that you have labored over for two years and cannot get published, then writing a 50+ page tract is the way to go. You will get angry and frustrated and, in the end, be done in if you write a paper that nobody is willing to even consider.

But, if you have proved the Goldbach Conjecture, or found a zero of the zeta function that does not lie on the critical line, then you can probably justify writing a long tract. In this case, organization is particularly important. It is extremely useful for such a paper to have a thoughtful and detailed *Table of Contents*. You should be careful to isolate all your notation and definitions. Give an informal statement of your results before you give the detailed formulation. Give an outline of your proof before you trot out all the dirty details. Formulate a thoughtful and enlightening closing section. The book [KRA1] gives copious advice in these matters.

After your paper is completed, checked, and ready-to-go, a very natural thing to do is to post it on an electronic preprint server. Many specialty areas—such as K-theory and linear algebraic groups—have their own dedicated preprint servers. Also a number of mathematics institutes (such as the American Institute of Mathematics) and most math departments have their own preprint servers. If nothing else you will probably want to put the paper on your own webpage. But, as of this writing, the canonical place to put a new paper is on `arXiv`. Created by Alan Ginsparg and now based at Cornell University, `arXiv` is the standard repository for new papers in mathematics, physics, statistics, computer science, biology, and other disciplines. Posting a paper there is straightforward (and particularly easy if you use Greg Kuperberg's front end called `Front`).[2] And

[1] *Theodore Streleski garnered some notoriety in the early 1970s for murdering his graduate advisor Karel de Leeuw at Stanford University. He had always been rather unstable, but the straw that broke the camel's back was that the* Bulletin of the American Mathematical Society *had rejected his Ph.D. thesis. As you may know, the* Bulletin *specializes in research announcements, research expository articles, and book reviews. It simply does not publish entire theses. It seems that Streleski was the victim of bad advice or bad judgment or both.*

[2] *The preprint server* `arXiv` *can be accessed at* `http://arxiv.org` *and* `Front` *can be accessed at* `http://front.math.ucdavis.edu`.

then your paper will be freely accessible to all the world. Many journals allow you to submit a paper simply by pointing to the Web address of your paper on arXiv!

There are copyright issues to consider here. The moment you write something it is copyrighted to you. And you certainly then have the right to put it on a preprint server. But when your paper is accepted by a journal then you will probably be asked to sign a Transfer of Copyright Agreement. Then the paper is copyrighted to the journal. In principle the journal could ask you to take the paper *off* the preprint server. These days most journals have made peace with how the world works and they will not ask you to do so. You can leave your paper on arXiv and go ahead and have it published in a journal. An alternative approach is to decline to sign the Transfer of Copyright agreement and tell the journal that you wish to hold the copyright. Many journals will go along with that request (although many will not!). It may actually happen that a journal will ask you to take your paper off the Web, but it has never happened to me.

Practical Matters

My detailed thoughts about the chapter and verse of writing a paper are already recorded in [KRA1]. I shall not repeat them here. The main point of the present tract is to discuss how to submit your new paper and how to deal with the journal and its editors.

The choice of journal to which to submit your work is not a trivial matter. It is well known that the best journals are the *Annals of Mathematics*, *Acta Mathematica*, *Inventiones mathematicae*, *The Journal of the American Mathematical Society*, and a few others. It is quite an accomplishment to get a paper into one of these journals. But sending all your work into these recondite forums is not the way to go. If you have shown your work to colleagues, given some talks on it, and received copious praise and adulation, then perhaps it is appropriate to consider sending the paper to a top journal. Usually it is not, and you should set your sights a bit lower. As a beginning mathematician, you should be spending a good deal of time browsing journals, acquainting yourself with the literature, understanding what is published where. You should get a sense of where papers in your subject area are published. Some observations are obvious. *The Journal of Symbolic Logic* will not publish papers on pseudodifferential operators. *The Journal of Differential Geometry* will not publish papers on Moufang loops. With *The Transactions of the American Mathematical Society*, matters are less clear. Most journals have an *Instructions to Authors* page that will tell you this journal's conception of itself, and what types of papers it seeks. It will also acquaint you with the specific mechanism for actually submitting a paper to that particular journal.

The main point is that you are trying to establish yourself in the profession, your tenure clock is running, and you cannot afford to fritter away five years getting your first paper published. You want to handle the matter expeditiously so that you can move on to the next project. Therefore choose a journal that is (a) well-suited to the subject matter of your paper and (b) at the right level. It helps if you know one or more of the editors. That will make you feel more comfortable with the process, and also will perhaps suggest that this is a periodical that will appreciate your work.

Another consideration if your tenure clock is ticking away is how long it will take any given journal to get your paper into print. Some deans are extremely punctilious and only believe that a paper exists when they hold the reprint in their hands. So you do not simply want to have your paper accepted, you want it to be in print. There *is* information available about journal backlogs. The *Notices* regularly collects and publishes such data. And many journals put backlog information on their webpages.

I must stress here that it is a hard and fast rule in academics—and most journals will state this explicitly on their Instructions to Authors page—that you may submit a paper to only one journal at a time. This dictum is in place partly because of tradition, but primarily because the journal does not want to waste referees' time nor its own time. And journals certainly want to prevent various forms of academic dishonesty that could propagate from multiple submissions.[3] The books [KRA1] and [KRA2] discuss these matters in some detail.

The traditional way to submit a paper is in hard copy. *In a single envelope*, you send in two—or perhaps more!—copies of the paper printed one side only and a cover letter telling the editor or secretary what he/she is receiving. The cover letter should give your name (and those of your co-authors), the paper's name, your affiliation, and all your contact information (mailing address, email address, phone number, fax number, and so forth). If you are going to be traveling, or going on sabbatical, that should be mentioned in the letter. At various times the journal will need to contact you (to read proofs, sign copyright transfer forms,

[3] *Matters are different when you are attempting to get a book manuscript published by a commercial publisher. Then it is allowed, and indeed expected, that you will submit your project to more than one publisher at once. The reason for this difference in the rules is partly custom, but also that referees for book manuscripts are paid for their work.*

and so forth). Most likely email will expedite communication, but it is always a good idea to have all the key information about yourself on a single sheet of paper that the journal has on file.

These days many journals will accept a paper electronically. That means that you send an email to a designated address (the Instructions to Authors page will provide that information), and include the paper as an attachment. Well, electronics are confusing. Should you send your TEX source file and all the `*.eps` files for your figures plus all your style files and your font files? Decidedly not. This would give the recipient myocardial infarction, and it is highly inappropriate. The right thing to send in at first[4] is an `Acrobat` or `*.pdf` file. If properly prepared, this will have all the graphics and fonts embedded in it, so that anyone with an `Acrobat` reader (freely downloadable from the Web) can read it or print it out just as it was meant to appear. The referees will have no trouble reading the file, and neither will the editors or the clerical staff.[5] Be sure that the cover email contains all the contact information that was described above.

Patience

Dealing with an academic journal requires a good dose of patience. Generally speaking such operations are understaffed, or perhaps only staffed part-time. You may have to wait a month just to receive an acknowledgement that your paper has been received. That communication will often contain some generalized platitudes about when you can expect a referee's report, but they will usually not be very specific. And that is because they do not know. The journal will be well acquainted with its associate editors—those who handle the papers and do the legwork of getting the papers refereed—but they have no control whatever over the referees themselves. Even a well-meaning referee will have many distractions—a cat that is about to have kittens, a child graduating from high school, a house renovation, an upcoming surgery, or any number of other vicissitudes of life. Worse, the referee may be recovering from a drug dependency or getting a divorce. Or he/she may be terminally disorganized or hopelessly irresponsible. Who knows? So, if you are lucky, you will get a referee's report in three to four months. If you are not, it could take a year or more.

Most math journals use just one referee for a paper (in other disciplines this is *not* at all the norm; biology journals typically use two or three). But the *Annals* has an extremely high standard, and often uses at least two. The *Monthly* also has a high standard (of a somewhat different sort) and typically uses at least two referees. Thomas Hales's solution of the Kepler sphere packing problem, which appeared recently in the *Annals*, posed a particularly thorny refereeing problem (because the work involves massive computer calculations). The *Annals* enlisted a team of about a dozen Hungarian mathematicians who spent several years at the refereeing task.

I am an old dead white guy, and I usually do not care how long it takes for my papers to be refereed. I am busy writing other papers or doing other interesting tasks. I can wait. If your career is hanging in the balance, however, your view may be somewhat different. As a journal editor, I have certainly received very sincere and fervent letters from authors that said, "My tenure case is coming up in two months" or "my promotion is imminent" or "my grant is in the offing" and "I really need a decision." I do what I can to help—in some cases refereeing the paper myself—but in most instances I am at the mercy of the referee. I have had to abandon some referees—because they were so unresponsive—in effect forgetting that I had sent the paper to referee *A* and just starting again from scratch and sending the paper to referee *B*. Because of my experience and my contacts, I can usually get a paper refereed fairly expeditiously. In a crisis situation, I can usually help out. But you may be dealing with an editor who is less in tune, or less effectual, and your choices may be limited.

It is perfectly acceptable, after four or five or six months have elapsed, to write a note (by email or snail mail) to the editor or secretary who received your paper and inquire about its status. For this reason it is essential that you keep good records. Save all your correspondence concerning the paper. That way you will have, for example, a printout of the email acknowledging receipt (which will usually include the all-important manuscript number), and you will know just whom to write to and just what to say.

Of course always be polite in your correspondence. A two- or three-sentence note saying, "I submitted MS #xyzw on this date. Can you bring me up to date on the refereeing process? When might I expect a report?" will certainly do the job.

I once waited four years for a referee's report on a pretty good paper (from a journal that I am now too polite to name). I finally sent them a letter saying that if they could not come up with a report in six months then I would withdraw my paper and submit my work elsewhere. They got a report back to me in three months. I am not sure that this

[4] *Likely as not, as a result of the referee's reports, your paper will be revised. So it makes no sense to send in your TEX and other source files at the first submission. When the situation is finalized, and your paper is accepted, then the journal will certainly want your source files.*

[5] *Some journals have a webpage and accept submissions by way of* `ftp`. *The process is usually self-explanatory, and the Instructions to Authors page will tell you all the steps.*

is a good role model for you. Threatening people is no way to do business. But I was desperate.

The Denouement

Eventually your paper will be refereed and you will hold in your hands a referee's report (assuming that you know how to print out email text). You must learn to read referee's reports dispassionately. I have very occasionally received a report that said, "Krantz is a hail fellow well met. We are so lucky to have this paper. Publish it with all dispatch." But such is not the norm. Most referee's reports will contain a mixture of praise and constructive criticism. More often than not (assuming that the paper was accepted) you will have to revise the paper as a result of the report. Do so earnestly. Take all of the recommendations very seriously. Re-submit the paper with a careful log of how you handled each suggestion. If you disagree with a suggestion, say why (politely). Usually the editor will respect your judgment. Frequently the editor will send the paper back to a referee (it really ought to be the *same* referee, and that is usually who it will be, but not always). If you have played the game sincerely and carefully, the referee should then give your work his seal of approval and the paper will be accepted.

If your paper is rejected, do not lose heart. Most everyone has had papers rejected. Some of my most important and most influential papers have not only been rejected, but were treated rather shabbily. Celebrated authors from Jane Austen to Agatha Christie to Henrik Ibsen had their best work rejected. Be of stout heart. Learn what you can from the referee's report, and from the editor's comments, and then make the paper stronger. Submit to another journal. Do not waste time bemoaning your fate. Get the paper re-submitted and move on to more fertile territory.

Now let us return to the happy situation in which your paper (at least in principle) has been accepted. The rest is a formality. You will eventually receive page proofs of your paper (usually in electronic form, as a `*.pdf` file). You must respond to the proofs in a timely manner, offering any corrections that you may have. Then that is it. Eventually your paper will appear—either in the printed journal or the electronic journal or both. In the old days you would also get about 50 reprints of your paper, though this is a tradition that is fast vanishing. Many journals now will send you a `*.pdf` file of the paper in final form, and you can then print out reprints if you wish. The fact of the matter is that, if you want to distribute the paper among friends and colleagues, it is probably most expeditious to just send them the `*.pdf` file.[6] Or post the paper on a website like `arXiv`, or both. In fact you can post the paper on `arXiv` as soon as it is completed—even before you submit it to a journal. And you should. For the most important feature of the Web is that it can make your work available to a broad audience (essentially the entire world) rapidly and at no charge. Since you are trying to establish your reputation, you should do so.

[6] *On the other hand, if you want to give a copy of your paper to your grandmother, then hard copy is probably the way to go.*

Closing Thoughts

Developing your own ideas and publishing them is one of the most important and rewarding parts of academic life. For me, the best part is receiving feedback from students and colleagues and then engaging in useful repartee. This often leads to new insights and new collaborations, and makes the whole exercise productive and worthwhile. I hope that this article will have made it easier for you to become a part of this happy process.

References

[KRA1] S. G. Krantz, *A Primer of Mathematical Writing*, American Mathematical Society, Providence, RI, 1996.

[KRA2] ———, *Mathematical Publishing, A Guidebook*, American Mathematical Society, Providence, RI, 2005.

Sobolev Institute of Mathematics Celebrates Its Fiftieth Anniversary

Victor Alexandrov

On May 18, 1957, the Soviet government approved the initiative of academicians M. A. Lavrent'ev (1900–1980), S. L. Sobolev (1908–1989), and S. A. Khristianovich (1908–2000) to create a new type of research center in Siberia which would integrate research institutes of all basic scientific, technological, and humanitarian disciplines, such as mathematics, physics, mechanics, chemistry, geology, biology, history, economics, etc. It was decided to build the center near Novosibirsk, approximately 3,000 kilometers east of Moscow. The center has the status of a branch of the Academy of Sciences of the USSR, and academician M. A. Lavrent'ev was appointed as its head.

During the next five to ten years, 24 research institutes,[1] the Novosibirsk State University, and numerous apartment blocks and cottages for researchers and staff were built in a picturesque pine forest on the coast of a man-made lake. It was the beginning of the famous Akademgorodok (which means academy town), to which songs and books are devoted [1] and which was built by a generation of enthusiasts devoted to the triumph of science and human intellect: their fathers were victors over fascism; their brothers launched the first Sputnik and the first astronaut.

Within the framework of that ambitious project, the Institute of Mathematics was opened in 1957. The founding father and the first director of the institute was academician Sergej Sobolev,[2] one of the most prominent mathematicians of the twentieth century [2]. The main idea was to invite prominent mathematicians from Moscow and Leningrad[3] who were willing to move to Siberia, together with their disciples. This idea was successfully realized. Let me list just a few members of the Academy of Sciences of the USSR[4] who have worked within the Institute's walls for years or decades:

- A. D. Alexandrov (1912–1999): One of the greatest Russian geometers of the twentieth century, founder of the Soviet school of geometry "in the large", who is known worldwide due to his contributions to the theory of mixed volumes and the theory of surfaces "in the large", the theory of metric spaces with bounded curvature and the theory of Monge-Ampère equations, the maximum principle for elliptic partial differential equations, and the foundations of relativity [3].
- L. V. Kantorovich (1912–1986): A Nobel Prize winner in economics (1975), one of the creators of a mathematical approach to economics based on the study of linear extremal problems; his investigations in functional analysis, computational mathematics, the theory of extremal problems, and the descriptive theory of functions and set theory strongly affected those subjects and gave rise to new fields of research [4].
- A. A. Lyapunov (1911–1973): Starting with descriptive set theory under the supervision of N. N. Luzin (1883–1950), he later worked on mathematical aspects of cybernetics and linguistics; he was awarded the "Computer Pioneer" medal from the IEEE Computer Society (1996).
- A. I. Mal'tsev (1909–1967): The founder of the Siberian school of algebra and logic, his contributions were mainly to algebra (group theory, theory of rings, topological algebra), and mathematical

Victor Alexandrov is leading researcher at the Sobolev Institute of Mathematics. His email address is alex@math.nsc.ru.

[1] *During the next fifty years the number of institutes was nearly doubled.*

[2] *In 1986 academician M. M. Lavrent'ev (a son of M. A. Lavrent'ev) was named his successor, followed by academician Yu. L. Ershov, who has been on duty since 2002.*

[3] *Now St. Petersburg.*

[4] *Now the Russian Academy of Sciences.*

logic (theory of algorithms) and its applications to algebra [5].

• S. L. Sobolev (1908–1989): He contributed mainly to the theory of waves in solids, the theory of equations of mathematical physics, functional analysis, the theory of cubature formulas; he introduced a new class of functional spaces, now known as Sobolev spaces, and the notion of a generalized solution to a partial differential equation [6].

In the early 1990s, the Institute of Mathematics was named after S. L. Sobolev and, since that time, has been called the Sobolev Institute of Mathematics, or SIM for short. At the beginning of 2007 there were 282 research fellows at SIM, among them 9 members of the Russian Academy of Sciences, 108 professors, and 165 fellows with Ph.D. degrees.[5]

In general, SIM fellows devote themselves to pure research without having obligations to spend time on undergraduate teaching, though many of them supervise postgraduate students and, as a part-time job, give lectures or even teach undergraduate students at the Novosibirsk State University. SIM fellows work in most of the fields of modern mathematics. In order to provide the reader with an impression of how wide the variety of research is, we list just a few groups headed by members of the Russian Academy of Sciences and mention some of their latest books and research interests:

• Mathematical logic (Yu. L. Ershov [7] and S. S. Goncharov [8] lead a group of mathematicians who work in algebra, mathematical and applied logic, information theory, and philosophy of mathematics).

• Group theory (V. D. Mazurov [9] is head of the laboratory dedicated to classification of finite groups, recognition of finite simple groups by their element orders, groups of automorphisms of free groups, etc.).

• Real functions, potential theory, geometry (Yu. G. Reshetnyak [10] and his disciples develop geometry "in the large", the theory of quasiconformal and quasiregular mappings, the theory of Sobolev spaces, and other fields of mathematics related to geometry and analysis).

• Partial differential equations (M. M. Lavrent'ev [11] and V. G. Romanov [12] and their colleagues work on differential equations, inverse and ill-posed problems, tomography, computational and applied mathematics).

• Dynamical systems (I. A. Tajmanov [13] and research fellows of his laboratory study dynamical systems and related problems of geometry, analysis and partial differential equations).

• Probability theory and statistics (A. A. Borovkov [14] and his scientific school study limit theorems of the theory of probability (including boundary value problems, analysis of large deviations, and functional limit theorems), ergodicity and stability of random processes, asymptotic methods of mathematical stochastics, asymptotic analysis of multidimensional Markov chains, etc.).

• Numerical analysis (S. K. Godunov [15] is known worldwide due to a method for calculating shock waves which is usually referred to as the Godunov method. He contributed to the theory of difference schemata and especially to the theory of difference methods for the numerical solution of problems in gas dynamics, to the problems of guaranteed accuracy in numerical linear algebra, to the theory of ordinary differential equations, and to many other fields of mathematics and mechanics).

Photographs courtesy of the Sobolev Institute.

Sergej Sobolev.

Approximately twenty-five permanent research seminars are held at SIM. Every year two to four international conferences are organized.

SIM has the right to award the Ph.D. degree or habilitation in the following fields: mathematical logic, algebra and number theory, mathematical analysis, geometry and topology, differential equations, and computational mathematics. Each year SIM enrolls twelve postgraduate students[6] in these fields. These students are supposed to complete their Ph.D. theses in three years.

The SIM library is one of the best mathematical libraries in Russia east of the Ural Mountains. It contains approximately 150,000 items: more than 30,000 books (including about 20,000 books in foreign languages, including a few books published in the seventeenth century) and more than 100,000 issues of journals (including about 75,000 issues of foreign journals).

SIM publishes several journals on mathematics and applied mathematics in Russian: *Algebra and Logic,*[7] *Discrete Analysis and Operations Research,*[8]

[5] *In fact SIM has its department in Omsk (the next city with a population of more than one million west of Novosibirsk, 700 km apart), which additionally includes 9 professors and 27 fellows with Ph.D. degrees.*

[6] *Additionally, the Omsk department enrolls four students.*

[7] *ISSN 0373-9252; a cover-to-cover English translation is available.*

[8] *ISSN 1560-7542 for Series I and ISSN 1560-9901 for Series II; for selected articles an English translation is available in the* Journal of Applied and Industrial Mathematics, *ISSN 1990-4789.*

Sobolev Institute of Mathematics

Mathematical Transactions,[9] *The Siberian Journal for Industrial Mathematics,*[10] *Siberian Mathematical Journal,*[11] and *Siberian Electronic Mathematical Reports.*[12]

SIM is involved in numerous Russian and international research programs; it has been a partner of Zentralblatt MATH for more than ten years. Many mathematicians who started their careers as SIM fellows have received international honors for their contributions to mathematics and have received professorships all over the world. To name a few of them, we mention Efim Zel'manov (awarded a Fields Medal in 1994, he is now a professor at the University of California, San Diego) and Ivan Shestakov (awarded the 2007 Moore Research Article Prize, he is now a professor at the University of São Paulo, Brazil).

A conference dedicated to the Institute's fiftieth anniversary took place in Novosibirsk September 18-22, 2007. It was attended by 276 participants from eighteen Russian cities and from Canada, France, Germany, Hungary, Italy, Kazakhstan, the Netherlands, Slovenia, Switzerland, Ukraine, the United Kingdom, and the U.S.A.

Detailed information can be found on the Institute's website, `http://math.nsc.ru/english.html`.

References

[1] M. A. Lavrent'ev, *…Will Be Enlarged by Siberia* (in Russian), Novosibirsk, 1982.

[2] J. Leray, La vie et l'oeuvre de Serge Sobolev. *C. R. Acad. Sci., Paris, Sér. Gén.*, Vie Sci. 7, No. 6, 467–471 (1990).

[3] A. D. Alexandrov, *Selected Works,* Part 1: Gordon and Breach Publishers, Amsterdam, 1996; Part 2: Chapman & Hall/CRC, Boca Raton, FL, 2005.

[4] L. V. Kantorovich, *Selected Works,* Parts 1, 2, Gordon and Breach Publishers, Amsterdam, 1996.

[5] A. I. Mal'tsev, *Selected Works* (in Russian), Vols. 1, 2., Nauka, Moscow, 1976.

[6] S. L. Sobolev, *Selected Works*, Springer, New York, 2006.

[7] Yu. L. Ershov, *Multi-valued Fields,* Kluwer Academic, New York, 2001.

[8] S. S. Goncharov, *Countable Boolean Algebras and Decidability*, Plenum, New York, 1997.

[9] V. D. Mazurov (ed.) and E. I. Khukhro (ed.), *The Kourovka Notebook. Unsolved Problems in Group Theory*, 16th ed, Sobolev Institute of Mathematics, Novosibirsk, 2006.

[10] Yu. G. Reshetnyak, *Stability Theorems in Geometry and Analysis*, Kluwer Academic Publishers, Dordrecht 1994.

[11] M. M. Lavrent'ev, V. G. Romanov, and S. P. Shishatskij, *Ill-posed Problems of Mathematical Physics and Analysis*, American Mathematical Society, Providence, RI, 1986.

[12] V. G. Romanov, *Stability in Inverse Problems* (in Russian), Nauchnyj Mir, Moscow, 2005.

[13] I. A. Tajmanov, *Lectures in Differential Geometry* (in Russian), Institut Komp'yuternykh Issledovanij, Izhevsk 2002.

[14] A. A. Borovkov, *Probability Theory*, Gordon and Breach, Amsterdam, 1998.

[15] S. K. Godunov, *Modern Aspects of Linear Algebra*, American Mathematical Society, Providence, RI, 1998.

[9] *ISSN 1560-750X; for most of the articles an English translation is available in* Siberian Advances in Mathematics, *ISSN 1055-1344.*

[10] *ISSN 1560-7518; for selected articles an English translation is available in the* Journal of Applied and Industrial Mathematics, *ISSN 1990-4789*

[11] *ISSN 0037-4474; a cover-to-cover English translation is available.*

[12] *Electronic only, available at* `http://semr.math.nsc.ru/english.html`. *ISSN 1813-3304.*

About the Cover

The Museum of Associahedra

This month's cover was suggested by Andrei Zelevinsky's article on clusters. As he mentions, certain convex polytopes arise in the theory of clusters that generalize the older construction of *associahedra*. The story of associahedra is in itself remarkable, although by now somewhat familiar.

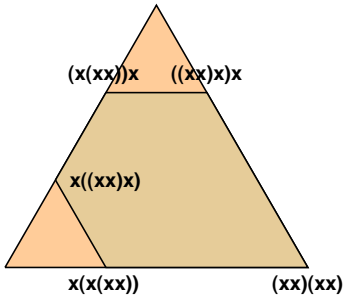
Start with a single product of n variables. Then make a list of all possible ways to insert a proper pair of balanced parentheses in this product. If n is 4, for example, we start with *xxxx* and get the list

(xx)xx
(xxx)x
x(xxx)
xx(xx)
x(xx)x.

Continue by inserting correctly other pairs of balanced parentheses. If n is 4 we get

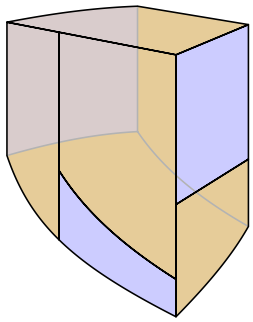
(x(xx))x
((xx)x)x
(xx)(xx)
x(x(xx))
x((xx)x)

It turns out that what we obtain finally is a cellular complex K_n topologically equivalent to an n-2 ball and its boundary sphere. Its vertices are the expressions which are saturated, and two vertices are joined by an edge if they differ by a single application of associativity. For example, (*xx*)(*xx*) and *x*(*x*(*xx*)) would be joined, and the entire cell for n=4 is a pentagon:



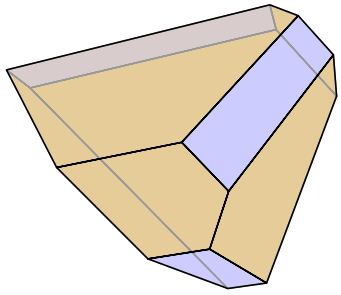
The associahedron for n=4, showing also the 2-simplex from which it is obtained by truncation.

In higher dimensions, this is a non-trivial fact. It was first observed by James Stasheff in his 1963 thesis on associativity and homotopy, but his cellular structure was, although ingenious, somewhat unsatisfying since it involved cells with curved boundaries.



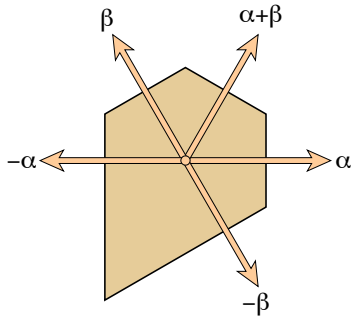
Stasheff's cell for n=5.

Since then numerous constructions of the associahedra as polytopes have been found, among the most recent one by Satyan Devadoss.



Devadoss' construction of K_5.

As Zelevinsky points out, these and similar polytopes occur in many incarnations, among them some related to root systems.



My thanks to James Stasheff, Mark Haiman, and Andrei Zelevinsky for assistance, even though I had insufficient space to incorporate their comments.

References

JAMES STASHEFF, Homotopy associativity of H-spaces, *Ann. of Math.* **108**.

SATAYAN DEVADOSS, A realization of graph associahedra, preprint, 2007.

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

Mathematics People

Kreps Awarded 2007 CME/MSRI Prize

The Chicago Mercantile Exchange (CME), the largest and most diverse financial exchange, through its Center for Innovation has partnered with the Mathematical Sciences Research Institute (MSRI) to award the second annual CME/MSRI Prize. This award is designed to recognize individuals or groups who contribute original concepts and innovation in the use of mathematical, statistical, or computational methods for the study of the behavior of markets and, more broadly, of economics.

CME and MSRI have awarded the 2007 CME/MSRI Prize in Innovative Quantitative Applications to DAVID M. KREPS, Senior Associate Dean for Academic Affairs and the Theodore J. Kreps Professor of Economics at the Stanford University Graduate School of Business.

Kreps's prolific and seminal research in microeconomics has probed deeply into dynamic choice in both single-person and multiperson settings. In 1979 he was part of a team that placed the concept of risk-neutral asset pricing in the framework of "martingale measures", an approach that is now standard for the pricing and risk management of financial products. He has had influential insights across a host of different topics, including dynamic choice, in which parties exhibit a preference for flexibility or concern over the timing of resolution of uncertainty; processes of learning both in markets and in games; and models of reputation in repeated games, with applications to corporate culture and human resource management.

As this year's recipient, Kreps was presented with the CME/MSRI Prize medal and a cash award of US$25,000 at a recognition ceremony held on September 20, 2007, at CME in Chicago. In conjunction with the award ceremony, a seminar was held with Milton Harris of the University of Chicago; Nobel Laureate Myron Scholes of Platinum Grove Asset Management; last year's CME/MSRI awardee, Stephen A. Ross of MIT Sloan School of Management; and Luigi Zingales of the University of Chicago Graduate School of Business on the topic "What's the Deal with Private Equity?"

Members of the CME/MSRI Prize Selection Committee were: Leo Melamed, CME Group Chairman Emeritus; Myron Scholes; Stephen A. Ross; Darrell Duffie, James I. Miller Professor of Finance, Stanford University Graduate School of Business; Hugo Sonnenschein, president emeritus and Adam Smith Distinguished Service Professor, University of Chicago; and David Eisenbud, former director of MSRI.

—From a CME news release

Singapore National Science and Technology Awards Given

The Agency for Science, Technology, and Research (A*STAR) in Singapore has announced its National Science and Technology Awards (NSTA) for 2007. A. J. BERRICK and WU JIE of the National University of Singapore received a joint National Science Award for their work in mathematics. According to the prize citation, they have "uncovered deep connections between algebraic topology and the theory of braids. This fundamental work, which brought together two branches of mathematics, lays the foundation for other researchers to apply the mathematical structures to situations requiring precise control of complex multiobject, multidimensional movement, as in the case of air traffic control, robotic motion, and the folding of proteins to create new drugs."

The National Science Awards recognize research scientists and engineers in Singapore who have made outstanding contributions in basic research leading to the discovery of new knowledge or the pioneering development of scientific or engineering techniques and methods. Awardees receive a trophy, a citation, and a prize of US$15,000.

—From an Agency for Science, Technology, and Research announcement

NDSEG Fellowships Awarded

Fourteen young mathematicians have been awarded National Defense Science and Engineering Graduate (NDSEG) Fellowships by the Department of Defense (DoD). 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 fellowships are sponsored by the United States Army, Navy, and Air Force.

Following are the names of the fellows in mathematics, their institutions, and the offices that awarded the fellowships: MELODY CHAN (Princeton University), Army Research Office (ARO); DANIEL ERMAN (University of California, Berkeley), Office of Naval Research (ONR); LAUREN HUND (Harvard University), ARO; LINDA HUNG (Princeton University), Air Force Office of Scientific Research (AFOSR); QUINTINA JONES (University of Arizona), AFOSR; IRINA KALASHNIKOVA (Stanford University), AFOSR; DANIEL KANE (Harvard University), ONR; EMANUEL LAZAR (Princeton University), High Performance Computing Modernization Program (HPCMP); IAN LE (Northwestern University), ARO; CATHERINE LENNON (Massachusetts Institute of Technology), AFOSR; PO-RU LOH (Massachusetts Institute of Technology), ARO; JESSICA MCCOY (Stanford University), AFOSR; STEFAN PATRIKIS (Princeton University), ONR; AVIVA PRESSER (Harvard University), ONR.

—From an NDSEG announcement

B. H. Neumann Award Given

The B. H. Neumann Award for 2007 has been awarded by the Board of the Australian Mathematics Trust to ANNE HASTINGS, deputy principal at Kambala School, Sydney, Australia, for her significant service to the Australian Mathematics Trust, including serving the Australian Mathematics Competition Problems Committee and being a moderator for about fifteen years, a function she still serves. The awards, named for Bernhard H. Neumann, are presented each year to mathematicians who have made important contributions over many years to the enrichment of mathematics learning in Australia and its region.

—Board of the Australian Mathematics Trust

Pi Mu Epsilon Student Paper Presentation Awards

Pi Mu Epsilon (PME), the U.S. honorary mathematics society, makes annual awards to recognize the best papers by undergraduate students presented at a PME student-paper session. This year the PME held a session in conjunction with the Mathematical Association of America MathFest in San Jose, California, August 2–5, 2007. Seven students were designated as 2007 AMS Award Winning Pi Mu Epsilon Student Speakers, each of whom received a check for US$150. Their names, institutions, and paper titles follow.

JEFF CORNFIELD, Ohio Xi Chapter at Youngstown State University, "Napoleon Triangles—A Brief Presentation"; TYLER DROMBOSKY, Ohio Xi Chapter at Youngstown State University, "Effective Condition Number"; RACHEL GROTHEER, Ohio Iota Chapter at Denison University, "The tangled and knotted tale of two graphs"; DAVID HORN, Illinois Iota Chapter at Elmhurst College, "Cutting a Segment into Equal Areas without Cutting through the Curve OR Cutting Pie Fairly"; SARA JENSEN, Wisconsin Epsilon Chapter at Carthage College, "Population Genetics and the ABO Blood Type"; WILLIAM RYAN LIVINGSTON, Ohio Xi Chapter at Youngstown State University, "Statistical Observations on America's Colleges and Universities"; MATT WARD, Ohio Xi Chapter at Youngstown State University, "Are the Gaussian Integers Friends?".

—From a Pi Mu Epsilon announcement

Mathematics Opportunities

NSF Computing Equipment and Instrumentation Programs

The Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) plans a limited number of awards for the support of computing environments for research in the mathematical sciences. SCREMS (Scientific Computing Research Environments for the Mathematical Sciences) supports computing environments dedicated to research in the mathematical sciences. Proposals may request support for the purchase of computing equipment and limited support for professional systems administrators or programmer personnel for research computing needs. These grants are intended to support research projects of high quality that require access to advanced computing resources. Requests for routine upgrades of standard desk-environment workstations or laptop computers are not appropriate for this program. Awards are made to provide support for specific research projects rather than to provide general computing capacity. Proposers are encouraged to include projects involving symbolic and algebraic computations, numerical computations and simulations, and graphical representations (visualization) in aid of the research.

Please see `http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5616` for details. The deadline for proposals is **January 24, 2008**.

—From an NSF announcement

NRC-Ford Foundation Diversity Fellowships

The National Research Council (NRC) administers the Ford Foundation Diversity Fellowships program. The program seeks to promote the diversity of the nation's college and university faculties by increasing their ethnic and racial diversity, to maximize the educational benefits of diversity, and to increase the number of professors who can and will use diversity as a resource for enriching the education of all students. Predoctoral fellowships support study toward a Ph.D. or Sc.D., dissertation fellowships offer support in the final year of writing the Ph.D. or Sc.D. thesis, postdoctoral fellowships offer one-year awards for Ph.D. recipients. Applicants must be U.S. citizens or nationals in research-based fields of study and members of one of the following groups: Alaska Native (Eskimo or Aleut), Black/African American, Mexican American/Chicana/Chicano, Native American Indian, Native Pacific Islander (Polynesian/Micronesian), or Puerto Rican.

Approximately sixty predoctoral fellowships will be awarded for 2008. The awards provide three years of support and are made to individuals who, in the judgment of the review panels, have demonstrated superior academic achievement, are committed to a career in teaching and research at the college or university level, show promise of future achievement as scholars and teachers, and are well prepared to use diversity as a resource for enriching the education of all students. The annual stipend is US$20,000, with an institutional allowance of US$2,000. The deadline for applying online is **November 15, 2007**.

Approximately thirty-five dissertation fellowships will be awarded for 2008 and will provide one year of support for study leading to a Ph.D. or D.Sc. degree. The stipend for one year is US$21,000. The deadline for applying online is **November 29, 2007**.

The postdoctoral fellowship program offers one year of postdoctoral support for individuals who have received their Ph.D.'s no earlier than November 30, 2000, and no later than November 29, 2007. The stipend is US$40,000, with an employing institution allowance of US$1,500. Approximately twenty postdoctoral fellowships will be awarded for 2008. The deadline for applying online is **November 29, 2007**.

More detailed information and applications are available at the website `http://www7.nationalacademies.org/fordfellowships/`. The postal address is: Fellowships Office, Keck 576, National Research Council, 550 Fifth Street, NW, Washington, DC 20001. The telephone number is 202-334-2872. The email address is `infofell@nas.edu`.

—From an NRC 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 mathematical, physical, biological, ocean, and engineering sciences. Approximately 200 fellowships will be awarded in 2008.

The NDSEG Fellowship Program is open only to applicants who are citizens or nationals of the United States. NDSEG Fellowships are intended for students at or near the beginning of their graduate studies in science or engineering. Applicants must have received or be on track to receive their bachelor's degrees by fall of 2008. Fellows selected in spring 2008 must begin their fellowship tenure in fall 2008. Fellowships are tenable only at U.S. institutions of higher education offering doctoral degrees in the scientific and engineering disciplines specified above. Fellows will receive full tuition and a stipend for 12-month tenures. 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 or postmarked by **January 7, 2008.** Application materials are available from, and completed applications should be returned to, the American Society for Engineering Education (ASEE) at NDSEG Fellowship Program, c/o American Society for Engineering Education, 1818 N Street, N.W., Suite 600, Washington, DC 20036; telephone: 202-331-3516; email: ndseg@asee.org. For further information, see the website http://www.asee.org/ndseg/preface.cfm.

—From an NDSEG announcement

National Academies Graduate Fellowship Program

The Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies is designed to engage graduate science, engineering, medical, veterinary, business, and law students in the analysis and creation of science and technology policy and to familiarize them with the interactions of science, technology, and government. As a result, students develop essential skills different from those attained in academia and make the transition from graduate student to professional.

In 2008, programs will be held in the summer from June 2 through August 8, and in the fall from September 8 through November 14.

Applications for the fellowships are invited from scholars from graduate through postdoctoral levels in any physical, biological, or social science field or any field of engineering, medicine and health, or veterinary medicine, as well as business, law, education, and other graduate and professional programs. Postdoctoral scholars should have received their Ph.D.'s within the past five years.

The stipend for each 10-week program is US$5,300. The fellowship stipend is intended to cover all living expenses for the period.

Deadlines for receipt of materials for the summer program is **March 1, 2008**, and for the fall program, **June 1, 2008**. More information and application forms and instructions can be found on the website http://www7.nationalacademies.org/policyfellows or by contacting The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

—From a National Academies announcement

Call for Nominations for Waterman Award

Congress established the Alan T. Waterman Award in August 1975 to mark the twenty-fifth anniversary of the National Science Foundation (NSF) and to honor its first director. The annual award recognizes an outstanding young researcher in any field of science or engineering supported by the NSF. In addition to a medal, the awardee receives a grant of US$500,000 over a three-year period for scientific research or advanced study in the mathematical, physical, medical, biological, engineering, social, or other sciences at the institution of the recipient's choice.

Candidates must be U.S. citizens or permanent residents and must be thirty-five years of age or younger or not more than seven years beyond receipt of the Ph.D. degree by December 31 of the year in which they are nominated. Candidates should have demonstrated exceptional individual achievements in scientific or engineering research of sufficient quality to place them at the forefront of their peers. Criteria include originality, innovation, and significant impact on the field.

The deadline for nominations and all supporting material for the award is **December 7, 2007**. For more information, see the website http://www.nsf.gov/od/waterman/waterman.jsp.

—From an NSF announcement

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. The fellowship provides an aggregate stipend of US$90,000 over five years, a full-tuition scholarship for a master's-level teaching 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 able to demonstrate a strong interest in teaching. Applicants must be willing to commit to a five-year fellowship term in New York City. Individuals who are currently teaching, who are certified to teach, or who have completed an education

degree program are not eligible. Candidates must be U.S. citizens or permanent residents of the United States. The deadline for applications is **February 1, 2008**. For more detailed information, see the website at http://www.mathforamerica.org/.

—From an MfA announcement

CMI Liftoff Program for Summer 2008

The Clay Mathematics Institute (CMI) is currently accepting nominations for the 2008 Liftoff program. Through this program, CMI will employ recent Ph.D. recipients as Liftoff Fellows to carry out mathematics research for one month during the summer of 2008. This program provides a transition for young mathematicians from student to faculty member or to a postdoctoral position. Funds for travel to conferences or to visit collaborators are also available to Liftoff Fellows.

Nominations should be made by university mathematics departments; candidates may not apply directly. Criteria for selection are the quality and significance of mathematical research already achieved by the candidate and the potential of the candidate to become a leader in mathematical research.

Nomination packets should include: (1) a cover letter signed by the department chair; (2) two letters of recommendation, including one from the thesis supervisor (existing letters of recommendation already written for job applications can be used); (3) a CV from the nominee, including name, address, telephone, email, date of birth, citizenship, education, thesis title, honors, previous employment, reference to published work or submitted articles, and proposed research; and (4) a one-sentence signed statement from a mathematician agreeing to supervise the nominee on behalf of CMI with the proposed dates of employment.

Nominations can be sent electronically to the attention of Chelsea Chapko at liftoff@claymath.org or by post to Clay Mathematics Institute, One Bow Street, Cambridge, MA 02138. The deadline for nominations to be received is **February 15, 2008**. For more information, see the website http://claymath.org/fas/liftoff_fellows/; telephone: 617-995-2600; email: nominations@claymath.org.

—From a CMI announcement

Call for Applications for Kovalevskaja Award

The Alexander von Humboldt Foundation is seeking applications for the Sonja Kovalevskaja Award for 2008. The award is open to junior scientists and scholars from outside Germany who have received the Ph.D. within the past six years and have a record of publication in international journals or through scholarly presses. The foundation particularly welcomes applications from qualified women. The award provides funding of up to 1.65 million euros (approximately US$2.32 million) over a five-year period. The funding enables recipients to conduct independent research and finance a research team at a university or research institute of their choice in Germany.

Up to eight awards will be made for 2008. The deadline for applications is **January 4, 2008**. For more information see the website http://www.humboldt-foundation.de/en/programme/preise/kova.htm.

—From a Humboldt Foundation announcement

Virtual Exhibit at the Smithsonian

October 4, 2007, marked the 50th anniversary of the launch of the Sputnik satellite. The National Museum of American History, which houses the Smithsonian Institution's collection of mathematical artifacts, has prepared a virtual exhibit to mark the occasion (the museum is currently under renovation). The exhibit, "Mobilizing Minds: Teaching Math and Science in the Age of Sputnik", examines the reforms in American mathematics and science education launched at that time. Included are discussions about changes in curricula and teaching methods and about the use of technology for teaching. The exhibit may be found at http://americanhistory.si.edu/mobilizing.

—Allyn Jackson

ETS Visiting Scholars Program

The Educational Testing Service (ETS) established the ETS Visiting Scholar Program to further its commitment to creating a corporate environment that reflects the culture of its test takers. Each summer visiting scholars from underrepresented groups come to ETS to study fairness and other issues of test design and development while learning to write and review test questions and other related materials for a variety of testing programs. They may also work on educational measurement and policy issues related to equity.

Each visiting scholar will be in residence at ETS June 2–27, 2008. Applicants should be teachers at universities or community colleges, should be members of underrepresented groups, and should have at least three years of teaching experience in U.S. schools. The teaching experience can be in one of nine academic areas, including mathematics and statistics. Visiting scholars receive a US$3,500 honorarium plus transportation and accommodation.

Further information on is available at http://www.ets.org/visitingscholars. The deadline to apply is **December 3, 2007**.

—From an ETS announcement

Inside the AMS

Trjitzinsky Memorial Awards Presented

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

For the 2007 awards, the AMS chose six 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 2007, the names of the students receiving Trjitzinsky awards, and brief biographical sketches of the students.

Lewis and Clark College: AMY STREIFEL. Streifel lives in Damascus, Oregon, and plans to complete her B.A. in mathematics in spring 2008 and to continue on to graduate school and an academic career. She was co-valedictorian at Newport High School, Oregon, where she had teachers who made mathematics fun. She also minors in art and works as a tutor in the Math Skills Center. She recently spent a semester in Australia, returning with a tattoo that reads $e^{i\pi} + 1 = 0$ on her ankle. She enjoys reading, gardening, practicing origami, and raising chickens and pheasants.

Saint Louis University: EMILY J. OGNACEVIC. Ognacevic, a sophomore, graduated from Divine Savior Holy Angels High School in Milwaukee, Wisconsin, from which she received a Women in Math and Science award and scholarship and where she was president of the school's chapter of the National Honor Society. At Saint Louis University she works in the admissions office and tutors local high school students. She enjoys playing the piano and doing crossword puzzles. She plans to pursue a career as a mathematician or a cryptanalyst.

State University of New York, New Paltz: ROSEMARY HOLGUIN. Holguin came to the United States six years ago from her native Colombia. She is a first-generation college student, majoring in mathematics and adolescent education, and plans to graduate in the fall of 2008. Last summer she worked on two research projects with faculty members. She hopes to teach mathematics in high school as well as to continue to expand her knowledge through research.

University of Northern Iowa: KAYLA R. BOYLE. Boyle is a freshman carrying a double major in mathematics and chemistry, with a minor in Spanish. She graduated from Ankeny High School in Ankeny, Iowa, where she was a member of the concert and marching bands, concert and show choirs, and the debate and mock trial teams. She is involved in church activities, including choir, youth ministry, and the religious education program, and has volunteered in multiple organizations, including food pantries and Habitat for Humanity. She also spent two weeks on the Mississippi Gulf Coast helping families to rebuild after Hurricane Katrina.

University of Tennessee, Knoxville: BETSY K. BARR. Barr grew up in South Africa, where her parents were missionaries. She is a senior mathematics major and a member of the university's Chancellor's Honors Program and has served as president of the Honors Council. She and her husband, Philip, hope to live overseas one day, with the goal of opening a school in an underprivileged area,

where she would like to teach mathematics and have the opportunity to positively affect students' lives.

University of Washington: SUSAN C. MASSEY. Massey is a senior mathematics major. In the summer of 2007 she worked in a research laboratory developing a mathematical model of the genesis and evolution of glioma, a type of brain tumor; the research was funded by the Amgen Scholars Foundation. When her mother underwent a bone marrow transplant, Massey took off a quarter from her studies to care for her and her ten-year-old brother, and she continues to support her family while working toward her goal of being the first in her family to graduate from college. She plans to pursue an M.D./Ph.D. degree in neurology, with the aim of researching the causes and treatments of neurological diseases.

—Elaine Kehoe

Epsilon Scholarships Awarded for 2007

In 1999 the Society created the Epsilon Fund as an endowment for its support of young scholars programs for mathematically talented high school students. In recognition of the generosity of Epsilon Fund donors, supported programs award a number of named scholarships each year. This year, eight scholarships were awarded. Five students received Ky and Yu-Fen Fan Scholarships; one received a Roderick P. Caldwell Scholarship; and two received Robert H. Oehmke Scholarships, a new scholarship awarded for the first time this year.

The Fan Scholarships were awarded to: HENRY SCHER to attend the Ross Mathematics Program at Ohio State University; NATALIE LOPEZ for the Texas State University Honors Summer Math Camp in San Marcos, Texas; SARA WALKER for the Michigan Math and Science Scholars Summer Program at the University of Michigan, Ann Arbor; STERLING CHU for PROMYS (Program in Mathematics for Young Scholars) at Boston University; and JIN WAN for HCSSiM (Hampshire College Summer Studies in Mathematics) in Amherst, Massachusetts.

DANIEL LU was awarded the Caldwell Scholarship to attend PROMYS.

The Oehmke Scholarships were awarded to YING YING TRAN to attend the Ross Mathematics Program and to KRYSTAL SAXTON to attend the Texas State University Honors Summer Math Camp.

The Epsilon Scholarships are supported by the Ky and Yu-Fen Fan Endowment, by a gift from the Robert H. Oehmke Charitable Fund, and by a gift from Winifred A. Caldwell in memory of her husband, Roderick P. C. Caldwell. For more information on the Epsilon program, visit `http://www.ams.org/development/epsilon.html`.

—AMS announcement

Deaths of AMS Members

GRAHAM R. ALLAN, professor, University of Cambridge, England, died on August 9, 2007. Born on August 13, 1936, he was a member of the Society for 18 years.

GEORGE A. BAKER, professor, University of California, Davis, died in December 1996. Born in October 1903, he was a member of the Society for 63 years.

JAKOW BARIS, professor, Warminsko-Mazurski University, Belarus, died on July 26, 2007. Born on April 13, 1939, he was a member of the Society for 13 years.

JOHN BORISEWICH, from Tolland, CT, died in February 2001. Born on June 2, 1926, he was a member of the Society for 38 years.

JULIA W. BOWER, from Deland, FL, died on February 19, 1999. Born on December 27, 1903, she was a member of the Society for 73 years.

HOWARD H. BROWN, from Stoneham, MA, died in January 2005. Born on March 18, 1910, he was a member of the Society for 56 years.

JOHN A. CARLSON, from Spokane, WA, died in April 2000. Born on August 1, 1902, he was a member of the Society for 32 years.

SARVADAMAN CHOWLA, from Laramie, WY, died in December 1995. Born on October 22, 1907, he was a member of the Society for 47 years.

JAMES R. DEAN, from San Jose, CA, died in September 1993. Born on March 1, 1915, he was a member of the Society for 32 years.

LEAMAN A. DYE, from Charleston, SC, died in December 1999. He was a member of the Society for 73 years.

KRZYSZTOF GALICKI, associate professor, University of New Mexico, died on September 24, 2007. Born on August 10, 1958, he was a member of the Society for 14 years.

GABRIEL KLAMBAUER, retired, from Gloucester, Canada, died on January 11, 2007. Born on May 12, 1932, he was a member of the Society for 47 years.

HERMAN MEYER, retired, from Miami, FL, died on August 3, 2007. Born on May 29, 1912, he was a member of the Society for 67 years.

JOHANNES C. C. NITSCHE, professor, from Minneapolis, MN, died on August 9, 2006. Born on January 22, 1925, he was a member of the Society for 50 years.

ROBERT G. PAYTON, professor emeritus, Adelphi University, died on August 15, 2007. Born on January 1, 1929, he was a member of the Society for 37 years.

MIRCEA PUTA, professor, University of Timisoara, Romania, died on July 26, 2007. Born on February 1, 1950, he was a member of the Society for 28 years.

JOSHUA H. ROSENBLOOM, retired, from Brighton, MA, died on July 5, 2007. He was a member of the Society for 65 years.

RALPH G. TROSS, from Ottawa, Canada, died on July 21, 2006. Born on January 17, 1923, he was a member of the Society for 35 years.

STANLEY ZIETZ, professor, from Plymouth Meeting, PA, died on May 27, 2007. Born on July 23, 1950, he was a member of the Society for 17 years.

Reference and Book List

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

Contacting the *Notices*

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

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

The electronic-mail addresses are notices@math.ou.edu in the case of the editor and notices@ams.org in the case of the managing editor. The fax numbers are 405-325-7484 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines

November 15, 2007: Applications for NRC-Ford Foundation Diversity Predoctoral Fellowships. See "Mathematics Opportunities" in this issue.

November 15, 2007: Applications for NSA Mathematics Sabbatical program. See http://www.nsa.gov/msp/index.cfm or contact the program staff: MSP Director Michelle D. Wagner (mdwagn4@nsa.gov) or MSP Program Administrator Rosalie (Jackie) Smith (rjsmit2@nsa.gov). To obtain brochures or ask questions, please call 301-688-0400 or write to: Mathematical Sciences Program, National Security Agency, Suite 6557, Fort Meade, MD 20755-6557.

November 29, 2007: Applications for NRC-Ford Foundation Diversity

Where to Find It

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

Dissertation and Postdoctoral Fellowships. See "Mathematics Opportunities" in this issue.

December 1, 2007: Applications for AMS Centennial Fellowships. See http://www.ams.org/employment/centflyer.html or write to the Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; email: prof-serv@ams.org; telephone 401-455-4170.

December 6, 2007: Proposals for NSF ADVANCE Program Institutional Transformation (IT) awards and Institutional Transformation Planning Grants (IT-Start). See http://www.nsf.gov/pubs/2007/nsf07582/nsf07582.txt.

December 7, 2007: Nominations for Alan T. Waterman Award. See "Mathematics Opportunities" in this issue.

December 7, 2007: Applications for Fields Institute Postdoctoral Fellowships. See http://www.fields.utoronto.ca/proposals/postdoc.html.

December 11, 2007: Applications for NSF East Asia and Pacific Summer Institutes (EAPSI). See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5284.

December 15, 2007: Applications for AMS Epsilon Fund grants. See http://www.ams.org/outreach/epsilon.html or contact: Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; telephone 800-321-4267, ext. 4170; email: prof-serv@ams.org.

January 4, 2008: Nominations for Sonja Kovalevskaja Award. See "Mathematics Opportunities" in this issue.

January 5, 2008: Applications for IMA postdoctoral and New Directions program. See http://www/ima.umn.edu.

January 7, 2008: Applications for National Defense Science and Engineering Graduate (NDSEG) Fellowships. See "Mathematics Opportunities" in this issue.

January 10, 2008: Applications for AAUW Educational Foundation Fellowships and Grants. See http://www.aauw.org/fga/fellowships_grants/selected.cfm or contact the AAUW Educational Foundation, Selected Professions Fellowships, P.O. Box 4030, Iowa City, IA 52243-4030.

January 15, 2008: Applications for AMS-AAAS Mass Media Summer Fellowships. See http://www.aaas.org/programs/education/MassMedia/ or contact Stacey Pasco, Director, Mass Media Program, AAAS Mass Media Science and Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone 202-326-6645; fax 202-371-9849; email: spasco@aaas.org. Further information is also available at http://www.ams.org/government/massmediaann.html and through the AMS Washington Office, 1527 Eighteenth Street, NW, Washington, DC 20036; telephone 202-588-1100; fax 202-588-1853; email: amsdc@ams.org.

January 15, 2008: Applications for Jefferson Science Fellows Program. See http://www7.nationalacademies.org/jefferson/; email: jsf@nas.edu; telephone 202-334-2643.

January 17, 2008: Proposals for NSF ADVANCE Program Partnerships for Adaptation, Implementation, and Dissemination (PAID) awards. See http://www.nsf.gov/pubs/2007/nsf07582/nsf07582.txt.

January 24, 2008: Proposals for NSF Computing Equipment and Instrumentation Programs (SCREMS). See "Mathematics Opportunities" in this issue.

February 1, 2008: Applications for Math for America Foundation (MfA) Fellowships. See "Mathematics Opportunities" in this issue.

February 1, 2008: Applications for AWM Travel Grants and AWM Mentoring Grants. See http://www.awm-math.org/travelgrants.html; telephone 703-934-0163; email: awm@awm-math.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

February 1, 2008: Applications for 2008 IPAM workshops and programs. See http://www.ipam.ucla.edu.

February 15, 2008: Nominations for Clay Mathematics Institute (CMI) Summer Liftoff Program. See "Mathematics Opportunities" in this issue.

February 15, 2008: Applications for IPAM Research in Industrial Projects for Students (RIPS). See http://www.ipam.ucla.edu.

March 1, 2008: Applications for Christine Mirzayan Science and Technology Policy Graduate Fellowship Summer Program. See "Mathematics Opportunities" in this issue.

March 1, 2008 (tentative: Applications for Enhancing Diversity in Graduate Education (EDGE) Program. See http://www.edgeforwomen.org/enextyear.html.

April 15, 2008: Applications for Math in Moscow for fall 2008. See http://www.mccme.ru/mathinmoscow or write to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax +7095-291-65-01; email: mim@mccme.ru; or contact Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; email: student-serv@ams.org.

May 1, 2008: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone 703-934-0163; email: awm@awm-math.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

June 1, 2008: Applications for Christine Mirzayan Science and Technology Policy Graduate Fellowship Fall Program. See "Mathematics Opportunities" in this issue.

June 10, 2008: Proposals for Enhancing the Mathematical Sciences Workforce in the Twenty-First Century. See http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf05595.

August 18, 2008: Applications for NSF Research Experiences for Undergraduates (REU) program sites. See http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf07569.

October 1, 2008: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.edu; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

NSF Mathematics Education Staff

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

Division of Research on Learning in Formal and Informal Settings

Joan Ferrini-Mundy
Division Director
703-292-4682
`jferrini@nsf.gov`

Karen Marrongelle
Program Director
`kmarrong@nsf.gov`

John (Spud) Bradley
703-292-5091
`jbradley@nsf.gov`

John Cherniavsky
703-292-5136
`jchernia@nsf.gov`

Paola Sztajn
703-292-5105
`psztajn@nsf.gov`

Division of Undergraduate Education

Dan Maki
703-292-4620
`dmaki@nsf.gov`

Elizabeth Teles
703-292-4643
`eteles@nsf.gov`

Lee Zia
703-292-5140
`lzia@nsf.gov`

Division of Human Resource Development

Roosevelt Johnson
703-292-8640
`ryjohnso@nsf.gov`

Math and Science Partnership Program

Dan Maki
703-292-4620
`dmaki@nsf.gov`

Office of the Director/Office of Integrative Activities

James Lightbourne
703-292-4628
`jhlightb@nsf.gov`

IMU Executive Committee

The Executive Committee of the International Mathematical Union (IMU) consists of ten voting members elected for four-year terms: the four officers (president, two vice presidents, and secretary) and six other members. The retiring president is an ex-officio member of the Executive Committee without vote for a period of four years. The current members (terms January 1, 2007, to December 31, 2010) of the IMU Executive Committee are:

President: László Lovász (Hungary)

Secretary: Martin Grötschel (Germany)

Vice Presidents: Zhi-Ming Ma (China), Claudio Procesi (Italy)

Members at Large: M. Salah Baouendi (USA), Manuel de León (Spain), Ragni Piene (Norway), Cheryl E. Praeger (Australia), Victor A. Vassiliev (Russia), Marcelo Viana (Brazil)

Ex-Officio: John M. Ball, Past President (United Kingdom)

Book List

The Book List highlights books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. When a book has been reviewed in the Notices*, a reference is given to the review. Generally the list will contain only books published within the last two years, though exceptions may be made in cases where current events (e.g., the death of a prominent mathematician, coverage of a certain piece of mathematics in the news) warrant drawing readers' attention to older books. Suggestions for books to include on the list may be sent to* `notices-booklist@ams.org`.

*Added to "Book List" since the list's last appearance.

An Abundance of Katherines, by John Green. Dutton Juvenile Books, September 2006. ISBN 0-525-47688-1.

Alfred Tarski: Life and Logic, by Anita Burdman Feferman and Solomon Feferman. Cambridge University Press, October 2004. ISBN 0-521-80240-7. (Reviewed September 2007.)

Analysis and Probability: Wavelets, Signals, Fractals, by Palle E. T. Jorgensen. Springer, September 2006. ISBN 0-387-29519-4.

Ants, Bikes, and Clocks: Problem Solving for Undergraduates, by William Briggs. Society for Industrial and Applied Mathematics, 2005. ISBN 0-89871-574-1.

The Archimedes Codex, by Reviel Netz and William Noel. Weidenfeld and Nicolson, May 2007. ISBN-13: 978-0-29764-547-4.

The Art of Mathematics: Coffee Time in Memphis, by Béla Bollobás. Cambridge University Press, September 2006. ISBN-13: 978-0-52169-395-0.

The Artist and the Mathematician: The Story of Nicolas Bourbaki, the Genius Mathematician Who Never Existed, by Amir D. Aczel. Thunder's Mouth Press, August 2006. ISBN 1-560-25931-0. (Reviewed October 2007.)

**Benjamin Franklin's Numbers: An Unsung Mathematical Odyssey*, by Paul C. Pasles. Princeton University Press, October 2007. ISBN-13:978-0-69112-956-3.

The Best of All Possible Worlds: Mathematics and Destiny, by Ivar Ekeland. University of Chicago Press, October 2006. ISBN-13: 978-0-226-19994-8.

Bourbaki, a Secret Society of Mathematicians, by Maurice Mashaal. AMS, June 2006. ISBN 0-8218-3967-5. (Reviewed October 2007.)

**The Calculus Wars: Newton, Leibniz, and the Greatest Mathematical Clash of All Time*, by Jason Socrates

Bardi. Thunder's Mouth Press, April 2007. ISBN-13: 978-1-56025-992-3.

The Cat in Numberland, by Ivar Ekeland. Cricket Books, April 2006. ISBN-13: 978-0-8126-2744-2.

A Certain Ambiguity: A Mathematical Novel, by Gaurav Suri and Hartosh Singh Bal. Princeton University Press, June 2007. ISBN-13: 978-0-691-12709-5.

Chases and Escapes: The Mathematics of Pursuit and Evasion, by Paul J. Nahin. Princeton University Press, May 2007. ISBN-13: 978-0-69112-514-5.

Descartes: A Biography, by Desmond Clarke. Cambridge University Press, March 2006. ISBN 0-521-82301-3.

Einstein's Heroes: Imagining the World through the Language of Mathematics, by Robyn Arianrhod. Oxford University Press, July 2006. ISBN-13: 978-0-195-30890-7.

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

Evolutionary Dynamics: Exploring the Equations of Life, by Martin Nowak. Belknap Press, September 2006. ISBN 0-674-02338-2.

The Fabulous Fibonacci Numbers, by Alfred S. Posamentier and Ingmar Lehmann. Prometheus Books, February 2007. ISBN 1-591-02475-7.

Fearless Symmetry: Exposing the Hidden Patterns of Numbers, by Avner Ash and Robert Gross. Princeton University Press, May 2006. ISBN 0-691-12492-2. (Reviewed January 2007.)

**Flatland—The Movie: A Journey of Many Dimensions*. Flatworld Productions, 2007. Special Educator Edition DVD, http://store.flatlandthemovie.com. (Reviewed November 2007.)

Fly Me to the Moon: An Insider's Guide to the New Science of Space Travel, by Edward Belbruno. Princeton University Press, January 2007. ISBN-13: 978-0-691-12822-1.

From Cosmos to Chaos: The Science of Unpredictability, by Peter Coles. Oxford University Press, August 2006. ISBN 0-198-56762-6.

From Zero to Infinity: What Makes Numbers Interesting, by Constance Reid. Fiftieth anniversary edition, A K Peters, February 2006. ISBN 1-568-81273-6. (Reviewed February 2007.)

Gödel's Theorem: An Incomplete Guide to Its Use and Abuse, by Torkel Franzen. A K Peters, May 2005. ISBN 1-568-81238-8. (Reviewed March 2007.)

Great Feuds in Mathematics: Ten of the Liveliest Disputes Ever, by Hal Hellman. Wiley, September 2006. ISBN 0-471-64877-9.

The Great π/e Debate: Which Is the Better Number?, DVD by Colin Adams and Thomas Garrity. Mathematical Association of America, 2007. ISBN 0-88385-900-9.

How Mathematicians Think: Using Ambiguity, Contradiction, and Paradox to Create Mathematics, by William Byers. Princeton University Press, May 2007. ISBN-13: 978-0-69112-738-5. (Reviewed in this issue.)

How Mathematics Happened, by Peter S. Rudman. Prometheus Books, October 2006. ISBN 1-591-02477-3.

How to Cut a Cake: And Other Mathematical Conundrums, by Ian Stewart. Oxford University Press, November 2006. ISBN 0-199-20590-6.

I Am a Strange Loop, by Douglas R. Hofstadter. Basic Books, March 2007. ISBN-13: 978-0-46503-078-1. (Reviewed August 2007.)

**An Introduction to Gödel's Theorems*, by Peter Smith. Cambridge University Press, August 2007. ISBN-13: 978-0-52167-453-9.

John von Neumann: Selected Letters, edited by Miklós Rédei. AMS, November 2005. ISBN 0-8218-3776-1. (Reviewed June/July 2007.)

Karl Pearson: The Scientific Life in a Statistical Age, by Theodore M. Porter. Princeton University Press, (new edition) December 2005. ISBN-13: 978-0-69112-635-7. (Reviewed in this issue.)

Leonhard Euler, by Emil A. Fellmann. Birkhäuser, 2007. ISBN-13: 978-3-7643-7538-6.

Leonhard Euler, a Man to Be Reckoned With, by Andreas K. Heyne and Alice K. Heyne. Birkhäuser, 2007. ISBN-13: 978-3-7643-8332-9.

Letters to a Young Mathematician, by Ian Stewart. Perseus Books, April 2006. ISBN-13: 978-0-465-08231-5. (Reviewed May 2007.)

The Math behind the Music, by Leon Harkleroad. Cambridge University Press, August 2006. ISBN-13: 978-0-521-00935-5.

Math Doesn't Suck: How to Survive Middle-School Math without Losing Your Mind or Breaking a Nail, by Danica McKellar. Hudson Street Press, August 2007. ISBN-13: 978-1-5946-3039-2.

Mathematical Illustrations: A Manual of Geometry and PostScript, by Bill Casselman. Cambridge University Press, December 2004. ISBN 0-521-54788-1. (Reviewed January 2007.)

The Mathematician's Brain, by David Ruelle. Princeton University Press, July 2007. ISBN-13: 978-0-691-12982-2.

Mathematics and Common Sense: A Case of Creative Tension, by Philip J. Davis. A K Peters, October 2006. ISBN 1-568-81270-1.

Measuring the World, by Daniel Kehlmann. Pantheon, November 2006. ISBN 0-375-42446-6.

The Millennium Prize Problems, edited by James Carlson, Arthur Jaffe, and Andrew Wiles. AMS, June 2006. ISBN-13: 978-0-8218-3679-8.

The Mind of the Mathematician, by Michael Fitzgerald and Ioan James. Johns Hopkins University Press, May 2007. ISBN-13: 978-0-8018-8587-7.

More Mathematical Astronomy Morsels, by Jean Meeus. Willmann-Bell, 2002. ISBN 0-943396-743.

More Sex Is Safer Sex: The Unconventional Wisdom of Economics, by Steven E. Landsburg. Free Press, April 2007. ISBN-13: 978-1-416-53221-7.

The Motion Paradox: The 2,500-Year Old Puzzle behind All the Mysteries of Time and Space, by Joseph Mazur. Dutton Adult, April 2007. ISBN-13: 978-0-52594-992-3.

Mr. Hopkins' Men: Cambridge Reform and British Mathematics in the 19th Century, by A. D. D. Craki. Springer, July 2007. ISBN-13: 978-1-8462-8790-9.

Music and Probability, by David Temperley. MIT Press, January 2007. ISBN-13: 978-0-262-20166-7.

Music: A Mathematical Offering, by David J. Benson. Cambridge University Press, December 2006. ISBN-13: 978-0-521-61999-8.

Negative Math: How Mathematics Rules Can Be Positively Bent, by Alberto A. Martinez. Princeton

University Press, November 2005. ISBN-13: 978-0-691-12309-7.

New Theories of Everything, by John D. Barrow. Oxford University Press, July 2007. ISBN-13: 978-0-192-80721-2.

Nonplussed! Mathematical Proof of Implausible Ideas, by Julian Havil. Princeton University Press, May 2007. ISBN-13: 978-0-691-12056-0.

The Numbers behind NUMB3RS: Solving Crime with Mathematics, by Keith Devlin and Gary Lorden. Plume, August 2007. ISBN-13: 978-0-4522-8857-7.

Out of the Labyrinth: Setting Mathematics Free, by Robert Kaplan and Ellen Kaplan. Oxford University Press, January 2007. ISBN-13: 978-0-19514-744-5.

Piero della Francesca: A Mathematician's Art, by J. V. Field. Yale University Press, August 2005. ISBN 0-300-10342-5. (Reviewed March 2007.)

The Poincaré Conjecture: In Search of the Shape of the Universe, by Donal O'Shea. Walker, March 2007. ISBN-13: 978-0-8027-1532-6.

Poincaré's Prize: The Hundred-Year Quest to Solve One of Math's Greatest Puzzles, by George Szpiro. Dutton Adult, June 2007. ISBN-13: 978-0-525-95024-0.

Prince of Mathematics: Carl Friedrich Gauss, by M. B. W. Tent. A K Peters, January 2006. ISBN 1-568-81261-2.

Project Origami: Activities for Exploring Mathematics, by Thomas Hull. A K Peters, March 2006. ISBN 1-568-81258-2. (Reviewed May 2007.)

Pythagoras: His Life, Teaching and Influence, by Christoph Riedweg. Translated by Steven Rendall. Cornell University Press, March 2005. ISBN-13: 978-0-80144-240-7.

Pythagoras: The Mathemagician, by Karim El-koussa. Cloonfad Press, September 2005. ISBN-13: 978-0-97694-042-5.

**The Pythagorean Theorem: A 4000-Year History*, by Eli Maor. Princeton University Press, May 2007. ISBN-13: 978-0-69112-526-8.

Shadows of Reality: The Fourth Dimension in Relativity, Cubism, and Modern Thought, by Tony Robbin. Yale University Press, March 2006. ISBN 0-300-11039-1. (Reviewed April 2007.)

Solving Mathematical Problems: A Personal Perspective, by Terence Tao. Oxford University Press, September 2006. ISBN-13: 978-0-199-20560-8.

The Square Root of 2: A Dialogue Concerning a Number and a Sequence, by David Flannery. Springer, December 2005. ISBN-13: 978-0-38720-220-4.

Superior Beings: If They Exist, How Would We Know? Game-Theoretic Implications of Omnipotence, Omniscience, Immortality, and Incomprehensibility, by Steven Brams. Springer, second edition, November 2007. ISBN-13: 978-0-387-48065-7.

Symmetry and the Monster: The Story of One of the Greatest Quests of Mathematics, by Mark Ronan. Oxford University Press, May 2006. ISBN 0-192-80722-6. (Reviewed February 2007.)

Thinking about Gödel and Turing: Essays on Complexity, 1970–2007, by Gregory J. Chaitin. World Scientific, August 2007. ISBN-13: 978-9-8127-0895-3.

The Triumph of Numbers: How Counting Shaped Modern Life, by I. B. Cohen. W. W. Norton, July 2006. ISBN-13: 978-0-39332-870-7. (Reviewed in this issue.)

The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next, by Lee Smolin. Joseph Henry Press, October 2006. ISBN 0-309-10192-1. (Reviewed September 2007.)

Useless Arithmetic: Why Environmental Scientists Can't Predict the Future, by Orrin Pilkey and Linda Pilkey-Jarvis. Columbia University Press, February 2007. ISBN 0-231-13212-3.

The Volterra Chronicles: The Life and Times of an Extraordinary Mathematician, by Judith R. Goodstein. AMS, February 2007. ISBN-13: 978-0-8218-3969-0.

Why Beauty Is Truth: The Story of Symmetry, by Ian Stewart. Perseus Books Group, April 2007. ISBN-13: 978-0-46508-236-0.

Yearning for the Impossible: The Surprising Truths of Mathematics, by John Stillwell. A K Peters, May 2006. ISBN 1-568-81254-X. (Reviewed June/July 2007.)

You Failed Your Math Test, Comrade Einstein: Adventures and Misadventures of Young Mathematicians, or Test Your Skills in Almost Recreational Mathematics, edited by M. Shifman. World Scientific, June 2005. ISBN-13: 978-9-8125-6279-1.

Mathematics Calendar

The most comprehensive and up-to-date Mathematics Calendar information is available on the AMS website at http://www.ams.org/mathcal/.

December 2007

1 **National Conference on Technology and Innovation in Mathematics Education**, IIT Bombay, Mumbai, India. (Sept. 2007, p. 1070)

3–7 **Rigidity and polyhedral combinatorics**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2007, p. 782)

7–11 **Fourth Pacific Rim Conference on Mathematics: Celebrating the Tenth Anniversary of the Liu Bie Ju Centre for Mathematical Sciences**, City University of Hong Kong, Hong Kong. (Jan. 2007, p. 64)

10–12 **SIAM Conference on Analysis of Partial Differential Equations (PD07)**, Hilton Phoenix East/Mesa, Mesa, Arizona. (Apr. 2007, p. 560)

10–14 **Triangulations, Heegaard splittings and hyperbolic geometry**, American Institute of Mathematics, Palo Alto, California. (Apr. 2007, p. 560)

11–14 **Workshop on Chaos and Ergodicity of Realistic Hamiltonian Systems**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jun/Jul 2007, p. 782)

12–15 **First Joint International Meeting between the AMS and the New Zealand Mathematical Society (NZMS)**, Wellington, New Zealand. (Jun/Jul. 2006, p. 714)

*12–15 **Winter School "Geometric group theory"**, Georg-August Universit"at G"ottingen Mathematical Institute, Göettingen, Germany.
Description: Geometric group theory studies infinite (discrete) groups from the point of view of their geometric properties. A particularly interesting class of groups are those which share some aspects of negative curvature. Martin Bridson will give an introduction into some of the newer developments in this direction, studying, in particular, special properties of groups which act on spaces of non-positive curvature. Automorphism groups of free groups do not quite have negative curvature, but other methods from low-dimensional topology are available to study these groups and, in particular, their cohomology. This will be discussed by Karen Vogtman. A class of groups with rather different properties are the self-similar ones. Laurent Bartholdi will introduce us to tools to study these groups, coming from finite-state automata and actions on trees, and relate them to negatively curved group by explaining exciting CAT(0)-groups constructed that way by Burger and Mozes.
Information: http://www.uni-math.gwdg.de/GeoGT/.

15–17 **First Announcement and Call for Papers: The Eighth Asian Symposium on Computer Mathematics (ASCM 2007)**, National University of Singapore, Singapore. (Jun/Jul 2007, p. 782)

15–17 **International Symposium on Recent Advances in Mathematics & Its Applications (ISRAMA 2007)**, Calcutta, India. (Jun/Jul 2007, p. 782)

16–20 **The Twelfth Asian Technology Conference in Mathematics (ATCM2007)**, Taipei, Taiwan. (Mar. 2007, p. 441)

17–19 **The 3rd Indian International Conference on Artificial Intelligence (IICAI-07)**, Pune, India. (Jun/Jul 2007, p. 782)

17–22 **Transformation Groups 2007**, Independent University of Moscow, Moscow, Russia. (Apr. 2007, p. 560)

19–22 **International Conference on Advances in Mathematics: Historical Developments & Engineering Applications**, Indian

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 held in North America 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. Meetings held outside the North American area may carry more detailed information. In any case, if there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the *Notices* in care of the American Mathematical Society in Providence or electronically to notices@ams.org or mathcal@ams.org.
In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence **eight months** prior to the scheduled date of the meeting.
The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June/July, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.
The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through the AMS website on the World Wide Web. To access the AMS website, use the URL: http://www.ams.org/.

Society for History of Mathematics and G. B. Pant University at Pant Nagar, India. (Nov. 2007, p. 1402)

30–January 4 **Conference on Representations of Algebras, Groups and Semigroups**, Bar-Ilan University, Ramat-Gan, Israel and the Netanya Academic College, Netanya, Israel. (Jun/Jul 2007, p. 782)

January 2008

1–March 31 **DocCourse in Combinatorics and Geometry: Additive Combinatorics**, Centre de Recerca Matemàtica, Bellaterra, Italy. (Oct. 2007, p. 1189)

2–4 **Tenth International Symposium on Artificial Intelligence and Mathematics (ISAIM 2008)**, Fort Lauderdale, Florida. (Oct. 2007, p. 1189)

6–9 **Joint Mathematics Meetings**, San Diego, California. (Jun/Jul 2007, p. 782)

6–13 **1st Odense Winter School on Geometry and Theoretical Physics**, University of Southern Denmark, Campusvej 55, DK-5230, Odense M, Denmark. (Nov. 2007, p. 1403)

* 7–11 **Scientific Computing Applications in Surgical Simulation of Soft Tissues**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: Scientific Overview: In this short course, we will be investigating the most promising directions for algorithm design, use of architectures, surgical simulation interface design and procedures that lend themselves to simulation by encouraging interdisciplinary cooperation between medicine, engineering, applied math and computer science.
Organizing Committee: Court Cutting, Dwight Meglan, Silvia Salinas-Blemker, Joseph Teran.
Application/Registration: An application/registration form is available at: `http://www.ipam.ucla.edu/programs/vs2008/`. The application is for people requesting financial support to attend the workshop. If you don't intend to do this, you may simply register. Applications received by November 26, 2007 will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.
Information: email: `sbeggs@ipam.ucla.edu`; `http://www.ipam.ucla.edu/programs/vs2008/`.

7–27 **Data-driven and Physically-based Models for Characterization of Processes in Hydrology, Hydraulics, Oceanography and Climate Change**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Nov. 2007, p. 1403)

7–June 27 **Statistical Theory and Methods for Complex, High-Dimensional Data**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Jun/Jul. 2006, p. 714)

10–11 **IMA Tutorial: Mathematics of Proteins**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

10–13 **First Announcement for Thirteenth Annual Conference and First International Conference of Gwalior Academy of Mathematical Sciences (GAMS) with Symposium on Mathematical Modeling in Engineering and Biosciences**, Anand Engineering College, Agra, U.P. India. (Aug. 2007, p. 918)

14–18 **IMA Workshop: Protein Folding**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

14–18 **The uniform boundedness conjecture in arithmetic dynamics**, American Institute of Mathematics, Palo Alto, California. (May 2007, p. 666)

* 14–18 **Workshop on Random Walks, Particle Systems and Random Media**, Facultad de Matematicas, Pontificia Universidad Catolica de Chile, Santiago, Chile.
Description: The meeting will bring together mathematicians and mathematical-physicists working in the areas of random media, particle systems, random walks and reaction-diffusion equations.
Organizers: Alejandro Ramirez and Vladas Sidoravicius.
Sponsors: Pontificia Universidad Catolica de Chile, National Science Foundation-PIRE, Nucleo Milenio.
Information: `http://workshop2008.mat.puc.cl`.

14–July 4 **Combinatorics and Statistical Mechanics**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Dec. 2006, p. 1381)

20–22 **ACM-SIAM Symposium on Discrete Algorithms (SODA08)**, Holiday Inn Golden Gateway, San Francisco, California. (Jun/Jul 2007, p. 782)

* 21–24 **Conference in Geometric Analysis**, Institute of Mathematics, Universtiy of Bern, Bern, Switzerland.
Description: The main scope of the conference is presenting the recent development in the area of geometric analysis and its applications. Topics of interest include analysis on Carnot-Caratheodory spaces, calculus of variations, geometric measure theory and partial differential equations.
Sponsors: The conference is sponsored by the EU project GALA (Geometric Analysis on Lie Groups and Applications) and the ESF project HCAA (Harmonic and Complex Analysis and its Applications).
Information: `http://www.geoan.unibe.ch`.

* 28–February 1 **Holomorphic partial differential equations, small divisors and summability**, CIRM, Marseilles, France.
Description: We aim to bring together mathematicians working in holomorphic dynamics or PDEs/functional equations, at a time when important questions and methods in these domains appear to be increasingly interrelated.
Themes: The themes covered will include (i) holomorphic PDE's, obstruction to holomorphy of solutions, (ii) dynamics of nonlinear PDE's and their geometric features, (iii) Gevrey solutions, summability of divergent series, Stokes phenomena, (iv) small divisors phenomena, and (v) exact WKB analysis.
Information: `http://www.cirm.univ-mrs.fr/web.ang/liste_rencontre/Rencontres2008/Renc309/Renc309.html`.

28–February 1 **Image Analysis Challenges in Molecular Microscopy**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Aug. 2007, p. 918)

February 2008

* 1–June 15 **ESI Programme on "Combinatorics and Statistical Physics"**, The Erwin Schrödinger International Institute for Mathematical Physics, Vienna, Austria.
Description: The research programme's aim is to bring together researchers from, essentially, three communities from mathematics and physics: (1) Enumerative Combinatorics; (2) Analytic Combinatorics; (3) Statistical Physics, in order to intensify the fruitful interactions between the researchers in these and related communities which have become more and more frequent in the recent past. A Workshop on "Combinatorics and Statistical Physics" will take place May 18–31, 2008.
Organizers: Mireille Bousquet-Mélou (Université Bordeaux 1), Michael Drmota (Vienna University of Technology), Christian Krattenthaler (University of Vienna), Bernard Nienhuis (University of Amsterdam).
Information: `http://www.mat.univie.ac.at/~kratt/esi/`.

* 4–8 **Conference on Perspectives in Mathematical Sciences**, Indian Statistical Institute, Bangalore, India.
Description: The Theoretical Statistics and Mathematics Unit of the Indian Statistical Institute, Bangalore Centre, is organizing a 5 day Conference on "Perspectives in Mathematical Sciences" during February 4–8, 2008. This is the Platinum Jubilee year of the Indian

Statistical Institute. The idea is to bring in distinguished scientists to give the perspectives of current research and the directions for further research in the area of their expertise. We plan to publish the Proceedings of this Conference.
Contact: To participate in the Conference, please contact Prof. N. S. Narasimha Sastry by email (cpms@isibang.ac.in). After receiving the acceptance from us to you to participate in this Conference, kindly send a Demand Draft for Rs.1,000/- (Rupees One thousand only) towards the registration fee drawn in favour of the Indian Statistical Institute, Bangalore Centre.

4–14 **Advanced Course on Simplicial Methods in Higher Categories**, Centre de Recerca Matemàtica, Bellaterra, Italy. (Oct. 2007, p. 1190)

*6–12 **Workshop on Geometry and Integrability**, Melbourne, Australia.
Description: The aim of this workshop is to investigate interactions between two- and three-dimensional integrable lattice models and geometry and topology. This meeting will feature lecture series on 6, 7, and 8 February, and contributed talks by participants on 11 and 12 February. The lecture series are designed to range from an introductory and elementary level to a more advanced treatment.
Information: email: degier@ms.unimelb.edu.au; http://www.ms.unimelb.edu.au/~degier/GandI08.php.

11–15 **Expanders in Pure and Applied Mathematics**, Institute for Pure and Applied Math (IPAM), UCLA, Los Angeles, California. (Nov. 2007, p. 1403)

12–16 **Foundations of Lattice-Valued Mathematics with Applications to Algebra and Topology**, Linz, Austria. (Oct. 2007, p. 1190)

18–22 **Workshop on Algorithms (part of thematic programme Algorithms: New Directions and Applications**, Crown Hotel, Napier, New Zealand. (Nov. 2007, p. 1403)

*21–22 **February Fourier Talks 2008**, University of Maryland, College Park, Maryland.
Description: The two-day February Fourier Talks, organized by the Norbert Wiener Center in the Department of Mathematics at the University of Maryland, College Park, feature a diverse array of invited talks in the field of Harmonic Analysis and Applications. A single track of presentations from top academic, industry, and government researchers is scheduled, allowing ample time for interaction with other participants. FFT 2008 will take place February 21–22, in the Department of Mathematics at Maryland, with talks to run all day Thursday and Friday. Thursday evening will end with a keynote address by Peter Carr (Bloomberg; Courant), followed by light dinner and drinks for all participants and friends of the Norbert Wiener Center. A colloquium talk will be given on Friday afternoon by Victor Wickerhauser (Wash U.).
Information: http://www.norbertwiener.umd.edu/FFT/FFT08.

*25–29 **Graph Cuts and Related Discrete or Continuous Optimization Problems**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Scientific Overview: The aim of the workshop is to put together mathematicians and computer scientists interested in graph cuts (or network flows) to build a bridge between important classes of discrete and continuous optimization problems. The workshop will cover both theoretical/mathematical aspects, as well as algorithms and applications in computer vision and image processing.
Organizing Committee: Yuri Boykov, Daniel Cremers, Jerome Darbon, Hiroshi Ishikawa, Vladimir Kolmogorov, Stanley Osher.
Application/Registration: An application/registration form is available at: http://www.ipam.ucla.edu/programs/gc2008/. The application is for people requesting financial support to attend the workshop. If you don't intend to do this, you may simply register. Applications received by January 14, 2008, will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.
Information: http://www.ipam.ucla.edu/programs/gc2008/.

*25–29 **International School on Geometry and Physics: Moduli Spaces in Geometry, Topology and Physics**, International Center of Mathematical Meetings, Castro Urdiales, Cantabria, Spain.
Description: The purpose of this school is to introduce graduate students and postdocs to active fields in the theory of moduli spaces and their interplay with geometry, topology and theoretical physics.
Program: The school will consist of 5 introductory courses: Higgs Bundles (by P. Gothen, Univ. Porto), Tilings, Dimers and Quiver Gauge Theories (by A. Hanany, Imperial College and Technion), Derived Categories (by A. King, Univ. Bath), A Hitchin-Kobayashi Correspondence for Higgs Bundles (by I. Mundet i Riera, Univ. Barcelona), Geometric Invariant Theory and Moduli Spaces (by A. Schmitt, Freie Univ. Berlin). There will also be a special lecture: The Geometric Langlands Programme (by Tomas Gomez, CSIC Madrid).
Information: Registration period: November 1–December 31, 2007. Organizing Committee: L. Alvarez-Consul (CSIC Madrid, Chairman), M. Fernandez (Univ. Pais Vasco), O. Garcia-Prada (CSIC Madrid), D. Hernandez Ruiperez (Univ. Salamanca), R. M. Miro-Roig (Univ. Barcelona), Vicente Munoz (CSIC Madrid).

March 2008

2–7 **IX International Conference "Approximation and Optimization in the Caribbean"**, Sunrise Beach Hotel, San Andres Island, Colombia. (Jun/Jul 2007, p. 782)

3–7 **IMA Workshop: Organization of Biological Networks**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

9–12 **LUMS 2nd International Conference on Mathematics and its Applications in Information Technology 2008**, Lahore University of Management Sciences (LUMS), Lahore, Pakistan. (Sept. 2007, p. 1073)

10–June 13 **Optimal Transport (Long Program)**, UCLA, Los Angeles, California. (Jun/Jul 2007, p. 983)

*12–14 **International Workshop Moduli spaces of Vector Bundles: Algebro-Geometric Aspects**, Universitat de Barcelona, Barcelona, Spain.
Description: There will be a set of lectures offered by leaders in the field and designed to discuss on current research in theory of moduli spaces of vector bundles, both from the algebraic and geometric point of view. The list of confirmed speakers includes: L. Álvarez-Cónsul, O. Biquard, C. Brambilla, D. Faenzi, M. Lehn, C. Lopez, G. Ottaviani, A. Schmitt, C. Sorger, M. Teixidor, G. Trautmann, A. Werner (TBC).
Information:http://www.mat.csic.es/webpages/moduli2008/ub/ .

12–19 **Advanced Course on Geometric Flows and Hyperbolic Geometry**, Centre de Recerca Matemàtica, Bellaterra, Italy. (Oct. 2007, p. 1190)

13–15 **The 42nd Annual Spring Topology and Dynamical Systems Conference**, The University of Wisconsin Milwaukee, Milwaukee, Wisconsin. (Nov. 2007, p. 1403)

15–16 **AMS Eastern Section Meeting**, Courant Institute of New York University, New York, New York. (Jun/Jul 2007, p. 983)

17–21 **Nonlinear PDEs of mixed type arising in mechanics and geometry**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2007, p. 983)

19–21 **The IAENG International Conference on Operations Research 2008**, Regal Kowloon Hotel, Kowloon, Hong Kong. (Jun/Jul 2007, p. 983)

28–29 **The 34th Annual New York State Regional Graduate Mathematics Conference**, Syracuse University, Syracuse, New York. (Nov. 2007, p. 1403)

28–30 **AMS Southeastern Section Meeting**, Louisiana State University, Baton Rouge, Louisiana. (Jun/Jul 2007, p. 983)

31–April 2 **SIAM International Conference on Numerical Combustion (NC08)**, Portola Plaza at Monterey Bay, Monterey, California. (Sept. 2007, p. 1074)

31–April 4 **Applications of universal algebra and logic to the constraint satisfaction problem**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2007, p. 783)

* 31–April 4 **Aspects of Optimal Transport in Geometry and Calculus of Variations**, Institute for Pure and Applied Mathematics, UCLA, Los Angeles, California.
Description: This workshop will be devoted to the interplay between the theory of optimal transport, geometrical inequalities and nonlinear partial differential equations. Specific topics will include optimization and evolution problems arising in geometry, urban planning, mathematical biology, kinetic theory, and fluid flows. A major emphasis will be pinpointing new research directions and applications.
Organizing Committee: Wilfrid Gangbo, Luigi Ambrosio, Yann Brenier, José Carrillo, and Craig Evans.
Application/Registration: An application/registration form is available at: `http://www.ipam.ucla.edu/programs/otws1/`. Applications received by February 18, 2008 will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. You may also simply register and attend the workshop without IPAM funding.
Information: `http://www.ipam.ucla.edu/programs/otws1/`.

31–April 5 **International Workshop on Multi-Rate Processes and Hysteresis MURPHYS2008**, University College Cork, Cork, Ireland. (Nov. 2007, p. 1404)

April 2008

4–6 **AMS Central Section Meeting**, Indiana University, Bloomington, Indiana. (Jun/Jul 2007, p. 783)

11–13 **The Eleventh Rivière-Fabes Symposium on Analysis and PDE**, University of Minnesota, Minneapolis, Minnesota. (Nov. 2007, p. 1404)

* 14–18 **Numerics and Dynamics for Optimal Transport**, Institute for Pure and Applied Mathematics, UCLA, Los Angeles, California.
Description: The purpose of this workshop is to bring together a diverse group of mathematicians and other scientists to discuss dynamical and numerical aspects of optimal transport.
Organizing Committee: Yann Brenier, Karl Glasner, Allen Tannenbaum, and Richard Tsai.
Application/Registration: An application and registration form is available at `http://www.ipam.ucla.edu/programs/otws2/`. Applications received by March 3, 2008 will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications. You may also simply register and attend without IPAM funding.
Information: `http://www.ipam.ucla.edu/programs/otws2/`.

17–18 **IMA Workshop: Network Dynamics and Cell Physiology**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

21–25 **IMA Workshop: Design Principles in Biological Systems**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

24–26 **SIAM International Conference on Data Mining**, Hyatt Regency Hotel, Atlanta, Georgia. (Oct. 2007, p. 1190)

28–May 9 **NATO Advanced Study Institute, New Challenges in Digital Communications**, Vlora, Albania. (Sept. 2007, p. 1074)

May 2008

3–4 **AMS Western Section Meeting**, Claremont McKenna College, Claremont, California. (Jun/Jul 2007, p. 783)

* 5–9 **Percolation on transitive graphs**, American Institute of Mathematics, Palo Alto, California.
Description: Geometric properties of Cayley graphs often turn out to have counterparts in the probabilistic world, and vice versa, but the translations between the different viewpoints are not always trivial. The aim of this workshop is to bring together people working in geometric group theory, probability and dynamics to learn from each other about the relevant techniques in these fields and thus generate new momentum to solve some of the persistent open problems. This workshop will be devoted to percolation on transitive graphs, most importantly, on Cayley graphs of finitely generated infinite groups.
Organizers: Gabor Pete and Mark Sapir.
Sponsors: AIM and the NSF.
Deadline: February 1, 2008.
Information:`http://aimath.org/ARCC/workshops/percolation.html`.

* 5–9 **Topics in PDEs and Applications 2008**, Universitat Politènica de Catalunya, Barcelona, Spain.
Co-ordinators: Xavier Cabré, Universitat Politècnica de Catalunya; Juan Soler, Universidad de Granada.
Speakers: Henri Berestycki, EHESS-Paris; Haim Brezis, Université P. et M. Curie and Rutgers University; Carlos Kenig, University of Chicago; Robert Kohn, Courant Institute, New York University; Gan Tian, Princeton University.
Information: `http://www.crm.cat/pde2_2008`.

5–June 27 **Mathematical Imaging and Digital Media**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Nov. 2007, p. 1404)

10–13 **SIAM Conference on Optimization**, Boston Park Plaza Hotel and Towers, Boston, Massachusetts. (Oct. 2007, p. 1190)

11–14 **SIAM Conference on Mathematical Aspects of Materials Science (MS08)**, Doubletree Hotel Philadelphia, Philadelphia, Pennsylvania. (Sept. 2007, p. 1074)

11–16 **CHT-08: Advances in Computational Heat Transfer**, Kenzi Farah Hotel, Marrakech, Morocco. (Jun/Jul 2007, p. 783)

12–16 **Ferroelectric Phenomena in Soft Matter Systems**, American Institute of Mathematics, Palo Alto, California. (Jun/Jul 2007, p. 783)

13–17 **Spectral geometry and related topics**, University of Potsdam, Germany. (Nov. 2007, p. 1404)

* 15–17 **GESTA 2008**, Universitat Politènica de Catalunya, Barcelona, Spain.
Co-ordinators: Jaume Amorós, Universitat Politècnica de Catalunya; Eva Miranda, Universitat Autònoma de Barcelona; Ignasi Mundet, Universitat Politècnica de Catalunya.
Speakers: To be announced.
Information: `http://www.crm.cat/GESTA`.

15–17 **Twelfth International Conference Devoted to the Memory of Academician Mykhailo Kravchuk (Krawtchouk) (1892–1942)**, Kyiv, Ukraine. (Jun/Jul 2007, p. 783)

18–21 **The 7th AIMS International Conference on Dynamical Systems, Differential Equations and Applications**, University of Texas at Arlington, Arlington, Texas. (May 2007, p. 666)

* 19–23 **Optimal Transport in the Human Body: Lungs and Blood**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.

Description: This workshop will bring together experts, postdocs and students with research interests in the respiratory and cardiovascular systems, as well as in optimal transport. It will allow participants from a variety of fields to gain a perspective of cross-disciplinary aspects of the same fundamental topic and provide an opportunity to establish new research collaborations.
Organizing Committee: Suncica Canic, Denis Grebenkov, Bertrand Maury, Anne Marie Robertson.
Application/Registration: An application/registration form is available at: http://www.ipam.ucla.edu/programs/otws4/. The application is for people requesting financial support to attend the workshop. If you don't intend to do this, you may simply register. Applications received by April 7, 2008 will receive fullest consideration. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.
Information: http://www.ipam.ucla.edu/programs/otws4/.

19–24 **Lie Theory and Geometry: The Mathematical Legacy of Bertram Kostant**, Pacific Institute of Mathematical Sciences, Vancouver, Canada. (Nov. 2007, p. 1404)

26–30 **ICCA8: 8th International Conference on Clifford Algebras and their Applications in Mathematical Physics**, UNICAMP, Campinas, Brazil. (Nov. 2007, p. 1404)

*26–30 **The International Conferences: Inverse Problems: Modeling and Simulation**, Oludeniz–Fethiye, Turkey.
Description: The main aim of these conferences is to bring together all classical and new inverse problems from international scientific schools, and to discuss new challenges of inverse problems in current interdisciplinary science and future directions. All these International Conferences are organized under the auspices of the leading international journals *Inverse Problems*, *Inverse Problems in Science and Engineering* and *Inverse and Ill-Posed Problems*.
Organzers: The organizers of the conference, in particular the Oludeniz Municipality, are putting together an excellent social program consisting of tours to historic places and boat rides. The Conference is also sponsored by the Scientific and Technological Research Council of Turkey (TUBITAK), the International Association formed by the European Community, for the Promotion of Co-operation with Scientists from the New Independent States of the Former Soviet Union (INTAS).
Information: http://www.ipms-conference.org/.

26–30 **IMA Workshop: Quantitative Approaches to Cell Motility and Chemotaxis**, University of Minnesota, Minneapolis, Minnesota. (Dec. 2006, p. 1381)

26–30 **Spring school in nonlinear partial differential equations**, Université catholique de louvain, Louvain-La-Neuve, Belgium. (Sept. 2007, p. 1074)

*29–31 **Brownian Motion and Random Walks in Mathematics and in Physics**, Institut de Recherche Mathématique Avancée (Université Louis Pasteur), Strasbourg, France.
Confirmed Speakers: A. Comtet (Univ. Paris VI); F. Debbasch (Univ. Paris VI); F. Den Hollander (Math. Institute, Leiden); B. Duplantier (CEA, Saclay); V. Kaimanovitch (Jacobs Univ. Bremen); T. Lévy (Ecole Normale Supérieure, Paris); K. Schmidt (Erwin Schroedinger Institute, Wien); W. Werner (Univ. Paris Sud, Orsay).
Information: Consult the URL page and/or contact the organizers: Jacques Franchi (franchi@math.u-strasbg.fr) and Athanase Papadopoulos (papadop@math.u-strasbg.fr) URL: http://www-irma.u-strasbg.fr/article545.html.

June 2008

4–7 **First Joint International Meeting with the Sociedade Brasileira de Matematica**, Instituto Nacional de Matematica Pura e Aplicada (IMPA), Rio de Janeiro, Brazil. (Jun/Jul 2007, p. 784)

*6–10 **International Conference on Discrete Mathematics-ICDM 2008**, University of Mysore, Mysore, India.
Description: ICDM 2008 is being organized jointly by ADMA (Academy of Discrete Mathematics), SRCIIIDMS (Srinivasa Ramanujan Center for Intensification of Interdisciplinary Interaction in Discrete Mathematical Sciences, Mysore) and University of Mysore. The Academic Program will consist of plenary talks, other invited talks and poster presentations. Plenary talks will be given by Mike Fellows (Australia), Herbert Fleischner (Austria), Steve Hedetniemi(USA), Sandi Klavzar (Slovenia) and Xuding Zhu (Taiwan). There will be 30 other invited talks by leading discrete mathematicians of the world. Interested persons, both from within India and abroad, are welcome to register as participants. Notes of the lectures of all the invited speakers will be provided at the time of the conference. Refereed Proceedings of the conference will be published by March 2009.
Information: http://www.adma.co.in (or) ICDM 2008 through Google

*9–13 **Free Boundary Problems, Theory and Applications, 2008**, KTH, Stockholm, Sweden.
Description: Next year the meeting will take place in Stockholm. The meeting is, by now, a traditional event that gathers most people within the field of free boundary problems. The meeting will be held June 9-13, 2008, and will bring experts from the field of Partial Differential Equations, who are specialists in free boundary problems.
Information: http://www.math.kth.se/FBP08/.

9–13 **12th International Conference on Hyperbolic Problems: Theory, Numerics, Applications**, University of Maryland, College Park, Maryland. (Jun/Jul 2007, p. 784)

*9–13 **FVCA5 5th International Symposium on Finite Volumes for Complex Applications Problems and Perspectives**, Aussois, Savoiee, France.
Description: The goal of the symposium is to bring together mathematicians, physicists and engineers who are concerned with Finite Volume Techniques in a wide context. Examples for the broad field of applications are fluid dynamics, magnetohydrodynamics, structural analysis or nuclear physics. A closer look reveals many interesting phenomena and mathematical or numerical difficulties, such as true error analysis and adaptivity, modelling of multi-phase phenomena or fitting problems, stiff terms in convection/diffusion equations and sources. New ideas may be presented, even if they have not yet shown full success. The demonstration of limits or drawbacks of methods is explicitly welcome. Contributions may put main emphasis on theoretical as well as applied topics. Most welcome are contributions, concerned with unsolved or not yet fully solved problems and possible new attempts.
Information: http://www.latp.univ-mrs.fr/fvca5/.

9–19 **Advances in Set-Theoretic Topology: Conference in Honour of Tsugunori Nogura on his 60th Birthday**, Centre for Scientific Culture "Ettore Majorana", Erice, Sicily, Italy. (Jun/Jul 2007, p. 784)

*9–20 **Parallel Numerical Methods for Partial Differential Equations**, University of Wyoming, Laramie, Wyoming.
Purpose: To bring participants to a good understanding of the numerical methods presently in use for the solution of partial differential equations and have on-hand experience with their implementation in a modern computer environment. Emphasis will be put on high-order accurate methods for time-dependent problems such as Spectral Element and Discontinuous Galerkin methods. Applications include numerical solution of fluid flow equations, electromagnetic wave propagation and weather and climate prediction.
Speakers: Jan Hesthaven (Brown University), Henry Tufo (Colorado University Boulder and National Center for Atmospheric Research) and Tim Warburton (Rice University).

Sponsors: Rocky Mountain Mathematics Consortium. IMA and NSF Funding pending.
Deadline: For application/abstracts of talks: April 1, 2008.
Organizers: D. Stanescu and A.D. Porter (U. of Wyoming).
Information: D. Stanescu, Department of Mathematics, University of Wyoming, Laramie WY 82071; email: stanescu@uwyo.edu; http://www.uwyo.edu/rmmc_2008.

*16–22 **CRM-CIM Workshop GAP VI: Workshop on Geometry and Physics**, Universitat Politènica de Catalunya, Barcelona, Spain.
Co-ordinators: Rui Loja, Instituto Superior Técnico, Lisboa; Eva Miranda, Universitat Autònoma de Barcelona.
Speakers: Yves Colin de Verdiere, Institut Fourier; Johannes Duistermaat, Universiteit Utrecht; Hakan Eliasson, Institut de Mathématiques de Jussieu; Rahul Pandharipande, Princeton University.
Information: http://www.crm.cat/GAPVI.

17–20 **4th Croatian Mathematical Congress**, Department of Mathematics, University of Osijek, Osijek, Croatia. (Jun/Jul 2007, p. 784)

17–22 **Differential Equations and Topology**, Lomonosov Moscow State University, Moscow, Russia. (Nov. 2007, p. 1404)

18–21 **Conference on Algebra and its Applications, in honor of S. K. Jain's 70th birthday**, Ohio University, Athens, Ohio. (Nov. 2007, p. 1404)

22–28 **Combinatorics 2008**, Costermano, Verona, Italy. (Sept. 2007, p. 1075)

23–27 **Hermitian Symmetric Spaces, Jordan Algebras and Related Problems**, CIRM Luminy, Marseille, France. (Jun/Jul 2007, p. 784)

23–27 **Homotopical Group Theory and Topological Algebraic Geometry**, Max Planck Institute for Mathematics, Bonn, Germany. (Oct. 2007, p. 1190)

*23–28 **Conference on Moment Maps**, Universitat Politènica de Catalunya, Barcelona, Spain.
Co-ordinators: Rui Loja, Instituto Superior Técnico, Lisboa; Eva Miranda, Universitat Autònoma de Barcelona.
Speakers: To be announced.
Information: http://www.crm.cat/GAPVI.

25–27 **ICNPAA 2008: Mathematical Problems in Engineering, Aerospace and Sciences [Theory, Methods (includes Experimental, Computational) and Applications]**, University of Genoa, Italy. (Jun/Jul 2007, p. 784)

29–July 4 **IWASAWA 2008**, Kloster Irsee, Germany. (Jun/Jul 2007, p. 784)

*30–July 3 **Analysis, PDEs and Applications. On the occasion of the 70th birthday of Vladimir Maz'ya**, INDAM (Istituto Nazionale di Alta Matematcia "Francesco Severi") - Università degli Studi di Roma "La Sapienza", Roma, Italy.
Topics: Linear and non-linear PDEs, Asymptotic and numerical methods for PDEs including homgenization and boundary elements, Spectral theory, Harmonic Analysis, Approximation theory, Wavelets, Elasticity Theory, Function Spaces, Ill-posed problems, Non-linear potential theory, Fluid Mechanics, History of Mathematics.
Information: http://www.mat.uniroma1.it/~mazya08/.

30–July 4 **ICMI/IASE Study: Statistics Education in School Mathematics: Challenges for Teaching and Teacher Education**, ITESM, Monterrey, Mexico. (Dec. 2006, p. 1381)

*30–July 5 **HOCAT 2008: Homotopy Structures in Geometry and Algebra; Derived Categories, Higher Categories**, Universitat Politènica de Catalunya, Barcelona, Spain.
Co-ordinators: Carles Casacuberta, University de Barcelona; Joachim Kock, Universitat Autònoma de Barcelona.
Speakers: John Baez, University of California at Riverside; Paul Balmer, ETH Zürich; Dave Benson, University of Aberdeen; Tom Bridgeland, University of Sheffield; Soren Galatius, Stanford University; Ezra Getzler, Northwestern University; Mikhail Kapranov, Yale University; Jacob Lurie, Harvard University; Haynes Miller, Massachusetts Institute of Technology; Raphaël Rouquier, University of Oxford; Bertrand Toën, Université Paul Sabatier; Michel van der Bergh, Universiteit Hasselt.
Information: http://www.crm.cat/HOCAT2008.

July 2008

2–4 **The 2008 International Conference of Applied and Engineering Mathematics (ICAEM 2008)**, Imperial College London, London, United Kingdom. (Nov. 2007, p. 1404)

7–9 **SIAM Conference on Imaging Science (IS08)**, Town & Country Resort and Convention Center, San Diego, California. (Nov. 2007, p. 1405)

7–11 **Spring Meeting of the Swiss Mathematical Society: Conference on Complex Analysis 2008–In honour of Linda Rothschild**, University of Fribourg, Switzerland. (Nov. 2007, p. 1405)

7–11 **VIII International Colloquium on Differential Geometry (E. Vidal Abascal Centennial Congress)** (Sept. 2007, p. 1076), Santiago de Compostela, Spain.

13–16 **CTAC08: The 14th Biennial Computational Techniques and Applications Conference**, Australian National University, Canberra, ACT, Australia. (Nov. 2007, p. 1405)

*14–17 **Random Matrix Theory and Wireless Communication**, Boulder, Colorado.
Description: The workshop aims to bring together researchers in both mathematics and engineering working at the intersection of these exciting fields.
Information: http://math.colorado.edu/~brider/RMT_workshop/rmt_workshop.html.

14–18 **5th European Congress of Mathematics**, Amsterdam, the Netherlands. (Feb. 2007, p. 308)

14–December 19 **Mathematics and Physics of Anderson Localization: 50 Years After**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Jun/Jul. 2006, p. 714)

22–26 **International Workshop on Operator Theory and its Applications (IWOTA)**, College of William and Mary, Williamsburg, Virginia. (Feb. 2007, p. 308)

*22–26 **Noncommutative Structures in Mathematics and Physics**, Brussels, Belgium.
Description: Among the recent developments in the study of algebraic structures, three strongly interrelated trends seem to be outstanding: a quest for a more algebraic version of noncommutative geometry, generalizations of Hopf algebras as symmetry structures, and the program of categorification. A powerful complement to the latter is the idea of considering algebraic or physical structures on whole categories rather than on individual mathematical objects. The conference aims to relate progress in these directions stemming from work in different subfields of mathematics, including algebra, representation theory, algebraic geometry, operator algebras, and theoretical and mathematical physics.
Speakers include: J. Andersen, G. Bohm, C. De Concini, K. Fredenhagen, M. Kapranov, E. Karolinsky, C. Kassel, M. Khovanov, G. Landi, Y. Manin, M. Markl, H.-J. Schneider, M. Van den Bergh, S. Waldmann.
Information: http://dwispc8.vub.ac.be/NoMaP.

*24–26 **Current Trends and Challenges in Model Selection and Related Areas**, University of Vienna, Vienna, Austria.
Description: The workshop will provide a forum for presentation and discussion of current trends and challenging problems in

model selection and related shrinkage methods.
Invited Speakers: Yannick Baraud (Universite de Nice Sophia-Antipoli), Rudy Beran (UC Davis), Ed George (The Wharton School), Patrik Guggenberger (UCLA), Ching-Kang Ing (Academia Sinica), Paul Kabaila (LaTrobe Univ.), Gabor Lugosi (Pompeu Fabra Univ.), and Yuhong Yang (Univ. of Minnesota). Contributed presentations are welcome.
Information: See http://www.univie.ac.at/workshop_modelselection/;email: hannes.leeb@yale.edu.

August 2008

19–22 **Duality and Involutions in Representation Theory**, National University of Ireland, Maynooth, Co. Kildare, Ireland. (Nov. 2007, p. 1405)

* 25–29 **Geometry and Analysis**, Royal Institute of Technology, Stockholm, Sweden.
Description: This conference, to be held at the Royal Institute of Technology in Stockholm, brings together leading specialists on nonlinear wave equations, geometric analysis and general relativity. Among the topics to be covered are Ricci flow, conformal geometry, nonlinear wave equations, black hole uniqueness and stability, as well as aspects of the constraint equations and the initial value problem for the Einstein equations.
Confirmed Speakers: Serge Alinhac (Paris), Håkan Andreasson (Göteborg), Simon Brendle (Stanford), Alice Chang (Princeton), Helmut Friedrich (Albert Einstein Institute), Gregory Galloway (Miami), Gerhard Huisken (Albert Einstein Institute), Alexandru Ionescu (Wisconsin), Sergiu Klainerman (Princeton), Bruce Kleiner (Yale), Heinz-Otto Kreiss (UCLA), Dan Lee (Duke), Frank Merle (Paris), Alan Rendall (Albert Einstein Institute), Igor Rodnianski (Princeton), Wilhelm Schlag (Chicago), Richard Schoen (Stanford), Daniel Tataru (Berkeley).
Information: http://www.math.kth.se/ag08/.

26–December 19 **The Nature of High Reynolds Number Turbulence**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Jun/Jul. 2006, p. 714)

September 2008

* 2–5 **X Spanish Meeting on Cryptology and Information Security (X RECSI)**, Hospederia Fonseca, Salamanca, Spain.
Description: The Spanish Meeting on Cryptology and Information Security is a biennial conference that can be considered as the most important Spanish conference that works on Cryptology and Information Security. X RECSI will be the tenth of a series. The main goals of X RECSI are two: To show the most important and recent advances in the design, development, implementation, realisation and application of efficient and secure cryptographic algorithms, and to review the first two years of the establishment of the DNI-e. Three lectures will be presented by international researchers of prestige as for the Cryptology and Information Security community. Also people from Spanish government and private sector will present another four lectures. Moreover several contributions will be presented in two parallel sessions (Cryptology and Information Security) and a roundtable will be organized whose participants belong to the most important Spanish security companies.
Information: http://www.usal.es/xrecsi/english/main.htm.

* 8–12 **Long Program: Internet Multi-Resolution Analysis: Foundations, Applications and Practice**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
Description: The focus of this IPAM program will be on innovations and breakthroughs in the theoretical foundations and practical implementations of a network-centric multi-resolution analysis (MRA). Participants will learn about Internet MRA from the perspectives of mathematics, statistics, computer science and engineering–and will meet a diverse group of people and have an opportunity to form new collaborations. There will be opening tutorials, four workshops, and a culminating workshop at Lake Arrowhead.
Organizing Committee: Paul Barford, John Doyle, Anna Gilbert, Mauro Maggioni, Craig Partridge, Matthew Roughan, and Walter Willinger.
Application: An application form is available at: http://www.ipam.ucla.edu/programs/mra2008/. Applications for individual workshops will be posted on individual workshop home pages. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.
Information: http://www.ipam.ucla.edu/programs/mra2008/.

12–18 **Models in Developing Mathematics Education**, Dresden University of Applied Sciences, Dresden, Germany. (Apr. 2007, p. 498)

24–27 (REVISED INFORMATION) **Vector Measures, Integration and Applications**, Katholische Universitaet Eichstaett-Ingolstadt, Eichstaett, Germany. (Feb. 2007, p. 308)

October 2008

4–5 **AMS Western Section Meeting**, University of British Columbia and the Pacific Institute of Mathematical Sciences, Vancouver, Canada. (Jun/Jul 2007, p. 784)

11–12 **AMS Eastern Section Meeting**, Wesleyan University, Middletown, Connecticut. (Jun/Jul 2007, p. 784)

17–19 **AMS Central Section Meeting**, Western Michigan University, Kalamazoo, Michigan. (Jun/Jul 2007, p. 784)

24–26 **AMS Southeastern Section Meeting**, University of Alabama, Huntsville, Alambama. (Jun/Jul 2007, p. 784)

December 2008

17–21 **First Joint International Meeting with the Shanghai Mathematical Society**, Shanghai, China. (Jun/Jul 2007, p. 784)

November 2009

1–30 **5th Asian Mathematical Conference (AMC 2009)**, Penang/Kulalumpur, Malaysia.

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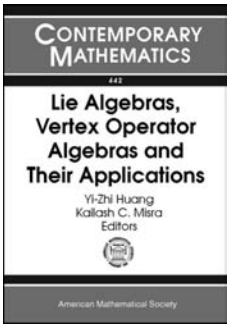
Algebra and Algebraic Geometry



Lie Algebras, Vertex Operator Algebras and Their Applications

Yi-Zhi Huang, *Rutgers University, Piscataway, NJ*, and **Kailash C Misra**, *North Carolina State University, Raleigh, NC*, Editors

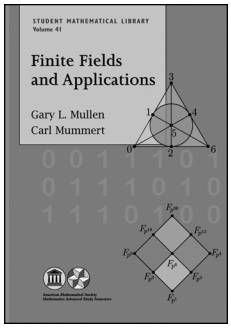
The articles in this book are based on talks given at the international conference "Lie algebras, vertex operator algebras and their applications", in honor of James Lepowsky and Robert Wilson on their sixtieth birthdays, held in May of 2005 at North Carolina State University. Some of the papers in this volume give inspiring expositions on the development and status of their respective research areas. Others outline and explore the challenges as well as the future directions of research for the twenty-first century. The focus of the papers in this volume is mainly on Lie algebras, quantum groups, vertex operator algebras and their applications to number theory, combinatorics and conformal field theory.

This book is useful for graduate students and researchers in mathematics and mathematical physics who want to be introduced to different areas of current research or explore the frontiers of research in the areas mentioned above.

Contents: *Lie algebras and related topics:* **K. Baur** and **N. Wallach**, A class of gradings of simple Lie algebras; **S. Berman** and **J. Morita**, Conjugacy results for the Lie algebra $\mathfrak{sl}_2$ over an algebra which is a UFD; **V. Chari** and **A. Moura**, Kirillov-Reshetikhin modules associated to G_2; **R. Farnsteiner**, Support spaces and Auslander-Reiten components; **J. Feldvoss**, On the cohomology of modular Lie algebras; **H. Garland**, Eisenstein series on loop groups: Maass-Selberg relations 4; **A. Hoshino**, Generalized Littlewood-Richardson rule for exceptional Lie algebras E_6 and F_4; **D. Nacin**, An introduction to Q_n and its graph related quotients; **T. Nakashima**, Affine geometric crystal of type $G_2^{(1)}$; **F. F. Nichita** and **D. Parashar**, New constructions of Yang-Baxter systems; **V. Retakh**, **S. Serconek**, and **R. L. Wilson**, Construction of some algebras associated to directed graphs and related to factorizations of noncommutative polynomials; **A. Savage**, Geometric and combinatorial realizations of crystals of enveloping algebras; **H. Strade**, Lie algebras of small dimension; *Vertex (operator) algebras and related topics:* **I. I. Anguelova**, Symmetric polynomials and H_D-quantum vertex algebras; **M. J. Bergvelt**, H_T-vertex algebras; **C. Calinescu**, On intertwining operators and recursions; **C. Dong** and **C. Jiang**, Representations of vertex operator algebras; **J. Fuchs**, On non-semisimple fusion rules and tensor categories; **K. Hubbard**, The duality between vertex operator algebras and coalgebras, modules and comodules; **J. Lepowsky**, Some developments in vertex operator algebra theory, old and new; **H. Li**, Twisted modules and quasi-modules for vertex operator algebras; **G. Mason** and **M. P. Tuite**, Chiral algebras and partition functions; **A. Milas**, Modular forms and almost linear dependence of graded dimensions; **M. Primc**, (k, r)-Admissible configurations and intertwining operators; **Z. Qin** and **W. Wang**, Hilbert schemes of points on the minimal resolution and soliton equations; **C. Schweigert**, **J. Fuchs**, and **I. Runkel**, Twining characters and Picard groups in rational conformal field theory.

Contemporary Mathematics, Volume 442

November 2007, 474 pages, Softcover, ISBN: 978-0-8218-3986-7, LC 2007060784, 2000 *Mathematics Subject Classification:* 17B10, 17B37, 17B50, 17B65, 17B67, 17B68, 17B69, 81T40, 82B23, **AMS members US$103**, List US$129, Order code CONM/442



Finite Fields and Applications

Gary L. Mullen, *Pennsylvania State University, University Park, PA*, and **Carl Mummert**, *University of Michigan, Ann Arbor, MI*

This book provides a brief and accessible introduction to the theory of finite fields and to some of their many fascinating and practical applications.

The first chapter is devoted to the theory of finite fields. After covering their construction and elementary properties, the authors discuss the trace and norm functions, bases for finite fields, and properties of polynomials over finite fields.

Each of the remaining chapters details applications. Chapter 2 deals with combinatorial topics such as the construction of sets of orthogonal latin squares, affine and projective planes, block designs, and Hadamard matrices. Chapters 3 and 4 provide a

number of constructions and basic properties of error-correcting codes and cryptographic systems using finite fields.

Each chapter includes a set of exercises of varying levels of difficulty which help to further explain and motivate the material. Appendix A provides a brief review of the basic number theory and abstract algebra used in the text, as well as exercises related to this material. Appendix B provides hints and partial solutions for many of the exercises in each chapter. A list of 64 references to further reading and to additional topics related to the book's material is also included.

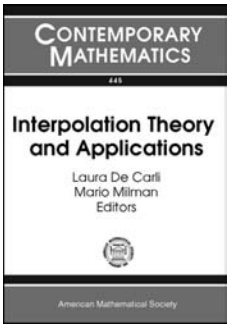
Intended for advanced undergraduate students, it is suitable both for classroom use and for individual study.

Contents: Finite fields; Combinatorics; Algebraic coding theory; Cryptography; Background in number theory and abstract algebra; Hints for selected exercises; References; Index.

Student Mathematical Library, Volume 41

December 2007, approximately 182 pages, Softcover, ISBN: 978-0-8218-4418-2, 2000 *Mathematics Subject Classification:* 11-01, 11Txx; 11T71, 05Bxx, **AMS members US$28**, List US$35, Order code STML/41

Analysis



Interpolation Theory and Applications

Laura De Carli, *Florida International University, Miami, FL*, and **Mario Milman**, *Florida Atlantic University, Boca Raton, FL*, Editors

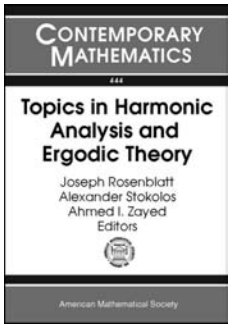
This volume contains the Proceedings of the Conference on Interpolation Theory and Applications in honor of Professor Michael Cwikel (Miami, FL, 2006). The central topic of this book is interpolation theory in its broadest sense, with special attention to its applications to analysis. The articles include applications to classical analysis, harmonic analysis, partial differential equations, function spaces, image processing, geometry of Banach spaces, and more. This volume emphasizes remarkable connections between several branches of pure and applied analysis. Graduate students and researchers in analysis will find it very useful.

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

Contents: **M. Milman** and **R. Rochberg**, Michael Cwikel: Mathematician; **O. Blasco**, Dyadic BMO, paraproducts and Haar multipliers; **A. Brudnyi** and **Y. Brudnyi**, Remez type inequalities and Morrey-Campanato spaces on Ahlfors regular sets; **J. Cerdá**, Lorentz capacity spaces; **D.-C. Chang**, **J.-F. Li**, and **J. Xiao**, Weighted scale estimates for Calderón-Zygmund type operators; **M. Cwikel** and **S. Janson**, Complex interpolation of compact operators mapping into the couple (FL^∞, FL_1^∞); **D. D. Haroske**, Envelope functions in real interpolation spaces. A first approach.; **B. Jawerth** and **M. Milman**, Weakly rearrangement invariant spaces and approximation by largest elements; **N. J. Kalton** and **T. Kucherenko**, Sectorial operators and interpolation theory; **N. J. Kalton**, **S. Mayboroda**, and **M. Mitrea**, Interpolation of Hardy-Sobolev-Besov-Triebel-Lizorkin spaces and applications to problems in partial differential equations; **N. Kruglyak**, An elementary proof of the real version of the Riesz-Thorin theorem; **N. Kruglyak**, The K-functional and Calderón-Zygmund type decompositions; **T. Kühn** and **T. Schonbek**, Extrapolation of entropy numbers; **T. M. Le** and **L. A. Vese**, Additive and multiplicative piecewise-smooth segmentation models in a functional minimization approaach; **A. Manzano** and **M. Mastyło**, Duality for coorbit interpolation functors generated by operator ideals; **J. Martin** and **M. Milman**, A note on Sobolev inequalities and limits of Lorentz spaces; **V. Maz'ya**, Bourgain-Brezis type inequality with explicit constants; **L. Pick**, Optimality and interpolation; **E. Pustylnik**, Some properties of ultrasymmetric spaces; **R. Rochberg**, Uses of commutator theorems in analysis; **C. Sadosky**, A unified view of disparate results from scattering systems; **A. Sparr**, On the conjugate space of the Lorentz space $L(\phi, q)$; **T. Weidl**, Nonstandard Cwikel type estimates.

Contemporary Mathematics, Volume 445

December 2007, 357 pages, Softcover, ISBN: 978-0-8218-4207-2, LC 2007060780, 2000 *Mathematics Subject Classification:* 46M35, 46E35, 46E30, **AMS members US$79**, List US$99, Order code CONM/445



Topics in Harmonic Analysis and Ergodic Theory

Joseph M. Rosenblatt, *University of Illinois at Urbana-Champaign, IL*, and **Alexander M. Stokolos** and **Ahmed I. Zayed**, *DePaul University, Chicago, IL*, Editors

There are strong connections between harmonic analysis and ergodic theory. A recent example of this interaction is the proof of the spectacular result by Terence Tao and Ben Green that the set of prime numbers contains arbitrarily long arithmetic progressions. The breakthrough achieved by Tao and Green is attributed to applications of techniques from ergodic theory and harmonic analysis to problems in number theory.

Articles in the present volume are based on talks delivered by plenary speakers at a conference on Harmonic Analysis and Ergodic Theory (DePaul University, Chicago, December 2–4, 2005). Of ten articles, four are devoted to ergodic theory and six to harmonic analysis, although some may fall in either category. The articles are grouped in two parts arranged by topics. Among the topics are ergodic averages, central limit theorems for random walks, Borel foliations, ergodic theory and low pass filters, data fitting using smooth surfaces, Nehari's theorem for a polydisk, uniqueness theorems for multi-dimensional trigonometric series, and Bellman and s-functions.

In addition to articles on current research topics in harmonic analysis and ergodic theory, this book contains survey articles on convergence problems in ergodic theory and uniqueness problems on multi-dimensional trigonometric series.

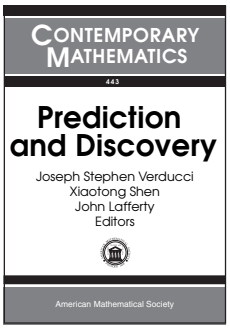
Contents: **A. I. Zayed**, Topics in ergodic theory and harmonic analysis: An overview; **J. Rosenblatt**, The mathematical work of Roger Jones; **Y. Derriennic** and **M. Lin**, The central limit theorem for random walks on orbits of probability preserving transformations; **R. F. Gundy**, Probability, ergodic theory, and low-pass filters; **D. J. Rudolph**, Ergodic theory on Borel foliations by $\mathbb{R}^n$ and $\mathbb{Z}^n$; **G. V. Welland**, Short review of the work of Professor J.

Marshall Ash; **J. M. Ash** and **G. Wang**, Uniqueness questions for multiple trigonometric series; **C. Fefferman**, Smooth interpolation of functions on $\mathbb{R}^n$; **P. A. Hagelstein**, Problems in interpolation theory related to the almost everywhere convergence of Fourier series; **M. T. Lacey**, Lectures on Nehari's theorem on the polydisk; **L. Slavin** and **A. Volberg**, The s-function and the exponential integral.

Contemporary Mathematics, Volume 444

November 2007, 228 pages, Softcover, ISBN: 978-0-8218-4235-5, LC 2007060789, 2000 *Mathematics Subject Classification:* 37A30, 37A50, 42A63, 42B30, 42B35, 42C15, 42C40, 47A35, 60F05, 65D10, **AMS members US$55**, List US$69, Order code CONM/444

Applications



Prediction and Discovery

Joseph Stephen Verducci, *Ohio State University, Columbus, OH*, **Xiaotong Shen**, *University of Minnesota, Minneapolis, MN*, and **John Lafferty**, *Carnegie Mellon University, Pittsburgh, PA*, Editors

These proceedings feature some of the latest important results about machine learning based on methods originated in Computer Science and Statistics. In addition to papers discussing theoretical analysis of the performance of procedures for classification and prediction, the papers in this book cover novel versions of Support Vector Machines (SVM), Principal Component methods, Lasso prediction models, and Boosting and Clustering. Also included are applications such as multi-level spatial models for diagnosis of eye disease, hyperclique methods for identifying protein interactions, robust SVM models for detection of fraudulent banking transactions, etc.

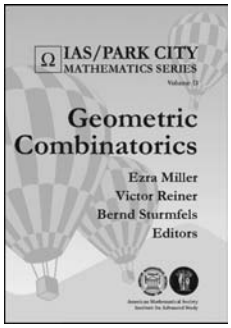
This book should be of interest to researchers who want to learn about the various new directions that the field is taking, to graduate students who want to find a useful and exciting topic for their research or learn the latest techniques for conducting comparative studies, and to engineers and scientists who want to see examples of how to modify the basic high-dimensional methods to apply to real world applications with special conditions and constraints.

Contents: **J. S. Verducci** and **X. Shen**, Introduction; **J. Wang**, **X. Shen**, and **W. Pan**, On transductive support vector machines; **X. Deng**, **M. Yuan**, and **A. Sudjianto**, A note on robust kernel principal component analysis; **Y. Liu**, **H. H. Zhang**, **C. Park**, and **J. Ahn**, The L_q support vector machine; **Y. Wu** and **Y. Liu**, On multicategory truncated-hinge-loss support vector machines; **A. B. Owen**, A robust hybrid of lasso and ridge regression; **Y. Kim**, **Y. Kim**, and **J. Kim**, A gradient descent algorithm for LASSO; **B. Li** and **P. K. Goel**, Additive regression trees and smoothing splines-predictive modeling and interpretation in data mining; **E. P. Fokoué**, Estimation of atom prevalence for optimal prediction; **C. Rudin**, **R. E. Schapire**, and **I. Daubechies**, Precise statements of convergence for AdaBoost and arc-gv; **K. Marsolo**, **S. Parthasarathy**, **M. Twa**, and **M. Bullimore**, Ensemble-learning by model-based spatial averaging; **H. Zou**, **J. Zhu**, **S. Rosset**, and **T. Hastie**, Automatic bias correction methods in semi-supervised learning; **S. Wang** and **J. Zhu**, Variable selection for model-based high-dimensional clustering; **W. Pan** and **X. Shen**, Semi-supervised learning via constraints; **M. Steinbach**, **P - N. Tan**, **H. Xiong**, and **V. Kumar**, Objective measures for association pattern analysis.

Contemporary Mathematics, Volume 443

October 2007, 226 pages, Softcover, ISBN: 978-0-8218-4195-2, LC 2007060788, 2000 *Mathematics Subject Classification:* 62-04, 62-06, **AMS members US$55**, List US$69, Order code CONM/443

Discrete Mathematics and Combinatorics



Geometric Combinatorics

Ezra Miller and **Victor Reiner**, *University of Minnesota, Minneapolis, MN*, and **Bernd Sturmfels**, *University of California, Berkeley, CA*, Editors

Geometric combinatorics describes a wide area of mathematics that is primarily the study of geometric objects and their combinatorial structure. Perhaps the most familiar examples are polytopes and simplicial complexes, but the subject is much broader. This volume is a compilation of expository articles at the interface between combinatorics and geometry, based on a three-week program of lectures at the Institute for Advanced Study/Park City Math Institute (IAS/PCMI) summer program on Geometric Combinatorics. The topics covered include posets, graphs, hyperplane arrangements, discrete Morse theory, and more. These objects are considered from multiple perspectives, such as in enumerative or topological contexts, or in the presence of discrete or continuous group actions.

Most of the exposition is aimed at graduate students or researchers learning the material for the first time. Many of the articles include substantial numbers of exercises, and all include numerous examples. The reader is led quickly to the state of the art and current active research by worldwide authorities on their respective subjects.

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

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

Contents: What is geometric combinatorics?–An overview of the graduate summer school; Bibliography; *A. Barvinok, Lattice points, polyhedra, and complexity:* Introduction; Inspirational examples. Valuations; Identities in the algebra of polyhedra; Generating functions and cones. Continued fractions; Rational polyhedra and rational functions; Computing generating functions fast; Bibliography; *S. Fomin and N. Reading, Root systems and generalized associahedra:* Introduction; Reflections and roots; Dynkin diagrams and Coxeter groups; Associahedra and mutations; Cluster algebras; Enumerative problems; Bibliography; *R. Forman, Topics in combinatorial differential*

topology and geometry: Introduction; Discrete Morse theory; Discrete Morse theory, continued; Discrete Morse theory and evasiveness; The Charney-Davis conjectures; From analysis to combinatorics; Bibliography; *M. Haiman and A. Woo, Geometry of q and q,t-analogs in combinatorial enumeration:* Introduction; Kostka numbers and q-analogs; Catalan numbers, trees, Lagrange inversion, and their q-analogs; Macdonald polynomials; Connecting Macdonald polynomials and q-Lagrange inversion; (q,t)-analogs; Positivity and combinatorics?; Bibliography; *D. N. Kozlov, Chromatic numbers, morphism complexes, and Stiefel-Whitney characteristic classes:* Preamble; Introduction; The functor $\mathrm{Hom}(-,-)$; Stiefel-Whitney classes and first applications; The spectral sequence approach; The proof of the Lovász conjecture; Summary and outlook; Bibliography; *R. MacPherson, Equivariant invariants and linear geometry:* Introduction; Equivariant homology and intersection homology (Geometry of pseudomanifolds); Moment graphs (Geometry of orbits); The cohomology of a linear graph (Polynomial and linear geometry); Computing intersection homology (Polynomial and linear geometry II); Cohomology as functions on a variety (Geometry of subspace arrangements); Bibliography; *R. P. Stanley, An introduction to hyperplane arrangements:* Basic definitions, the intersection poset and the characteristic polynomial; Properties of the intersection poset and graphical arrangements; Matroids and geometric lattices; Broken circuits, modular elements, and supersolvability; Finite fields; Separating hyperplanes; Bibliography; *M. L. Wachs, Poset topology: Tools and applications:* Introduction; Basic definitions, results, and examples; Group actions on posets; Shellability and edge labelings; Recursive techniques; Poset operations and maps; Bibliography; *G. M. Ziegler, Convex polytopes: Extremal constructions and f-vector shapes:* Introduction; Constructing 3-dimensional polytopes; Shapes of f-vectors; 2-simple 2-simplicial 4-polytopes; f-vectors of 4-polytopes; Projected products of polygons; A short introduction to polymake; Bibliography.

IAS/Park City Mathematics Series, Volume 13

November 2007, 691 pages, Hardcover, ISBN: 978-0-8218-3736-8, LC 2007060782, 2000 *Mathematics Subject Classification:* 05-02, 52-02; 05C15, 05Exx, 05E25, 06Axx, 14F43, 52B05, 52B11, 52C35, 57Qxx, **AMS members US$79**, List US$99, Order code PCMS/13

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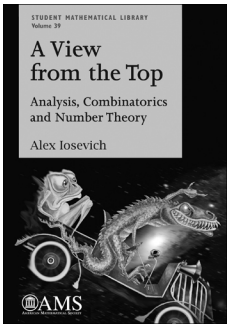


A View from the Top

Analysis, Combinatorics and Number Theory

Alex Iosevich, *University of Missouri, Columbia, MO*

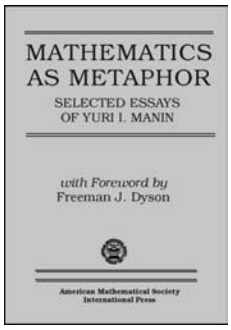
This book is based on a capstone course that the author taught to upper division undergraduate students with the goal to explain and visualize the connections between different areas of mathematics and the way different subject matters flow from one another. In teaching his readers a variety of problem solving techniques as well, the author succeeds in enhancing the readers' hands-on knowledge of mathematics and provides glimpses into the world of research and discovery. The connections between different techniques and areas of mathematics are emphasized throughout and constitute one of the most important lessons this book attempts to impart. This book is interesting and accessible to anyone with a basic knowledge of high school mathematics and a curiosity about research mathematics.

The author is a professor at the University of Missouri and has maintained a keen interest in teaching at different levels since his undergraduate days at the University of Chicago. He has run numerous summer programs in mathematics for local high school students and undergraduate students at his university. The author gets much of his research inspiration from his teaching activities and looks forward to exploring this wonderful and rewarding symbiosis for years to come.

Contents: The Cauchy-Schwarz inequality; Projections in $\mathbb{R}^3$—The elephant makes an appearance; Projections in four dimensions; Projections and cubes; Incidences and matrices; Basics of grids over finite fields; Besicovitch-Kakeya conjecture in two dimensions; A gentle entry into higher dimensions; Some basic counting, probability and a few twists; A more involved taste of probability; Oscillatory integrals and fun that lies beyond; Integer points and a crash course on Fourier analysis; Return of the Fourier transform; It is time to say goodbye; Bibliography.

Student Mathematical Library, Volume 39

December 2007, 136 pages, Softcover, ISBN: 978-0-8218-4397-0, LC 2007060833, 2000 *Mathematics Subject Classification:* 05-XX, 11-XX, 28-XX, 30-XX, 40-XX, 42-XX, 52-XX, **AMS members US$23**, List US$29, Order code STML/39



Mathematics as Metaphor

Selected Essays of Yuri I. Manin

Yuri I. Manin, *Northwestern University, Evanston, IL, and Steklov Mathematical Institute, Moscow, Russia*

The book includes fifteen essays and an interview. The essays are grouped in three parts: Mathematics; Mathematics and Physics; and Language, Consciousness, and Book reviews. Most of the essays are about some aspects of epistemology and the history of sciences, mainly mathematics, physics, and the history of language. English translations of some of the essays, originally published in Russian, appear for the first time in this selection. One of them is the introduction to the book *Computable and Uncomputable*, where the idea of a quantum computer was first proposed in 1980. Another is an essay on the mythological trickster figure, where the evolutionary role of manipulative behavior is discussed in connection with the problem of the origin of human language. With the foreword by Freeman Dyson, this book will be of interest to anyone interested in the philosophy and history of mathematics, physics, and linguistics.

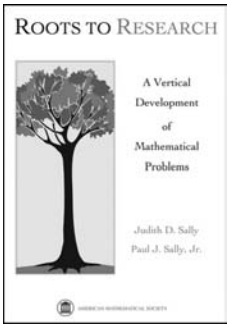
Contents: Mathematical knowledge: Internal, social, and cultural aspects; *Part I. Mathematics as metaphor:* Mathematics as metaphor; Truth, rigour, and common sense; Georg Cantor and his heritage; Gödel's theorem; Introduction to the book *Computable and uncomputable*; Mathematics as profession and vocation; *Part II. Mathematics and physics:* Mathematics and physics; Interrelations between mathematics and physics; Reflections on arithmetical physics; *Part III. Language, consciousness, book reviews:* The

mythological trickster: A study in psychology and culture theory; On early development of speech and consciousness (phylogeny); The empty city archetype; Triangle of thoughts by A. Connes, A. Lichnerowicz, and M. P. Schützenberger; "It is still love"–The Siege by Clara Park; "Good proofs are proofs that make us wiser"–Interview by Martin Aigner and Vasco A. Schmidt; List of publications.

Collected Works, Volume 20

December 2007, 236 pages, Hardcover, ISBN: 978-0-8218-4331-4, LC 2007060838, 2000 *Mathematics Subject Classification:* 01A75, **AMS members US$39**, List US$49, Order code CWORKS/20

COURSE ADOPTION



Roots to Research

A Vertical Development of Mathematical Problems

Judith D. Sally, *Northwestern University, Evanston, IL*, and **Paul J. Sally, Jr.**, *University of Chicago, IL*

Certain contemporary mathematical problems are of particular interest to teachers and students because their origin lies in mathematics covered in the elementary school curriculum and their development can be traced through high school, college, and university level mathematics. This book is intended to provide a source for the mathematics (from beginning to advanced) needed to understand the emergence and evolution of five of these problems: The Four Numbers Problem, Rational Right Triangles, Lattice Point Geometry, Rational Approximation, and Dissection.

Each chapter begins with the elementary geometry and number theory at the source of the problem, and proceeds (with the exception of the first problem) to a discussion of important results in current research. The introduction to each chapter summarizes the contents of its various sections, as well as the background required.

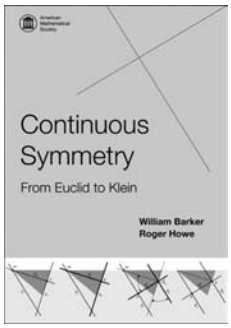
The book is intended for students and teachers of mathematics from high school through graduate school. It should also be of interest to working mathematicians who are curious about mathematical results in fields other than their own. It can be used by teachers at all of the above mentioned levels for the enhancement of standard curriculum materials or extra-curricular projects.

Contents: The four numbers problem; Rational right triangles and the congruent number problem; Lattice point geometry; Rational approximation; Dissection; Appendix A. Volume; Appendix B. Convexity; Index.

December 2007, 340 pages, Hardcover, ISBN: 978-0-8218-4403-8, LC 2007060836, 2000 *Mathematics Subject Classification:* 00-01, 00-02, 11Hxx, 11Gxx, 11Jxx, 52-XX, **AMS members US$39**, List US$49, Order code MBK/48

Geometry and Topology

COURSE ADOPTION



Continuous Symmetry

From Euclid to Klein

William Barker, *Bowdoin College, Brunswick, ME*, and **Roger Howe**, *Yale University, New Haven, CT*

The fundamental idea of geometry is that of symmetry. With that principle as the starting point, Barker and Howe begin an insightful and rewarding study of Euclidean geometry.

The primary focus of the book is on transformations of the plane. The transformational point of view provides both a path for deeper understanding of traditional synthetic geometry and tools for providing proofs that spring from a consistent point of view. As a result, proofs become more comprehensible, as techniques can be used and reused in similar settings.

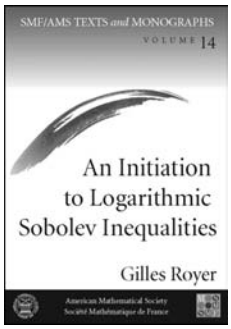
The approach to the material is very concrete, with complete explanations of all the important ideas, including foundational background. The discussions of the nine-point circle and wallpaper groups are particular examples of how the strength of the transformational point of view and the care of the authors' exposition combine to give a remarkable presentation of topics in geometry.

This text is for a one-semester undergraduate course on geometry. It is richly illustrated and contains hundreds of exercises.

Contents: Foundations of geometry in the plane; Isometries in the plane: Products of reflections; Isometries in the plane: Classification and structure; Similarities in the plane; Conjugacy and geometric equivalence; Applications to plane geometry; Symmetric figures in the plane; Frieze and wallpaper groups; Area, volume, and scaling; References; Index.

December 2007, 544 pages, Hardcover, ISBN: 978-0-8218-3900-3, LC 2007060795, 2000 *Mathematics Subject Classification:* 51-01, 20-01, **AMS members US$55**, List US$69, Order code MBK/47

Mathematical Physics



An Initiation to Logarithmic Sobolev Inequalities

Gilles Royer, *Université d'Orléans, France*

This book provides an introduction to logarithmic Sobolev inequalities with some important applications to mathematical statistical physics. Royer begins by gathering and reviewing the necessary background material on selfadjoint operators, semigroups, Kolmogorov diffusion processes, solutions of stochastic differential equations,

and certain other related topics. There then is a chapter on log Sobolev inequalities with an application to a strong ergodicity theorem for Kolmogorov diffusion processes. The remaining two chapters consider the general setting for Gibbs measures including existence and uniqueness issues, the Ising model with real spins and the application of log Sobolev inequalities to show the stabilization of the Glauber–Langevin dynamic stochastic models for the Ising model with real spins. The exercises and complements extend the material in the main text to related areas such as Markov chains.

Titles in this series are co-published with Société Mathématique de France. SMF members are entitled to AMS member discounts.

Contents: Self-adjoint operators; Semi-groups; Logarithmic Sobolev inequalities; Gibbs measures; Stabilization of the Langevin dynamic; Appendix A; Bibliography.

SMF/AMS Texts and Monographs, Volume 14

November 2007, 119 pages, Softcover, ISBN: 978-0-8218-4401-4, LC 2007060798, 2000 *Mathematics Subject Classification:* 60-02; 35J85, 47B25, 47D07, 60J60, 82C20, **AMS members US$31**, List US$39, Order code SMFAMS/14

New AMS-Distributed Publications

Algebra and Algebraic Geometry

Representations of Linear Groups

An Introduction Based on Examples from Physics and Number Theory

Rolf Berndt, *University of Hamburg, Germany*

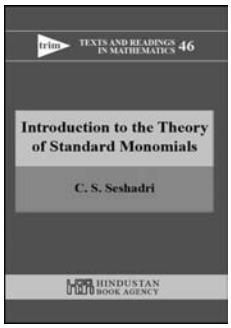
This is an elementary introduction to the representation theory of real and complex matrix groups. The text is written for students in mathematics and physics who have a good knowledge of differential/integral calculus and linear algebra and are familiar with basic facts from algebra, number theory and complex analysis. The goal is to present the fundamental concepts of representation theory, to describe the connection between them, and to explain some of their background. The focus is on groups which are of particular interest for applications in physics and number theory (e.g. Gell-Mann's eightfold way and theta functions, automorphic forms). The reader finds a large variety of examples which are presented in detail and from different points of view. The examples motivate the general theory well covered already by the existing literature. Hence for complete proofs of most of the essential statements and theorems the reader is often referred to the standard sources. Plenty of exercises are included in the text. Some of these exercises and/or omitted proofs may give a starting point for a bachelor's thesis and further studies in a master's program.

A publication of Vieweg Verlag. The AMS is exclusive distributor in North America. Vieweg Verlag Publications are available worldwide from the AMS outside of Germany, Switzerland, Austria, and Japan.

Contents: Some groups and their actions; Basic algebraic concepts; Representations of finite groups; Continuous representations; Representations of compact groups; Representations of Abelian groups; The infinitesimal method; Induced representations; Geometric quantization and the orbit method; Outlook to number theory.

Vieweg Monographs

July 2007, 270 pages, Softcover, ISBN: 978-3-8348-0319-1, 2000 *Mathematics Subject Classification:* 20G05; 22E45, **AMS members US$44**, List US$49, Order code VW/15



Introduction to the Theory of Standard Monomials

C. S. Seshadri, *Chennai Mathematical Institute, Tamil Nadu, India*

The aim of this book is to give an introduction to what has come to be known as Standard Monomial Theory (SMT). SMT deals with the construction of nice bases of finite dimensional irreducible representations of semi-simple algebraic groups or, in geometric terms, nice bases of coordinate rings of flag varieties (and their Schubert subvarieties) associated to these groups. Besides its intrinsic interest, SMT has applications to the study of the geometry of Schubert varieties. SMT has its origin in the work of Hodge, giving bases of the coordinate rings of the Grassmannian and its Schubert subvarieties by "standard monomials". In its modern form, SMT was developed by the author in a series of papers written in collaboration with V. Lakshmibai and C. Musili.

This book is a reproduction of a course of lectures given by the author in 1983-84 which appeared in the Brandeis Lecture Notes series. The aim of this course was to give an introduction to the series of papers by concentrating on the case of the full linear group. In recent years, there has been great progress in SMT due to the work of Peter Littelmann. Seshadri's course of lectures (reproduced in this book) remains an excellent introduction to SMT.

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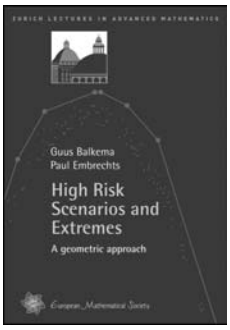
Contents: Introduction; Standard monomial theory on $SL_n(k)/Q$; Applications; Schubert varieties in G/Q; Appendix A; Appendix B; Bibliography; Notation; Index; Index of Symbols.

Hindustan Book Agency

August 2007, 180 pages, Softcover, ISBN: 978-81-85931-78-4, **AMS members US$27**, List US$34, Order code HIN/34

Applications



High Risk Scenarios and Extremes

A Geometric Approach

Guus Balkema, *University of Amsterdam, Netherlands*, and **Paul Embrechts**, *Eidgen Technische Hochschule, Zurich, Switzerland*

Quantitative Risk Management (QRM) has become a field of research of considerable importance to numerous areas of application, including insurance, banking, energy, medicine, and reliability. Mainly motivated by examples from insurance and finance, the authors develop a theory for handling multivariate extremes. The approach borrows ideas from portfolio theory and aims at an intuitive approach in the spirit of the Peaks over Thresholds method. The point of view is geometric. It leads to a probabilistic description of what in QRM language may be referred to as a high risk scenario: the conditional behaviour of risk factors given that a large move on a linear combination (portfolio, say) has been observed. The theoretical models which describe such conditional extremal behaviour are characterized and their relation to the limit theory for coordinatewise maxima is explained.

The first part is an elegant exposition of coordinatewise extreme value theory; the second half develops the more basic geometric theory. Besides a precise mathematical deduction of the main results, the text yields numerous discussions of a more applied nature. A twenty page preview introduces the key concepts; the extensive introduction provides links to financial mathematics and insurance theory.

The book is based on a graduate course on point processes and extremes. It could form the basis for an advanced course on multivariate extreme value theory or a course on mathematical issues underlying risk. Students in statistics and finance with a mathematical, quantitative background are the prime audience. Actuaries and risk managers involved in data based risk analysis will find the models discussed in the book stimulating. The text contains many indications for further research.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Introduction; Preview; Point processes; Maxima; High risk limit laws; Thresholds; Open problems; Bibliography; Index.

Zurich Lectures in Advanced Mathematics

September 2007, 388 pages, Softcover, ISBN: 978-3-03719-035-7, 2000 *Mathematics Subject Classification:* 60G70, 60F99, 91B30, 91B70, 62G32, 60G55, **AMS members US$51**, List US$64, Order code EMSZLEC/5

Mathematical Physics

Contributions in Mathematical Physics

A Tribute to Gerard G. Emch

S. Twareque Ali, *Concordia University, Montreal, Quebec, Canada, and* **Kalyan B. Sinha**, *Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India, Editors*

Gerard G. Emch is one of the pioneers of the C*-algebraic approach to quantum and classical statistical mechanics. In a prolific scientific career spanning nearly five decades, he has been one of the creative influences in the general area of mathematical physics. The present volume is a collection of tributes, from former students, colleagues, and friends, on the occasion of his 70th birthday. The articles featured here are a small yet representative sample of the breadth and reach of some of the ideas from mathematical physics.

It is also a testimony to the impact that Emch's work has had on several generations of mathematical physicists as well as to the diversity of mathematical methods used to understand them.

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Contents: S. T. Ali and **M. Englis**, Berezin–Toeplitz quantization over matrix domains; **J.-P. Antoine**, Partial *-algebras, a tool for the mathematical description of physical systems; **G. A. Ascoli** and **G. A. Goldin**, Some variations on Maxwell's equations; **F. Bagarello**, Physical applications of algebras of unbounded operators; **S. De Bievre**, Where's that quantum?; **V. M. Kenkre** and **F. J. Sevilla**, Thoughts about anomalous diffusion: Time-dependent coefficients versus memory functions; **J. R. Klauder**, Infinite divisibility in Euclidean quantum mechanics; **M. Ohya**, Adaptive dynamics and its application to chaos; **F. E. Schroeck, Jr.**, The C^* axioms and the phase space formalism of quantum mechanics; **K. B. Sinha**, Stochastic flow on the quantum Heisenberg manifold.

Hindustan Book Agency

August 2007, 236 pages, Hardcover, ISBN: 978-81-85931-79-1, 2000 *Mathematics Subject Classification:* 81Q99, 81R15, 81S25, 81P05, 78A25, 82C05, **AMS members US$34**, List US$42, Order code HIN/35

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The Department of Mathematics at the University of Alabama at Birmingham (UAB) is soliciting applications for a tenure-track assistant professor position beginning August 15, 2008. Applicants whose research is compatible with the department's strengths in differential equations, differential geometry, dynamical systems, mathematical physics, and topology, including computational aspects of these areas, are encouraged to apply. Those with expertise in geometric or harmonic analysis, inverse problems, or probability are of particular interest in this search. For additional information about the department please visit: http://www.math.uab.edu.

Applicants should have demonstrated the potential to excel in one of these areas and in teaching at all levels of instruction. They should also be committed to professional service including departmental service. Postdoc experience is preferred.

Applications should include a curriculum vita with a publication list, a statement of future research plans, a statement on teaching experience and philosophy, and minimally three letters of reference with at least one letter addressing teaching experience and ability. We prefer applications and all other materials be submitted electronically at: http://www.mathjobs.org, although applicants may submit an application including an AMS cover sheet to:

Math Faculty Search
Department of Mathematics
The University of Alabama at Birmingham
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The department and university are committed to building a culturally diverse workforce and strongly encourage applications from women and individuals from underrepresented groups. UAB has an active NSF-supported ADVANCE program and a Spouse Relocation Program to assist in the needs of dual career couples. UAB is an Affirmative Action/Equal Employment Opportunity employer.

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UNIVERSITY OF ALABAMA IN HUNTSVILLE
Department of Mathematical Sciences
Faculty Position

The Department of Mathematical Sciences at the University of Alabama in Huntsville invites applications for a tenure-track position at the rank of assistant professor, beginning August 2008. A Ph.D. degree in mathematics or applied mathematics is required. Applicants must show evidence of excellent research potential in an area that matches the interests of the department. Applicants must also have a strong commitment to teaching and show evidence of excellent teaching ability. Preference will be given to applicants whose research area is partial differential equations, mathematical modeling, or mathematical biology.

Applicants should send a curriculum vita with the AMS standard cover sheet and three letters of recommendation (with at least one letter addressing teaching) to: Chairman, chair@math.uah.edu, Department of Mathematical Sciences, University of Alabama in Huntsville, Huntsville, AL 35899.

For more information about the department, visit our website at http://www.math.uah.edu.

Review of applicants will begin February 15, 2008, and will continue until the position is filled. Women and minorities are encouraged to apply. The University of Alabama in Huntsville is an Affirmative Action, Equal Opportunity Institution.

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CALIFORNIA

MILLS COLLEGE
Department of Mathematics
Assistant Professor of Mathematics

Mills College invites applications for a full-time, tenure-track position at the rank of assistant professor to teach a variety of courses in mathematics, beginning fall 2008. The successful candidate will carry a teaching load equivalent of five courses per year, contribute to an environment that excites women about mathematics and prepares them for careers that use mathematics, and assist in efforts to attract and retain students with diverse backgrounds and interests to the mathematics program. Required: Ph.D. in mathematics and a broad background in mathematics. Applicants must submit evidence of superior teaching and research abilities and a strong interest in advancing

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 2007 rate is $110 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. 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 2008 issue–October 26, 2007; February 2008 issue–November 28, 2007; March 2008–December 28, 2007; April 2008 issue–January 28, 2008; May 2008–February 28, 2008; June/July 2008 issue–April 28, 2008.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to classads@ams.org. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

women in mathematics in a liberal arts college setting.

Mills offers 41 undergraduate majors and 23 graduate degree and certificate programs, including a master's program in interdisciplinary computer science, and a B.A./M.A. program in mathematics. The faculty/student ratio is 1:11.

Please send a vita; three letters of recommendation; and statements of teaching philosophy, research agenda, and interest in advancing women in mathematics in a liberal arts college setting to: Dr. Barbara Li Santi, Chair of the Mathematics Search Committee, Mills College, 5000 MacArthur Blvd., Oakland, CA 94613 (email address: barbara@mills.edu). The deadline for receiving this material is December 17, 2007.

Located in the San Francisco Bay Area, Mills College is a selective liberal arts college for women with co-educational graduate programs (see http://www.mills.edu). Persons of color and those committed to working in a multicultural environment are encouraged to apply. AA/EOE.

000161

SAN DIEGO STATE UNIVERSITY
Department of Mathematics and Statistics

The Department of Mathematics and Statistics invites applications for a tenure-track assistant professor position in applied mathematics, beginning in fall 2008. Preference may be given to candidates in research areas that include but are not limited to dynamical systems, nonlinear waves, communication systems, climate dynamics, asymptotics, and linear algebra. Candidates must have a Ph.D. in mathematics or a closely related field, and demonstrate excellent teaching skills and outstanding research potential. 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. Salary will be competitive.

Applications should include a cover letter, curriculum vita, a description of research program, a statement of teaching philosophy, and three letters of recommendation. Send to: Antonio Palacios, Applied Mathematics Search Committee Chair, Department of Mathematics and Statistics, San Diego State University, San Diego, CA 92182-7720. Applications received by January 18, 2008, will be given full consideration.

SDSU is a Title IX, Equal Opportunity Employer and does not discriminate against individuals on the basis of race, religion, national origin, sexual orientation, gender, marital status, age, disability or veteran status, including veterans of the Vietnam era.

000127

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Department of Mathematics
2008-2009 Faculty Positions

The Mathematics Department is in a period of increased hiring of tenured and tenure-track faculty. Subject to administrative approval, we expect to make several regular appointments in a wide range of possible fields. We will also be making temporary and visiting appointments beginning in the academic year 2008-09 in the following categories:

(1) Tenure-Track/Tenured Faculty Position.

(2) E. R. Hedrick Assistant Professorships. Salary is $55,400. Appointments are for three years. The teaching load is four quarter courses per year.

(3) Research Assistant Professorships in Computational and Applied Mathematics (CAM). The salary is $55,400, and appointments are for three years. The teaching load is normally reduced to two or three quarter courses per year by research funding as available.

(4) Assistant Adjunct Professorships in the Program in Computing (PIC). Applicants for these positions must show very 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 seminar every two years. Initial appointments are for one year and possibly longer, up to a maximum service of four years. The salary is $59,100.

(5) 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 $50,900-$55,400. Teaching load for adjuncts is five quarter courses per year.

If you wish to be considered for any of these positions you must submit an application via http://www.mathjobs.org. Submit the AMS Cover Sheet and supporting documentation electronically.

For fullest consideration, an application must be submitted on or before December 12, 2007. Ph.D. is required for all positions.

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.

UCLA is an Equal Opportunity/Affirmative Action Employer.

000070

UNIVERSITY OF CALIFORNIA, SAN DIEGO
Department of Mathematics
Stefan E. Warschawski
Assistant Professorship - 7/1/2008

The Department of Mathematics at the University of California, San Diego, is seeking outstanding candidates for a special three-year assistant professorship, the S. E. Warschawski Assistant Professorship, pending funding approval. The nine-month salary is $48,000. This is a three-year nonrenewable appointment.

Applicants should possess a recent Ph.D. degree (received no earlier than 2005) in mathematics or expect to receive one prior to July 2008. We expect these candidates to have excellent teaching skills and excellent research potential. Candidates with teaching and research interests compatible with current faculty are sought. To receive full consideration, applications should be submitted online through http://www.mathjobs.org/ by November 30, 2007. For further instructions and information, see http://math.ucsd.edu/about/employment/faculty.

In compliance with the Immigration Reform and Control Act of 1986, individuals offered employment by the University of California will be required to show documentation to prove identity and authorization to work in the United States before hiring can occur. UCSD is an Equal Opportunity/Affirmative Action Employer with a strong institutional commitment to the achievement of diversity among its faculty and staff.

All applications should include the following items: 3 Reference Letters (Writers should upload their reference letters to mathjobs.org or send them under separate cover; at least one letter should address teaching experience in some depth.) 1 Cover Letter, 1 Curriculum Vitae, 1 Publications List, 1 Research Statement, 1 Teaching Statement, and optionally a statement about contributions to diversity.

000154

CONNECTICUT

FAIRFIELD UNIVERSITY
Department of Mathematics

The Department of Mathematics and Computer Science at Fairfield University invites applications for three tenure-track assistant professorships, to begin in September 2008. A doctorate in mathematics is required. A solid commitment to teaching and strong evidence of research potential, are essential. We are looking for (1) one person who will be expected to conduct research with undergraduate students and (2) two people who will be expected to teach some courses in our graduate program. Graduate courses in-

clude, but are not limited to, year-long sequences in abstract and linear algebra, applied mathematics, financial mathematics, real and complex analysis, and probability and statistics. In addition, the successful candidates will share a willingness to participate in the university's core curriculum, which includes two semesters of mathematics for all undergraduates.

Fairfield University, the Jesuit University of Southern New England, is a comprehensive university with about 3,200 undergraduates and a strong emphasis on liberal arts education. The department offers a BS and an MS in mathematics. The MS program is an evening program and attracts students from various walks of life—secondary school teachers, eventual Ph.D. candidates, and people working in industry, among others. The teaching load is 3 courses/9 credit hours per semester and consists predominantly of courses at the undergraduate level.

Fairfield offers competitive salaries and compensation benefits. The picturesque campus is located on Long Island Sound in southwestern Connecticut, about 50 miles from New York City. Fairfield is an Affirmative Action/Equal Opportunity Employer. For further details see http://cs.fairfield.edu/mathhire. Applicants should send a letter of application, a curriculum vitae, teaching and research statements, and three letters of recommendation commenting on the applicant's experience and promise as a teacher and scholar, to Matt Coleman, Chair of the Department of Mathematics and Computer Science, Fairfield University, Fairfield CT 06824-5195. Please indicate in your cover letter the position for which you are applying. Full consideration will be given to complete applications received by January 15, 2008. We will be interviewing at the Joint Mathematics Meetings in San Diego, January 6-9. Please let us know if you will be attending.

000135

GEORGIA

GEORGIA INSTITUTE OF TECHNOLOGY
School of Mathematics

The School of Mathematics at Georgia Tech is now in the fourth year of an ambitious faculty recruitment program—one which will be sustained over a five-year period. During the first three years, ten appointments were made, including four tenured appointments, two at the full professor level and two at the associate professor level. Building on past successes, this recruiting effort is intended to make rapid advances in the scope and quality of our research and graduate education programs. Candidates will be considered at all ranks, with priority given to those candidates who (1) bring exceptional quality research credentials to Georgia Tech; (2) complement existing strengths in the School of Mathematics; (3) reinforce bridges to programs in engineering and the physical, computing and life sciences; (4) have strong potential for external funding; and (5) have a demonstrated commitment to high quality teaching at both the undergraduate and graduate levels. Consistent with these priorities, candidates will be considered in all areas of pure and applied mathematics and statistics. Candidates should arrange for a resume, at least three letters of reference, and a summary of future research plans to be sent to the Hiring Committee, School of Mathematics, Georgia Institute of Technology, Atlanta, GA, 30332-0160, USA. Candidates for associate and full professor positions should also submit a statement outlining their vision for service as a senior faculty member at Georgia Tech. Review of applications will begin in September 2007, and the roster of candidates being considered will be updated on a monthly basis. Georgia Tech, an institution of the University System of Georgia, is an Equal Opportunity/Affirmative Action Employer.

000102

IDAHO

BOISE STATE UNIVERSITY
Department of Mathematics

The Mathematics Department at Boise State University invites applications for a tenure-track position at the assistant professor level starting in August 2008. The position being filled is in the general area of set theory. Further details can be found at the department's webpage: http://math.boisestate.edu/. Screening will begin January 15, 2008. EOE/AA Institution, Veterans preference.

000159

ILLINOIS

NORTHWESTERN UNIVERSITY
Department of Mathematics
2033 Sheridan Road
Evanston, Illinois 60208-2730
Boas Assistant Professor

Applications are solicited for up to three Ralph Boas assistant professorships of three years each starting September 2008. These are non-tenure-track positions with a teaching load of four quarter courses per year. We invite applications from qualified mathematicians in all fields.

Applications should be made electronically at http://www.mathjobs.org and should include (1) the American Mathematical Society Cover Sheet for Academic Employment, (2) a curriculum vitae, (3) a research statement, and (4) three letters of recommendation, one of which discusses the candidate's teaching qualifications. Inquiries may be sent to: boas@math.northwestern.edu.

Applications are welcomed at any time, but the review process starts December 1, 2007. Northwestern University is an Affirmative Action, Equal Opportunity Employer committed to fostering a diverse faculty; women and minority candidates are especially encouraged to apply.

000065

NORTHWESTERN UNIVERSITY
Department of Mathematics
2033 Sheridan Road,
Evanston, Illinois 60208-2730

Applications are invited for anticipated tenured or tenure-track positions starting September 2008. Priority will be given to exceptionally promising research mathematicians. We invite applications from qualified mathematicians in all fields.

Applications should be made electronically at http://www.mathjobs.org and should include (1) the American Mathematical Society Cover Sheet for Academic Employment, (2) a curriculum vitae, (3) a research statement, and (4) three letters of recommendation, one of which discusses the candidate's teaching qualifications. Inquiries may be sent to: boas@math.northwestern.edu.

Applications are welcome at any time. Northwestern University is an Affirmative Action, Equal Opportunity Employer committed to fostering a diverse faculty; women and minority candidates are especially encouraged to apply.

000066

UNIVERSITY OF ILLINOIS AT CHICAGO
Department of Mathematics, Statistics, and Computer Science

Applications are invited for the following position, effective August 16, 2008, subject to budgetary approval.

Tenure-track position in mathematics education.

The department has active research programs in centrally important areas of pure mathematics, computational and applied mathematics, combinatorics and mathematical computer science, statistics, and mathematics education. See http://www.math.uic.edu for more information.

The position is at the assistant professor level. Applicants must have a Ph.D. or equivalent degree in the mathematical sciences or mathematics education, or equivalent qualification, a promising record of research in mathematics education, and evidence of strong teaching ability. The salary is negotiable.

Send a letter indicating interest in the mathematics education position, vita, statement of research and teaching interests, and at least three (3) letters of recommendation, to: Mathematics Education

Search Committee; Dept. of Mathematics, Statistics, and Computer Science; University of Illinois at Chicago; 851 S. Morgan (m/c 249); Box E; Chicago, IL 60607. Applications through mathjobs.org are encouraged. No email applications will be accepted. To ensure full consideration, materials must be received by January 1, 2008. However, we will continue considering candidates until all positions have been filled. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000164

UNIVERSITY OF ILLINOIS AT CHICAGO
Department of Mathematics, Statistics, and Computer Science

The department has active research programs in centrally important areas of pure mathematics, computational and applied mathematics, combinatorics and mathematical computer science, statistics, and mathematics education. See http://www.math.uic.edu for more information.

Applications are invited for the following position, effective August 16, 2008, subject to budgetary approval.

Research Assistant Professorship. This is a non-tenure-track position, normally renewable annually to a maximum of three years. This position carries a teaching responsibility of one course per semester, and the expectation that the incumbent play a significant role in the research life of the department. The salary for AY 2007-2008 for this position is $53,500, the salary for AY 2008-2009 may be higher. Applicants must have a Ph.D. or equivalent degree in mathematics, computer science, statistics, mathematics education or related field, and evidence of outstanding research potential.

Send vita and at least three (3) letters of recommendation, clearly indicating the position being applied for, to: Appointments Committee; Dept. of Mathematics, Statistics, and Computer Science; University of Illinois at Chicago; 851 S. Morgan (m/c 249); Box R; Chicago, IL 60607. Applications through mathjobs.org are encouraged. No email applications will be accepted. To ensure full consideration, materials must be received by December 31, 2007. However, we will continue considering candidates until all positions have been filled. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000165

UNIVERSITY OF ILLINOIS AT CHICAGO
Department of Mathematics, Statistics, and Computer Science

The department has active research programs in centrally important areas of pure mathematics, computational and applied mathematics, combinatorics and mathematical computer science, statistics, and mathematics education. See http://www.math.uic.edu for more information.

Applications are invited for the following positions, effective August 16, 2008, subject to budgetary approval.

Tenure-track positions. Candidates in all areas of interest to the department will be considered. The position is at the assistant professor level. Applicants must have a Ph.D. or equivalent degree in mathematics, computer science, statistics, mathematics education or related field, an outstanding research record, and evidence of strong teaching ability. The salary is negotiable.

Send vita and at least three (3) letters of recommendation, clearly indicating the position being applied for, to: Appointments Committee; Dept. of Mathematics, Statistics, and Computer Science; University of Illinois at Chicago; 851 S. Morgan (m/c 249); Box T; Chicago, IL 60607. Applications through mathjobs.org are encouraged. No email applications will be accepted. To ensure full consideration, materials must be received by November 16, 2007. However, we will continue considering candidates until all positions have been filled. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000166

INDIANA

UNIVERSITY OF NOTRE DAME
Department of Mathematics
Notre Dame NSF-SUMR Instructorship in Mathematics

The Department of Mathematics of the University of Notre Dame invites applications from recent doctorates (since 2005) for the position of Notre Dame NSF-SUMR instructor in mathematics. Candidates in any specialty compatible with the research interests of the department will be considered. The position is for a term of three years beginning August 22, 2008; it is not renewable and is not tenure-track. The teaching load is one course per semester. Additional duties include mentoring of honors mathematics majors, and applicants should provide evidence of prior experience mentoring undergraduates. The salary will be competitive with those of distinguished instructorships at other AMS Group I universities, and the position includes $10,000 per year of summer research support for each of the first two summers. The position is associated with the department's recent successful five-year NSF grant in the program "Mentoring Through Critical Transition Points". Applications, including a curriculum vitae and a completed AMS standard cover sheet, should be filed through MathJobs (http://www.MathJobs.org). Applicants should also arrange for at least three letters of recommendation to be submitted through the MathJobs system. These letters should address the applicant's research accomplishments and supply evidence that the applicant has the ability to communicate articulately and teach effectively. Notre Dame is an Equal Opportunity Employer, and we particularly welcome applications from women and minority candidates. The evaluation of candidates will begin December 1, 2007. Information about the department is available at http://math.nd.edu.

000100

UNIVERSITY OF NOTRE DAME
NOTRE DAME, IN 46556
Department of Mathematics

The Department of Mathematics of the University of Notre Dame invites applications from recent doctorates (since 2007) in mathematical logic for a postdoctoral position. Candidates in any area of mathematical logic compatible with the research interests of the logicians in the department will be considered. The position is contingent upon the availability of funding and, if funded, will extend for a term of three years beginning August 22, 2008. It is not renewable and is not tenure-track; the teaching load is one course per semester. The salary will be competitive with those of distinguished instructorships at other AMS Group I universities, and the position includes summer research support for each of the first two summers and some discretionary funding each year. Applications, including a curriculum vitae and a completed AMS standard cover sheet, should be filed through MathJobs (http://www.MathJobs.org). Applicants should also arrange for at least three letters of recommendation to be submitted through the MathJobs system. These letters should address the applicant's research accomplishments and supply evidence that the applicant has the ability to communicate articulately and teach effectively. Notre Dame is an Equal Opportunity Employer, and we particularly welcome applications from women and minority candidates. The evaluation of candidates will begin December 1, 2007. Information about the department is available at http://math.nd.edu.

000106

IOWA

THE UNIVERSITY OF IOWA
Department of Mathematics

The Department of Mathematics at the University of Iowa invites applications for the following positions: (i) A tenure-track assistant professorship, starting in August 2008, in the area, broadly defined, of computational and mathematical biol-

ogy. Selection will be based on evidence of outstanding research accomplishments or potential and excellent teaching. (ii) A tenure-track assistant professorship, starting in August 2008, in the areas, broadly defined, of algebra and geometric analysis. Selection will be based on evidence of outstanding research accomplishments or potential and excellent teaching. (iii) Two or more three-year visiting assistant professorships, including one VIGRE postdoctoral associate positions, starting in August 2008. These positions are open as to research area but preference will be given to applicants whose scholarly activity is of particular interest to current faculty members. Selection will be based on excellent research accomplishments or potential, and excellent teaching. These positions carry a reduced teaching load. (iv) One or more visiting positions for all or part of the 2008-2009 academic year. Preference will be given to applicants whose scholarly activity is of particular interest to current faculty members. Selection will be based on research expertise and teaching ability. Assignment to rank will be commensurate with qualifications. A Ph.D. or equivalent is required for these positions. Screening of applications will begin December 15, 2007. Applications will be accepted until the position is filled. To apply, please submit applications and all supporting materials electronically through http://www.mathjobs.org. No paper submission is needed. Candidates who cannot submit electronically may submit their applications to the address below. Applications must include the following: a completed AMS cover sheet, a cover letter, a complete vita, three letters of recommendation, a research statement and a teaching statement. Reference letter writers should be asked to submit their letters online through http://mathjobs.org. If they are unable to do so, they may send their letters to the address below:

Professor Yi Li, Chair
Department of Mathematics
The University of Iowa
Iowa City, Iowa 52242-1419

The University of Iowa is an Equal Opportunity/Affirmative Action Employer. The department and the College of Liberal Arts and Sciences are strongly committed to gender and ethnic diversity; the strategic plans of the university, college and department reflect this commitment. Applications from women and minorities are strongly encouraged. For further information about the department see http://www.math.uiowa.edu.

000151

KANSAS

KANSAS STATE UNIVERSITY
Department of Mathematics

Subject to budgetary approval, applications are invited for tenure-track positions at the assistant professor rank; positions commence August 10, 2008, with salary commensurate with qualifications. A Ph.D. in mathematics is required and preference will be given to candidates with some postdoctoral experience. The department seeks candidates whose research interests mesh well with current faculty. The department has research groups in the areas of algebra, analysis, differential equations, geometry/topology, and number theory. Successful candidates should have strong research credentials as well as strong accomplishment or promise in teaching and should demonstrate a strong commitment to mentoring students, and to serving a diverse population. Applicants must submit the following: a letter of application, curriculum vita, outline of teaching philosophy, and a statement of research objectives. Four letters of reference, at least one of which addresses the applicant's teaching ability and potential, should be sent to: Louis Pigno, Department of Mathematics, Cardwell Hall 138, Kansas State University, Manhattan, KS 66506. Offers may begin by December 1, 2007, but applications for positions will be reviewed until February 1, 2008, or until positions are closed. Kansas State University is an Equal Opportunity Employer and actively seeks diversity among its employees.

000170

KANSAS STATE UNIVERSITY
Department of Mathematics

Subject to budgetary approval, applications are invited for one or more visiting assistant professorships commencing August 10, 2008. These will be annual appointments with the possibility of two subsequent one-year appointments depending on performance, funding, and need for services. A Ph.D. in mathematics or a Ph.D. dissertation accepted with only formalities to be completed is required by the time of appointment. The department seeks candidates whose research interests mesh well with current faculty. The department has research groups in the areas of algebra, analysis, differential equations, geometry/topology, and number theory. Preference will be given to candidates with strong research credentials who have a strong commitment to and demonstrable excellence in teaching undergraduate and graduate courses, mentoring students, and to serving a diverse population. Successful candidate(s) will be expected to participate in the department's REU and graduate research program. Applicants must submit the following: a letter of application, curriculum vita, outline of teaching philosophy, and a statement of research objectives. Four letters of reference, at least one of which addresses the applicant's teaching ability, should be sent to: Louis Pigno, Department of Mathematics, Cardwell Hall 138, Kansas State University, Manhattan, KS 66506. Applications will be reviewed beginning December 1, 2007, and continue until positions are closed. Kansas State University is an Equal Opportunity Employer and actively seeks diversity among its employees.

000171

MAINE

COLBY COLLEGE
Mathematics Department

The Department of Mathematics at Colby College invites applications for a one-year sabbatical replacement position in mathematics at the assistant professor or instructor level, beginning September 1, 2008. Ph.D. in mathematics preferred; A.B.D. considered. Five course teaching load. Evidence of exceptional teaching ability is required. The ability to teach a course in the history of mathematics is desirable but not required.

Send curriculum vitae, a statement on teaching and research, and three letters of recommendation (all in hard copy) to: Mathematics Search Chair, Department of Mathematics, Colby College, 5830 Mayflower Hill, Waterville, ME 04901. We cannot accept applications in electronic form. Review of applications will begin on January 15, 2008, and will continue until the position is filled.

Colby is a highly selective liberal arts college located in central Maine. The college is a three-hour drive north of Boston and has easy access to lakes, skiing, the ocean, and other recreational and cultural activities. For more information about the position and the department, visit our website at http://www.colby.edu/math.

Colby is an Equal Opportunity/Affirmative Action Employer, committed to excellence through diversity, and strongly encourages applications and nominations of persons of color, women, and members of other underrepresented groups. For more information about the college, please visit the Colby website at: http://www.colby.edu.

000149

MARYLAND

JOHNS HOPKINS UNIVERSITY
Department of Mathematics

Subject to availability of resources and administrative approval, the Department of Mathematics solicits applications for two non-tenure-track J. J. Sylvester Assistant Professors for the 2008-2009 academic year. The J. J. Sylvester Assistant Professorship is a three-year position offered to recent Ph.D.'s with outstanding research potential. Candidates in all areas of pure mathematics, including analysis, mathematical physics, geometric analysis, complex and algebraic geometry, number

theory, and topology are encouraged to apply. The teaching load is three courses per academic year. To submit your applications go to http://www.mathjobs.org/jobs/jhu. Applicants are strongly advised to submit their other materials electronically at this site. If you do not have computer access, you may mail your application to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218, and should include a vita, at least four letters of recommendation of which one concerns teaching, and a description of current and planned research. Write to: math@math.jhu.edu for questions concerning these positions. Applications received by November 16, 2007, will be given priority. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

000052

JOHNS HOPKINS UNIVERSITY
Department of Mathematics

Subject to availability of resources and administrative approval, the Department of Mathematics solicits applications for two tenure-track assistant professors for the 2008-2009 academic year. The assistant professorship is a three-year position. Candidates in all areas of pure mathematics, including analysis, mathematical physics, geometric analysis, complex and algebraic geometry, number theory, and topology are encouraged to apply. The teaching load is three courses per academic year. To submit your applications go to http://www.mathjobs.org/jobs/jhu. Applicants are strongly advised to submit their other materials electronically at this site. If you do not have computer access, you may mail your application to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218, and should include a vita, at least four letters of recommendation of which one concerns teaching, and a description of current and planned research. Write to: math@math.jhu.edu for questions concerning these positions. Applications received by November 16, 2007, will be given priority. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

000053

UNITED STATES NAVAL ACADEMY
Mathematics Department

The USNA Mathematics Department anticipates at least one tenure-track position (subject to approval and funding) at the assistant professor level to start in August 2008. See website http://www.usna.edu/MathDept/website/Hire.htm for full information. Tel: 410-293-6701; Fax: 410-293-4883; email: chm@usna.edu. The United States Naval Academy is an Affirmative Action/Equal Employment Opportunity Employer and provides reasonable accommodations to applicants with disabilities.

000173

MASSACHUSETTS

BOSTON COLLEGE
Department of Mathematics

The Department of Mathematics at Boston College invites applications for a postdoctoral position beginning September 2008. 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 geometry, topology, number theory, representation theory or cognate 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 2007. Applications must include a cover letter, description of research plans, curriculum vitae, and four letters of recommendation, with one addressing the candidate's teaching qualifications. Applications received no later than January 1, 2008, will be assured our fullest consideration. Please submit all application materials through MathJobs.org. If necessary, printed materials may otherwise be sent to: Search Committee, Department of Mathematics, Boston College, Chestnut Hill, MA 02467-3806. Applicants may learn more about the department, its faculty and its programs at http://www.bc.edu/math. Electronic inquiries concerning this position may be directed to math-search@bc.edu. Boston College is an Affirmative Action/Equal Opportunity Employer. Applications from women, minorities and individuals with disabilities are encouraged.

000120

CLARK UNIVERSITY
Department of Mathematics and Computer Science
Assistant Professor of Statistics

The department of Mathematics and Computer Science at Clark University invites applications for a tenure track Assistant Professor in Statistics starting Fall, 2008. Review of applications will begin on December 15, 2007. Candidates are expected to have a Ph.D. in Statistics or closely related field at the time of appointment. They must demonstrate excellence in research with strong interests in applied interdisciplinary/interdepartmental collaboration. Candidates must also have a commitment to teaching excellence, with an ability to design and teach a variety of courses in Statistics, including an elementary course for Environmental Science majors. Additional information on the department and the university is available at: http://www.math.clarku.edu. To apply, please send CV, detailed statements of professional experience including research and teaching interests, and names of at least three references, at least one of which should comment on teaching, to mathsearch@clarku.edu. AA/EOE. Minorities and women are strongly encouraged to apply.

000158

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics

The Mathematics Department at MIT is seeking to fill positions at the level of assistant professor or higher for September 2008. Appointments are based on exceptional research contributions in pure mathematics. Appointees will be expected to fulfill teaching duties and pursue their own research program. We request that applications and other materials, including (a) curriculum vitae, (b) research description, and (c) three letters of recommendation, be submitted online at: http://www.mathjobs.org. Applications should be complete by **December 1, 2007**, to receive full consideration. We request that your letters of reference be submitted by the reviewers online via mathjobs. We will also accept recommendations either as PDF attachments sent to: kimm@math.mit.edu, or as paper copies mailed to: Pure Mathematics Committee, Room 2-263, Department of Mathematics, MIT, 77 Massachusetts Ave., Cambridge, MA 02139-4307. Please do not mail or email duplicates of items already submitted via mathjobs.

MIT is an Equal Opportunity, Affirmative Action Employer.

000082

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics
C. L. E. Moore Instructorships in Mathematics

These positions for September 2008 are open to mathematicians who show definite promise in research. Appointees will be expected to fulfill teaching duties and pursue their own research program. We request that applications and other materials, including (a) curriculum vitae, (b) research description, and (c) three letters of recommendation, be submitted online at: http://www.mathjobs.org. Applications should be complete by **December 1, 2007**, to receive full consideration. We request that your letters of reference be submitted by the reviewers online via

mathjobs. We will also accept recommendations either as PDF attachments sent to: kimm@math.mit.edu, or as paper copies mailed to: Pure Mathematics Committee, Room 2-263, Department of Mathematics, MIT, 77 Massachusetts Ave., Cambridge, MA 02139-4307. Please do not mail or email duplicates of items already submitted via mathjobs.

MIT is an Equal Opportunity, Affirmative Action Employer.

000083

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics
Applied Mathematics

The applied mathematics group at MIT is seeking to fill combined teaching and research positions at the level of instructor, assistant professor or higher, beginning September 2008. Appointments are mainly based on exceptional research qualifications. Candidates in all areas of applied mathematics, including physical applied mathematics, computational molecular biology, numerical analysis, scientific computation, and theoretical computer science will be considered. Current activities of the group include: combinatorics, operations research, theory of algorithms, numerical analysis, astrophysics, condensed matter physics, computational physics, fluid dynamics, geophysics, nonlinear waves, theoretical and computational molecular biology, material sciences, quantum computing and quantum field theory, but new hiring may involve other areas as well.

We request that applications and other materials, including (a) curriculum vitae, (b) research description, and (c) three letters of recommendation, be submitted online at: http://www.mathjobs.org, and preferably well in advance of our deadline of **January 1, 2008**, since we will begin our deliberations in December. We request that your letters of reference be submitted by the reviewers online via mathjobs. We will also accept recommendations either as PDF attachments sent to: applied@math.mit.edu, or as paper copies mailed to: Applied Mathematics Committee, Room 2-345, Department of Mathematics, MIT, 77 Massachusetts Ave., Cambridge, MA 02139-4307. Please do not mail or email duplicates of items already submitted via mathjobs.

MIT is an Equal Opportunity, Affirmative Action Employer.

000084

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics: Statistics

The Department of Mathematics at MIT is seeking to fill combined teaching and research positions at the level of instructor, assistant professor, or higher in STATISTICS or APPLIED PROBABILITY beginning September 2008. Appointments are mainly based on exceptional research qualifications. We request that applications and other materials, including (a) curriculum vitae, (b) research description, and (c) three letters of recommendations, be submitted online at: http://www.mathjobs.org. Applications should be complete by **January 1, 2008**, to receive full consideration. We request that your letters of reference be submitted by the reviewers online via mathjobs. We will also accept recommendations either as PDF attachments sent to: kimm@math.mit.edu, or as paper copies mailed to: Committee on Statistics, Room 2-263, Department of Mathematics, MIT, 77 Massachusetts Ave., Cambridge, MA 02139-4307. Please do not mail or email duplicates of items already submitted via mathjobs.

MIT is an Equal Opportunity, Affirmative Action Employer.

000085

WILLIAMS COLLEGE
Department of Mathematics

The Williams College Department of Mathematics and Statistics invites applications for one tenure-track position in mathematics, beginning fall 2008, 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 and research, and who will have a Ph.D. by the time of appointment.

Williams College is a private, 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. In addition to excellence in teaching, an active and successful research program is expected.

To apply, please send a vita and have three letters of recommendation on teaching and research sent to the Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluation of applications will begin on or after November 15 and will continue until the position is filled. Williams College is dedicated to providing a welcoming intellectual environment for all of its faculty, staff, and students; as an EEO/AA employer, Williams especially encourages applications from women and minorities. For more information on the Department of Mathematics and Statistics, visit http://www.williams.edu/Mathematics.

000124

WILLIAMS COLLEGE
Department of Mathematics and Statistics

Williams College, Department of Mathematics and Statistics invites applications for a newly authorized visiting position in mathematics for the 2008-2009 year, at the rank of assistant professor. A Ph.D. is required. Send a vita and three letters of recommendation on teaching and research to: Visitor Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Consideration of applications will begin on November 15th and continue until the position is filled. Williams College is dedicated to providing a welcoming intellectual environment for all of its faculty, staff, and students; as an AA/EOE employer, Williams especially welcomes applications from women and minority candidates.

000167

WORCESTER POLYTECHNIC INSTITUTE
Mathematical Sciences

The Worcester Polytechnic Institute (WPI) Department of Mathematical Sciences invites applications for a Visiting Assistant Professorship position in applied mathematics to begin in the fall of 2008, in the areas compatible with the research interests in the department: partial differential equations with applications in continuum mechanics and composite materials, computational modeling and simulation, mathematical biology, financial mathematics, numerical analysis, optimization, control theory, applied probability, and discrete mathematics.

An earned Ph.D. or equivalent degree is required. Successful candidates must demonstrate strong research potential and evidence of quality teaching, and will be expected to contribute to the department's research activities and to its innovative, project-based educational programs.

Appointments will be made for one year, with possible renewal contingent upon satisfactory teaching and research, at the discretion of WPI and the appointee. The teaching load will be a combination seven-week undergraduate courses or semester-long graduate courses, to a total of five.

WPI is a private and highly selective technological university with an enrollment of 2,800 undergraduates and 1,100 full- and part-time graduate students. Worcester, New England's third largest city, offers ready access to the diverse economic, cultural and recreational resources of the region.

The Mathematical Sciences Department has 25 tenured/tenure-track faculty and supports BS, MS, and Ph.D. programs in applied and computational mathematics and applied statistics. Interactions with industry, business, and government are

facilitated by the Center for Industrial Mathematics and Statistics. For additional information, see http://www.wpi.edu/+math.

Qualified applicants should send a curriculum vitae, a statement of specific teaching and research objectives, and three letters of recommendation at least one of which addresses teaching potential, to Math Search Committee, Mathematical Sciences Department, WPI, 100 Institute Road, Worcester, MA 01609-2280, USA.

Applicants will be considered on a continuing basis beginning January 1, 2008, until the position is filled.

To enrich education through diversity, WPI is an Affirmative Action, Equal Opportunity Employer.

000155

MICHIGAN

MICHIGAN TECHNOLOGICAL UNIVERSITY
Department of Mathematical Sciences
Tenure-track Faculty Position in Statistics and Probabiiity

Applications are invited for one or more tenure-track positions in statistics and probability. Areas of particular interest are statistical genetics, biostatistics, survival analysis, computational statistics, and applied probability. Appointment is anticipated at the rank of assistant professor, although highly qualified candidates may be considered for appointment at the rank of associate professor. The Department of Mathematical Sciences has 7 statistics faculty (35 faculty total) and offers BS, MS and Ph.D. programs in statistics. Faculty are expected to develop and maintain strong research programs, direct graduate students in their thesis research, seek external funding, and be dedicated to excellence in teaching and education. Teaching loads are very competitive. The position starts 18 August 2008, and candidates must complete all requirements for the Ph.D. in statistics, mathematics, or a related field by that date. Review of applications will begin December 1, 2007, and continue until the position is filled. Qualified individuals should submit a letter of application, a curriculum vitae, a description of proposed research program, a statement of teaching interests, and arrange to have at least three letters of recommendation sent to: Search Committee, Statistics and Probability Position, Department of Mathematical Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931-1295 or to mathdept@mtu.edu (electronic submissions in PDF format are encouraged). Michigan Technological University is an Equal Opportunity Educational Institution/Equal Opportunity Employer/Affirmative Action Employer.

000142

NEBRASKA

UNIVERSITY OF NEBRASKA-LINCOLN
Department of Mathematics

Applications are invited for two tenure-track and two postdoctoral positions in mathematics, starting in August, 2008, as follows: 1. Hitz Research Assistant Professors. (Requisition #070738) Two three-year (non-tenure-track) positions in mathematics. 2. Analysis. (Requisition #070740) One tenure-track assistant professor position in modern analysis. 3. Teacher Education. (Requisition #070737) One tenure-track position (assistant, associate, or full professor rank) in mathematics with emphasis in the mathematical education of teachers.

First review of applications will begin on December 7, 2007. Successful candidates for each position should have a Ph.D. in mathematics and outstanding potential for research and teaching in mathematics. Applicants should submit a letter of application, a CV, statements addressing their research and teaching, and at least three letters of reference, at least one of which should address teaching, to: Search Committee Chair (position title), Department of Mathematics, University of Nebraska-Lincoln, Lincoln, NE 68588-0130. To be considered for the position, applicants must complete the Faculty/Administrative Information Form at: http://employment.unl.edu, (appropriate requisition #). For more information see the department's website: http://www.math.unl.edu. The University of Nebraska is committed to a pluralistic campus community through affirmative action and equal opportunity and is responsive to the needs of dual career couples. We assure reasonable accommodation under the Americans with Disabilities Act; contact Marilyn Johnson at (402) 472-8822 for assistance.

000148

NEW HAMPSHIRE

DARTMOUTH COLLEGE
John Wesley Young Research Instructorship

The John Wesley Young Instructorship is a postdoctoral, two- to three-year appointment intended for promising Ph.D. graduates with strong interests in both research and teaching and whose research interests overlap a department member's. Current research areas include applied mathematics, combinatorics, geometry, logic, non-commutative geometry, number theory, operator algebras, probability, set theory, and topology. Instructors teach four ten-week courses distributed over three terms, though one of these terms in residence may be free of teaching. The assignments normally include introductory, advanced undergraduate, and graduate courses. Instructors usually teach at least one course in their own specialty. This appointment is for 26 months with a monthly salary of $4,667 and a possible 12 month renewal. Salary includes two-month research stipend for instructors in residence during two of the three summer months. To be eligible for a 2008–2011 instuctorship, candidate must be able to complete all requirements for the Ph.D. degree before September 2008. Applications may be obtained at http://www.math.dartmouth.edu/recruiting/ or http://www.mathjobs.org—Position ID: 237-JWY. General inquiries can be directed to Annette Luce, Department of Mathematics, Dartmouth College, 6188 Kemeny Hall, Hanover, New Hampshire 03755-3551. At least one referee should comment on applicant's teaching ability; at least two referees should write about applicant's research ability. Applications received by January 5, 2008, receive first consideration; applications will be accepted until position is filled. Dartmouth College is committed to diversity and strongly encourages applications from women and minorities.

000142

NEW JERSEY

RUTGERS UNIVERSITY, CAMDEN
Department of Mathematical Sciences
Joseph and Loretta Lopez Endowed Chair in Mathematics

Applications and nominations are invited for the Joseph and Loretta Lopez Chair in Mathematics. The department seeks a distinguished scholar in mathematics with international reputation, well-established research and teaching record, and demonstrated ability to generate external funding. This endowed chair is the first at the Camden Campus of Rutgers University. It is a tenured faculty position and the chair is for a 5-year renewable term. The holder of this chair will be a senior faculty member and a vigorous participant in the research, instruction, and service work of the Department of Mathematical Sciences. The holder will also be expected to play a vital role in the campus' growing program in computational biology and the recently established Center for Computational and Integrative Biology. As such, applicants must demonstrate evidence of research in the areas of mathematical and/or computational biology.

The appointment will commence on September 1, 2008, and is at the rank of associate or full professor. The department will begin reviewing applications on December 17 and continue its review until the position is filled. Applications should be sent to:

Professor Gabor Toth
Chair, Search Committee
Department of Mathematical Sciences

Rutgers University, Camden
Camden, New Jersey, 08102

Applicants should also arrange for at least four letters of recommendation to be sent.

Rutgers University, Camden, is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minority-group members.

000153

NEW YORK

THE COURANT INSTITUTE
Department of Mathematics

The Courant Institute Department of Mathematics anticipates having a small number of faculty positions in mathematics to begin in September 2008. Appointments may be made at either a junior or senior level. These positions will be in a range of areas in computational, applied and pure mathematics; two particular areas of interest are computational statistics and atmosphere ocean science. Some may be multidisciplinary appointments that are joint with a science department from the Faculty of Arts and Sciences. Applications and supporting documents should be received by January 4th, 2008. For more information please visit http://www.math.nyu.edu/jobs/.

The Courant Institute/New York University is an Equal Opportunity/Affirmative Action Employer.

000109

THE COURANT INSTITUTE
Department of Mathematics

The Courant Institute is a center for advanced training and research in the mathematical sciences. It has long been an international leader in mathematical analysis, differential geometry, probability theory, applied mathematics, and scientific computation, with special emphasis on partial differential equations and their applications. Its scientific activities include an extensive array of research seminars and advanced graduate courses.

Each year a limited number of Courant Institute Instructorships in the Department of Mathematics are awarded to postdoctoral scientists. These appointments carry a light teaching load of one course per semester and ordinarily are for a three-year term. These positions are primarily for recent Ph.D.'s, and candidates must have a degree in mathematics or some affiliated field.

For more information please visit: http://www.math.nyu.edu/visiting_faculty. Applications and supporting documents are due by December 15th, 2007, for appointments to begin the following academic year.

The Courant Institute at New York University is an Equal Opportunity/Affirmative Action Employer.

000110

OKLAHOMA

THE UNIVERSITY OF OKLAHOMA
Department of Mathematics

Applications are invited for one full-time, tenure-track position in mathematics beginning 16 August 2008. The position(s) is initially budgeted at the assistant professor level, but an appointment at the associate professor level may be possible for an exceptional candidate with qualifications and experience appropriate to that rank. Normal duties consist of teaching two courses per semester, conducting research, and rendering service to the department, university, and profession at a level appropriate to the faculty member's experience. The position(s) requires an earned doctorate and research interests that are compatible with those of the existing faculty; preference will be given to applicants with potential or demonstrated excellence in research and prior successful undergraduate teaching experience. Salary and benefits are competitive. For full consideration, applicants should send a completed AMS cover sheet, curriculum vitae, a description of current and planned research, and have three letters of recommendation (at least one of which must address the applicant's teaching experience and proficiency) sent to:

Search Committee
Department of Mathematics
The University of Oklahoma
601 Elm, PHSC 423
Norman, OK 73019-0315
Phone: 405-325-6711;
fax: 405-325-7484;
email: search@math.ou.edu

Applications may also be submitted online through http://mathjobs.org.

Screening of applications will begin on December 15, 2007, and will continue until the position(s) is filled.

The University of Oklahoma is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

000162

PENNSYLVANIA

LEHIGH UNIVERSITY
Two Tenure-track Faculty Positions

The Lehigh Department of Mathematics seeks to hire an exceptional analyst for a tenure-track position at the assistant professor level. The candidate's research should enhance the department's strengths in analysis. Preference will be given to those working in stochastic or nonlinear differential equations, harmonic analysis, or random matrices. A successful candidate should demonstrate great research potential, and have a record of successful teaching commensurate with the position. Applicants with postdoctoral experience are strongly encouraged to apply and applications from new and recent Ph.D.'s are welcome.

The Lehigh University Department of Mathematics also seeks to hire a tenure-track assistant professor specializing in mathematical statistics or probability. The candidate's research should enhance the department's existing strengths in these areas. A candidate with a specialty in probability should be capable of teaching advanced courses in statistics. A successful candidate will demonstrate both outstanding research and teaching potential.

The College of Arts and Sciences at Lehigh is especially interested in qualified candidates who can contribute, through their research, teaching, and/or service, to the diversity and excellence of the academic community.

As part of their application, candidates should submit: (a) an AMS cover sheet; (b) a complete vita, including a list of publications; (c) a research plan; (d) a statement of teaching philosophy; and (e) at least four letters of recommendation, at least one of which addresses the candidate's teaching.

Applications received by November 15, 2007, will be assured of full consideration. Application materials should be sent to:

Analysis Hiring Committee
or
Statistics Hiring Committee
Department of Mathematics
Lehigh University
Bethlehem, PA 18015-3174

Lehigh University is an Equal Opportunity Affirmative Action Employer. Lehigh University provides comprehensive benefits including partner benefits.

For more information see our website http://www.lehigh.edu/~math.

000143

UNIVERSITY OF PITTSBURGH
Department of Mathematics
Representation Theory/Algebraic Geometry/
Number Theory/Combinatorics

The Mathematics Department of the University of Pittsburgh invites applications for a tenure-track or tenured position in representation theory/algebraic geometry/number/theory/combinatorics to begin in the fall term 2008, pending budgetary approval. The appointment is at the assistant professor level or above, depending on the credentials of the applicant. We seek excellence in teaching and research so applicants should demonstrate substantial research accomplish-

ment and dedication to teaching. Send a vita, three letters of recommendation, a research statement, and evidence of teaching accomplishments to: Search Committee in Algebra, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. Review of completed files will begin on November 30, 2007, and continue until the position is filled. The University of Pittsburgh is an Affirmative Action, Equal Opportunity Employer. Women and members of minority groups underrepresented in academia are especially encouraged to apply.

000116

UNIVERSITY OF PITTSBURGH
Department of Mathematics
Probability, Stochastic Analysis, Mathematical Finance

The Mathematics Department of the University of Pittsburgh invites applications for a tenure-track in probability, stochastic analysis, or mathematical finance to begin in the fall term 2008, pending budgetary approval. The appointment is at the assistant professor level. We seek excellence in teaching and research so applicants should demonstrate substantial research accomplishment and dedication to teaching. Send a vita, three letters of recommendation, a research statement, and evidence of teaching accomplishments to: Search Committee in Probability, Stochastic Analysis, aand Mathematical Finance, Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260. Review of completed files will begin on November 30, 2007, and continue until the position is filled. The University of Pittsburgh is an Affirmative Action, Equal Opportunity Employer. Women and members of minority groups underrepresented in academia are especially encouraged to apply.

000117

RHODE ISLAND

UNIVERSITY OF RHODE ISLAND
Assistant Professor, Mathematics

This is a tenure-track position in the Mathematics Department beginning Fall 2008.

Required: Ph.D. in mathematics or applied mathematics by June 2008; a research specialty in one of the following areas: difference equations, discrete dynamical systems, ergodic theory, mathematical biology, applied harmonic or numerical analysis, geometry, coding theory, cryptography, finite fields, probabilistic or algebraic methods in combinatorics; an ongoing research program and sustained record of high quality publications commensurate with experience; evidence of excellence in teaching, and commitment to undergraduate education; ability to contribute to our graduate research program and supervise Ph.D. students; demonstrated excellent English communication skills. Interest in innovative undergraduate teaching and interdisciplinary collaboration a plus. Visit our websites at `http://www.math.uri.edu` and `http://www.uri.edu/human_resources` for additional information. Submit (no emails or faxes, please) AMS Cover Sheet (preferred), cover letter, curriculum vitae, and at least three (3) letters of recommendation, one of which includes explicit appraisal of the candidate's teaching ability, postmarked by January 20, 2008, to: Nancy Eaton, Search Chair, (Req # 11954), UNIVERSITY OF RHODE ISLAND, P.O. Box G, Kingston, RI 02881. URI is an AA/EOD employer and values diversity and also is an NSF ADVANCE institutional transformation university, working to advance the careers of women faculty, especially in the science and engineering disciplines.

000152

TENNESSEE

UNIVERSITY OF TENNESSEE
Department of Mathematics

The Department of Mathematics of The University of Tennessee seeks to fill one tenure-track assistant professor position in differential geometry, including: geometric analysis, Riemannian geometry, geometric variational problems, and related evolution equations.

A Ph.D. is required. Some postdoctoral experience is desirable, though not required. Substantial research promise and dedication to excellent teaching are paramount. Employment begins August 1, 2008.

Applicants should arrange to have a vita, at least three reference letters, a research statement (including future plans and abstracts of finished papers), and evidence of quality teaching mailed to Differential Geometry Search, Department of Mathematics, The University of Tennessee, Knoxville, TN 37996-1300. Electronic application materials will not be accepted. Use of the AMS application form is appreciated. Review of applications will begin December 1, 2007, and will continue until the position is filled. Please see our website: `http://www.math.utk.edu` for information about the department.

The University of Tennessee is an EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA institution in the provision of its education and employment programs and services. All qualified applicants will receive equal consideration for employment without regard to race, color, national origin, religion, sex, pregnancy, marital status, sexual orientation, age, physical or mental disability, or covered veteran status.

000136

TEXAS

BAYLOR UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for a tenure-track position at the assistant professor level, starting in August 2008. Salary and benefits are competitive. Excellence in teaching and research is essential. Strong potential for obtaining extramural funding is desirable. Special consideration will be given to strong applicants with research interests in the general areas of analysis, topology, algebra, and numerical linear algebra. Exceptional scholars in any area of specialization are strongly encouraged to apply. An application must include a current curriculum vitae and statements describing interests and goals in research and in teaching. In addition, at least three recent letters of reference must be made available on `MathJobs.org` or be sent directly to the search committee. An applicant who has received the doctoral degree within the last four years is encouraged to include a copy of the doctoral transcript. Applications will be reviewed beginning November 1, 2007. To ensure full consideration, an application should be received by November 15, 2007, but applications will be accepted until the position is filled or the search is terminated. Baylor University has approximately 14,000 students. The department has 30 faculty members and offers B.A., B.S., M.S., and Ph.D. degrees. The university provides generous benefits including tuition remission for qualified family members. Please visit the Baylor websites: `http://www.baylor.edu` and `http://www.baylor.edu/math/` for further information about the university and the department. Baylor University is affiliated with the Baptist General Convention of Texas. As an Affirmative Action/Equal Employment Opportunity Employer, Baylor encourages minorities, women, veterans, and persons with disabilities to apply. Applicants are encouraged to submit all application materials online through `MathJobs.org` via the URL: `http://www.mathjobs.org/jobs`. Alternatively, send all materials to: Mathematics Search Committee, Baylor University, One Bear Place #97328, Waco, TX 76798-7328; email: `Math_Search@baylor.edu`.

000091

BAYLOR UNIVERSITY
Department of Mathematics

The Department of Mathematics invites applications for a postdoctoral position, starting in August 2008. This position may be renewable annually to a maximum of three years and is not a tenure-track position. Customarily, the teaching load is two three-hour courses each semester. Salary and benefits are competitive. Excellence in teaching and research is essential.

The department seeks candidates whose research interests are compatible with those of current faculty. Active research areas in the department are in the general areas of algebra, analysis, differential equations, mathematical physics, numerical analysis, representation theory, and topology. An application must include a current curriculum vitae and statements describing interests and goals in research and in teaching. In addition, at least three recent letters of reference must be made available on MathJobs.org or be sent directly to the search committee. An applicant who has received the doctoral degree within the last four years is encouraged to include a copy of the doctoral transcript. Applications will be reviewed beginning November 1, 2007. To ensure full consideration, an application should be received by November 15, 2007, but applications will be accepted until the position is filled or the search is terminated. Baylor University has approximately 14,000 students. The department has 30 faculty members and offers B.A., B.S., M.S., and Ph.D. degrees. Please visit the Baylor websites: http://www.baylor.edu and http://www.baylor.edu/math/ for further information about the university and the department. Baylor University is affiliated with the Baptist General Convention of Texas. As an Affirmative Action/Equal Employment Opportunity Employer, Baylor encourages minorities, women, veterans, and persons with disabilities to apply. Applicants are encouraged to submit all application materials online through MathJobs.org via the URL: http://www.mathjobs.org/jobs. Alternatively, send all materials to: Mathematics Search Committee, Baylor University, One Bear Place #97328, Waco, TX 76798-7328; email: Math_Search@baylor.edu.

000092

TEXAS A&M UNIVERSITY- QATAR (TAMUQ)
Department of Mathematics

The Department of Mathematics expects to have several open positions at Texas A&M University's affiliate campus in Doha, State of Qatar (which is in the Middle East, next to Saudi Arabia). Texas A&M University at Qatar (TAMUQ) is a partnership with Qatar Foundation. Now entering its fifth year of operation, TAMUQ offers Bachelor of Science degrees in chemical, electrical and computer, mechanical, and petroleum engineering. The degree programs are identical to those of the main campus at College Station, Texas. A Texas A&M University diploma is awarded to graduates. A new, state-of-the-art engineering building for teaching and research has recently opened. General information about TAMUQ is available at their website: http://www.qatar.tamu.edu/.

The mathematics faculty provides classes in calculus, differential equations, linear algebra, numerical methods, mathematical modeling, and other related coursework, all of which form an integral part of the engineering curricula. Teaching loads are kept low (approximately two or three small classes per academic year) to promote teacher-student mentoring and to allow time for faculty to pursue research.

Any level of appointment will be considered depending on the qualifications of the applicant. It is anticipated that most appointments will be non-tenure accruing, with an initial appointment period of one year, which is renewable for additional years, subject to satisfactory performance. A Ph.D. degree is required for all professorial level appointments (the equivalent of an assistant professor or higher). Applicants with a masters degree and teaching experience will be considered for non-professorial positions (e.g., lecturer) for more elementary instruction (and a higher teaching load). Salary rates are competitive and, in general, average 30% higher than comparable salary rates of similar positions in the U.S. In addition, summer funding is guaranteed. Liberal allowances for professional travel and for relocation to Qatar are provided. Fringe benefits include free furnished housing in one of several gated communities, K-12 education for dependents, group health insurance, annual leave allowance, and a car allowance.

Applicants should send the completed "AMS Application Cover Sheet", a vita, and arrange to have at least three letters of recommendation sent to: TAMU-Qatar-Faculty Hiring, Department of Mathematics, Texas A&M University, College Station, Texas 77843-3368. Further information and a link to our online application form is available at: http://www.math.tamu.edu. At least one recommendation letter should address the candidate's teaching qualifications. The complete dossier should be received by January 15, 2008. Early applications are encouraged since applications will be reviewed as they are received.

Texas A&M University is an Equal Opportunity Employer. The university is dedicated to the goal of building a culturally diverse and pluralistic faculty and staff committed to teaching and working in a multicultural environment and strongly encourages applications from women, minorities, individuals with disabilities, and veterans. The university is responsive to the needs of dual career couples.

000163

THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Mathematics Austin, Texas 78712

Expected openings for Fall 2008 include: (a) Instructorships, some that have R.H. Bing Faculty Fellowships attached to them, and (b) possibly two or more positions at the tenure-track/tenure level.

(a) Instructorships at The University of Texas at Austin are postdoctoral appointments, renewable for two additional years. It is assumed that applicants for instructorships will have completed all Ph.D. requirements by August 18, 2008. Other factors being equal, preference will be given to those whose doctorates were conferred in 2007 or 2008. Candidates should show superior research ability and have a strong commitment to teaching. Consideration will be given only to persons whose research interests have some overlap with those of the permanent faculty. Duties consist of teaching undergraduate or graduate courses and conducting independent research. The projected salary is $43,000 for the nine-month academic year.

Each R.H. Bing Fellow holds an instructorship in the Mathematics Department, with a teaching load of two courses in one semester and one course in the other. The combined Instructorship-Fellowship stipend for nine-months is $52,000, which is supplemented by a travel allowance of $1,000. Pending satisfactory performance of teaching duties, the Fellowship can be renewed for two additional years. Applicants must show outstanding promise in research. Bing Fellowship applicants will automatically be considered for other departmental openings at the postdoctoral level, so a separate application for such a position is unnecessary.

Those wishing to apply for instructor positions are asked to send a vita and a brief research summary to the above address c/o Instructor Committee. Transmission of the preceding items via the Internet (URL: http://www.ma.utexas.edu/jobs/application) is encouraged.

(b) An applicant for a tenure-track or tenured position must present a record of exceptional achievement in her or his research area and must demonstrate a proficiency at teaching. In addition to the duties indicated above for instructors, such an appointment will typically entail the supervision of M.A or Ph.D. students. The salary will be commensurate with the level at which the position is filled and the qualifications of the person who fills it.

Those wishing to apply for tenure-track/tenured positions are asked to send a vita and a brief research summary to the above address, c/o Recruiting Committee. Transmission of the preceding items via the Internet (URL: http://www.ma.utexas.edu/jobs/application/TenureTrack) is encouraged.

All applications must be supported by three or more letters of recommendation, at least one of which speaks to the applicant's teaching credentials. The screening of applications will begin on December 1, 2007.

Background check will be conducted on the applicant selected. The University of

Texas at Austin is an Affirmative Action/ Equal Opportunity Employer.

000174

UNIVERSITY OF TEXAS
Department of Mathematics

The University of Texas at Tyler invites applications for the position of chair of the Department of Mathematics to begin fall 2008. The university seeks candidates who will energetically lead the department in continuing to build excellent undergraduate and graduate programs and will mentor faculty in teaching, research, and service.

The successful candidate will have a Ph.D. in mathematics, an outstanding record of teaching and research commensurate with a tenured faculty appointment, effective leadership, administrative, and interpersonal skills, and the ability to lead the faculty in obtaining external funding.

Located 90 miles east of Dallas in the beautiful piney woods of East Texas, The University of Texas at Tyler has an enrollment of about 6,100 students. The Department of Mathematics offers degrees at the undergraduate and graduate levels. For general information about The University of Texas at Tyler, visit http://www.uttyler.edu. The Department of Mathematics has a website at http://math.uttyler.edu.

Please submit (electronically as attachments, if possible) a letter of application, curriculum vitae, unofficial transcripts, a brief description of research plans, statement of teaching philosophy, statement of leadership philosophy, and names and email addresses of at least four references to Dr. Don Killebrew, Chair, Department of Mathematics Chair Search Committee, dkille@mail.uttyl.edu. Paper submissions can be sent to Department of Mathematics, The University of Texas at Tyler, 3900 University Blvd., Tyler, Texas 75799.

Review of applications will begin immediately and continue until the position is filled. Applicants must be prepared to furnish the university with proof of eligibility to work in the United States. UT Tyler is an Equal Employment Opportunity/Affirmative Action Employer.

000160

WASHINGTON

PACIFIC LUTHERAN UNIVERSITY
Department of Mathematics

We seek to fill one tenure-track assistant professorship in mathematics beginning September 2008. Candidates for this position must have a deep interest in mathematics education. A terminal degree in either mathematics education or mathematics is required as is evidence of exemplary teaching. For further information visit our website at: http://www.plu.edu/~humr/jobs/ or http://www.plu.edu/~math.

000172

WEST VIRGINIA

WEST VIRGINIA UNIVERSITY
Eberly College of Arts and Sciences
Department of Mathematics

The Department of Mathematics solicits applications and nominations for a clinical assistant professor to support its teaching mission and its research goals in mathematics education. This position is non-tenure-track but promotion-eligible. Promotion for clinical assistant professors is based primarily on significant contribution in teaching and service. The teaching assignment will be two or three courses per semester (approximately 40%-60% of the position). The balance of the assignment will be working with the department and the Institute for Math Learning to develop and oversee a support program for mathematics service courses through elementary differential equations. Components may include working with course coordinators to design and administer a homework feedback system, facilitating out-of-class review sessions and/or group discussions, training and mentoring teaching assistants, working with other learning centers on campus to coordinate math tutoring (e.g., exchange tutors, provide tutor training, etc.), and aiding in research on pedagogical issues and other scholarly work related to the success of support programs and teaching methods. This position requires a doctorate in mathematics or a related area completed by the time of appointment.

West Virginia University is a Research-High Activity University enrolling over 25,000 students. The Department of Mathematics has 25 full-time faculty members and approximately 30 M.S. and Ph.D. students. The university is located in Morgantown, an award-winning city with a metropolitan population of 80,000, diverse cultural and recreational opportunities, excellent medical facilities, and a favorable location.

Applicants should provide a letter of application that addresses the goals of the position, a statement of teaching philosophy, a vita, and three letters of reference. Please have documentation and letters of reference sent to:

Department of Math
P.O. Box 6310
West Virginia University
Morgantown, WV 26506-6310
IMLjob@math.wvu.edu.

Applications will be reviewed as they are received. Priority review will be given to applications received through January 15. Preferred starting date is August 16, 2008.

West Virginia University is an Equal Opportunity/Affirmative Action Employer. Minority, disabled, and women candidates are urged to apply.

000137

WISCONSIN

UNIVERSITY OF WISCONSIN-MILWAUKEE
Department of Mathematical Sciences

The Department of Mathematical Sciences, University of Wisconsin-Milwaukee (UWM), invites applications to fill one open rank faculty position in Actuarial Science. Starting date is August 2008.

The department is seeking an outstanding candidate with a Ph.D. in actuarial science, statistics or a closely related area, with research expertise and teaching interests in actuarial science. The ideal candidate will have or be actively working towards Associateship/Fellowship of the Society of Actuaries or Casualty Actuarial Society. The successful applicant is expected to develop and teach new courses in actuarial science and to pursue further academic, government, and industrial partnerships/funding in the Milwaukee-Madison-Chicago region.

Candidates for this position must have a strong research record and a demonstrated commitment to teaching excellence. Responsibilities include teaching two courses per semester and taking active roles in the undergraduate, Masters, and Ph.D. programs. A competitive compensation, benefits, and research start-up package is provided. Additional information is available at http://www.math.uwm.edu/.

To apply, send a cover letter, vita, research plan, statement of teaching philosophy, and three letters of recommendation (at least one should address candidate's teaching abilities) to the Chairperson at the above address. Applications must be postmarked by January 4, 2008.

UW-Milwaukee is an AA/EEO employer and educator strongly committed to maintaining a climate supporting equality of opportunity and respect for difference based on gender, culture, ethnicity, disability, sexual orientation, marital status, race, color, religion, national origin or ancestry, age, and lawful activities. We particularly encourage applications from individuals who would enhance and diversify our workforce.

000168

CANADA

UNIVERSITY OF TORONTO
Department of Mathematics

The Department of Mathematics at the University of Toronto anticipates faculty

openings at various levels of seniority over the next several years, including:

COXETER ASSISTANT PROFESSORSHIPS and POSTDOCTORAL FELLOWSHIPS: The department invites applications for Coxeter Assistant Professorships (non-tenure stream) and Postdoctoral Fellowships (Code: CAP). Applicants must demonstrate strength in teaching and significant research promise. The appointments are effective July 1, 2008, and are contractually-limited term appointments for a term of up to three years. Preference will be given to recent Ph.D.'s whose applications are received by December 15, 2007.

TENURE-STREAM POSITIONS: The department anticipates having a number of tenure-stream positions over the next several years. Applicants must demonstrate excellent accomplishments and outstanding promise in research and strong commitment to graduate and undergraduate teaching. Preference will be given to researchers in the areas of Analysis (Code: ANA), Algebraic Geometry (Code: ALG), and Applied Mathematics/Scientific Computation (Code: APM). However, exceptional candidates in all fields of pure or applied mathematics are encouraged to apply (Code: OTHER). The possibility also exists for a joint position between the Departments of Mathematics and Computer Science (Code: CSM). Preference will be given to applications received by November 15, 2007.

Application material for all positions must include the candidate's Curriculum Vitae and list of publications. Applicants must arrange for a minimum of four letters of reference to be provided to the department, at least one of which primarily addresses the candidate's teaching. Candidates are encouraged to supply a cover letter specifying the code of the position(s) for which they wish to apply and specifying whether the candidate is a Canadian citizen / permanent resident. Candidates are also encouraged to supply a research statement, a teaching statement, and the AMS cover sheet. Online applications through http://www.|mathjobs.org/jobs| are preferred. Applications can alternately be sent directly to the Appointments Committee, Department of Mathematics, University of Toronto, 40 St. George Street, Room 6290, Toronto, Ontario M5S 2E4, Canada.

The University of Toronto offers the opportunity to teach, conduct research, and live in one of the most diverse cities in the world. The University of Toronto is strongly committed to diversity within its community and especially welcomes applicants from visible minority group members, women, Aboriginal persons, persons with disabilities, members of sexual minority groups, and others who may contribute to the further diversification of ideas. All qualified candidates are encouraged to apply; however, Canadian citizens and permanent residents will be given priority.

000146

ISRAEL

WEIZMANN INSTITUTE OF SCIENCE
Department of Mathematics

A number of fellowships for postdoctoral research in the fields of mathematics, applied mathematics and computer science, as well as a number of interdisciplinary areas including bioinformatics, neurosciences, computer vision and robotics will be offered by the Weizmann Institute of science. The deadlines for the submission of applications are January 5 and May 15, 2008. Additional information and application forms are available on the website http://www.weizmann.ac.il/feinberg or by writing to Postdoctoral Fellowship Program, Feinberg Graduate School, The Weizmann Institute of Science, Rehovot 76100, Israel; Fax: 972-8-934-4114.

000156

PORTUGAL

INSTITUTO SUPERIOR TÉCNICO
Departamento de Matemàtica, Center for Mathematical Analysis, Geometry, and Dynamical Systems

The Center for mathematical analysis, geometry, and dynamical systems of the department of mathematics of Instituto Superior Técnico, Lisbon, Portugal, invites applications for postdoctoral positions for research in mathematics, subject to budgetary approval. Positions are for one year, with the possibility of extension for a second year upon mutual agreement. Selected candidates will be able to take up their position between September 1, 2008, and January 1, 2009. Applicants should have a Ph.D. in mathematics preferably obtained after December 31, 2005. They must show very strong research promise in one of the areas in which the mathematics faculty of the center is currently active. There are no teaching duties associated with these positions. Applicants should send a curriculum vitae; reprints, preprints and/or dissertation abstract; description of research project (of no more than 1,000 words); and ask that three letters of reference are sent directly to the director. To insure full consideration, complete application packages should be received by January 15, 2008. Additional information about the Center and the positions is available at http://www.math.ist.utl.pt/cam/.

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SINGAPORE

NATIONAL UNIVERSITY OF SINGAPORE (NUS)
Department of Mathematics

The Department of Mathematics at the National University of Singapore (NUS) invites applications for tenured, tenure-track and visiting (including postdoctoral) positions at all levels, beginning in August 2008.

NUS is a research intensive university that provides quality undergraduate and graduate education. The Department of Mathematics, which is one of the largest in the university, has about 70 faculty members and teaching staff whose expertise cover major areas of contemporary mathematical research.

We seek promising scholars and established mathematicians with outstanding track records in any field of pure and applied mathematics. The department offers internationally competitive salaries with start-up grants for research. The teaching load is particularly light for young scholars, in an environment conducive to research with ample opportunities for career development.

Research areas which the department plans to expand in the near future include (but are not limited to): All areas of pure mathematics (especially analysis) financial mathematics, mathematical imaging, probability & stochastic analysis, scientific computing.

Application materials should be sent to:

Search Committee
Department of Mathematics
National University of Singapore
2 Science Drive 2, Singapore 117543
Republic of Singapore

In addition, applicants should submit electronically a PDF-file to search@math.nus.edu.sg. Inquiries may also be sent to this link.

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 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.

Review process will begin at the end of November and will continue until positions are filled. For further information about the department, please visit http://www.math.nus.edu.sg.

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Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices.* However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Wellington, New Zealand

Victoria University of Wellington

December 12–15, 2007

Wednesday – Saturday

Meeting #1034

First Joint International Meeting between the AMS and the New Zealand Mathematical Society (NZMS).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: June 2007
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

AMS Invited Addresses

Marston Conder, University of Auckland, *Chirality*.

Rodney G. Downey, Victoria University of Wellington, *Practical FPT and foundations of kernelization*.

Michael H. Freedman, Microsoft Research, *Physically motivated questions in topology: Manifold pairings*.

Bruce J. Kleiner, Yale University, *Bilipschitz embedding in Banach spaces*.

Gaven J. Martin, Massey University, *Curvature and dynamics*.

Assaf Naor, Microsoft Research/Courant Institute, *The story of the sparsest cut problem*.

Theodore A. Slaman, University of California Berkeley, *Effective randomness and continuous measures*.

Matthew J. Visser, Victoria University of Wellington, *Emergent spacetimes, rainbow geometries, and pseudo-Finsler geometries*.

AMS Special Sessions

Computability Theory, **Rodney G. Downey** and **Noam Greenberg**, Victoria University of Wellington, and **Theodore A. Slaman**, University of California Berkeley.

Dynamical Systems and Ergodic Theory, **Arno Berger**, University of Canterbury, **Rua Murray**, University of Waikato, and **Matthew J. Nicol**, University of Houston.

Geometric Numerical Integration, **Laurent O. Jay**, The University of Iowa, and **Robert McLachlan**, Massey University.

Group Theory, Actions, and Computation, **Marston Conder**, University of Auckland, and **Russell Blyth**, Saint Louis University.

History and Philosophy of Mathematics, **James J. Tattersall**, Providence College, **Ken Pledger**, Victoria

University of Wellington, and **Clemency Williams**, University of Canterbury.

Hopf Algebras and Quantum Groups, **M. Susan Montgomery**, University of Southern California, and **Yinhuo Zhang**, Victoria University of Wellington.

Infinite-Dimensional Groups and Their Actions, **Christopher Atkin**, Victoria University of Wellington, **Greg Hjorth**, University of California Los Angeles/University of Melbourne, **Alica Miller**, University of Louisville, and **Vladimir Pestov**, University of Ottawa.

Integrability of Continuous and Discrete Evolution Systems, **Mark Hickman**, University of Canterbury, and **Willy A. Hereman**, Colorado School of Mines.

Mathematical Models in Biomedicine, **Ami Radunskaya**, Pomona College, **James Sneyd**, University of Auckland, **Urszula Ledzewicz**, University of Southern Illinois at Edwardsville, and **Heinz Schaettler**, Washington University.

Matroids, Graphs, and Complexity, **Dillon Mayhew**, Victoria University of Wellington, and **James G. Oxley**, Louisiana State University.

New Trends in Spectral Analysis and Partial Differential Equations, **Boris P. Belinskiy**, University of Tennessee, Chattanooga, **Anjan Biswas**, Delaware State University, and **Boris Pavlov**, University of Auckland.

Quantum Topology, **David B. Gauld**, University of Auckland, and **Scott E. Morrison**, University of California Berkeley.

Special Functions and Orthogonal Polynomials, **Shaun Cooper**, Massey University, **Diego Dominici**, SUNY New Paltz, and **Sven Ole Warnaar**, University of Melbourne.

University Mathematics Education, **Patricia Cretchley**, University of Southern Queensland, **Derek Holton**, University of Otago, **William G. McCallum**, University of Arizona, and **Tim Passmore**, University of Southern Queensland.

Water-Wave Scattering Focusing on Wave-Ice Interactions, **Michael H. Meylan**, Massey University, and **Malte Peter**, University of Bremen.

San Diego, California

San Diego Convention Center

January 6–9, 2008

Sunday – Wednesday

Meeting #1035

Joint Mathematics Meetings, including the 114th Annual Meeting of the AMS, 91st 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: Michel L. Lapidus
Announcement issue of *Notices*: October 2007
Program first available on AMS website: November 1, 2007
Program issue of electronic *Notices*: January 2008
Issue of *Abstracts*: Volume 29, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/national.html`.

Program Updates

AMS-MAA Sessions

Grad School Fair, Tuesday, 9:30 a.m.–11:00 a.m. Here is the opportunity for undergrads to meet representatives from mathematical sciences graduate programs from universities all over the country. January is a great time for juniors to learn more, and college seniors may still be able to refine their search. This is your chance for one-stop shopping in the graduate school market.

The **AMS Committee on Science Policy-MAA Science Policy Committee Government Speaker** lecture on Tuesday has been cancelled.

AMS Sessions

Making Teacher Preparation Our Business, Tuesday, 1:00 p.m.–2:30 p.m., organized by **William G. McCallum**, The University of Arizona. Despite the existence of many excellent programs in teacher preparation, the problem of conducting such programs on the necessary scale remains unsolved. The panelists will consider how to make the preparation of teachers a core activity of mathematics departments, rather than a side activity conducted by specialized untenured staff or by tenured faculty with an idiosyncratic and fragile interest. Panelists include **Solomon Friedberg**, Boston College; **Theodore W. Gamelin**, University of California Los Angeles; **James Lewis**, University of Nebraska; and **Magnhild Lien**, California State University, Northridge. This panel is sponsored by the Committee on Education.

Advocating for Mathematics: Influencing Policymakers through Congressional Visits in Districts and States, Tuesday, 3:00 p.m.–4:30 p.m., organized by **Sheldon H. Katz**, University of Illinois at Urbana-Champaign. Constituent visits to state and district congressional offices can have considerable impact on building relationships with members of Congress. In fact, most congressional staff will tell you that local visits are a much better venue for getting your points across than a visit to Washington, DC. This session concentrates on scheduling and making visits to congressional district and state offices, along with tips on how to build lasting relationships with these offices. Mock meetings will illustrate how to carry out a successful congressional office visit. The session will serve as a prelude to the committee's plan to enlist mathematicians to make local office visits in the spring and summer of 2008. Sponsored by the Committee on Science Policy.

MAA Sessions

Flatland: The Movie, Sunday, 5:00 p.m.–6:00 p.m., organized by **Thomas F. Banchoff**, Brown University. This half-hour animated film produced in 2007 was inspired by Edwin A. Abbott's classic novel, *Flatland: A Romance of Many Dimensions*. Set in a world of only two dimensions inhabited by sentient geometrical shapes, the story follows Arthur Square and his ever-curious granddaughter, Hex. When a mysterious visitor arrives from Spaceland, Arthur and Hex must come to terms with the truth of the third dimension, risking dire consequences from the evil Circles that have ruled Flatland for a thousand years. A discussion will follow concerning its use in classroom teaching.

Putting Math on the Web the Correct Way, Monday, 1:00 p.m.–3:00 p.m., organized by **Paulo Ney de Souza**, UC Berkeley and Mathematical Sciences Publishers; **William F. Hammond**, SUNY at Albany; and **Patrick D. F. Ion**, *Mathematical Reviews* and W3C MathML working group. The correct way to place articles and course materials on the Web is to provide content in the modern form of HTML extended by MathML. Although this format cannot reasonably be written directly, there are readily available tools for generating it reliably. The session will feature presentations by members of the mathematical community who are now posting math to the Web in this correct way, emphasizing practicality and the reasons behind the claim of correctness. Cosponsored by the MAA and AMS.

Sharing Residues from College Algebra Workshops, Monday, 5:45 p.m.–7:45 p.m., organized by **Donald B. Small**, U.S. Military Academy, and **William E. Haver**, Virginia Commonwealth University. Participants from College Algebra Workshops (PREP, HBCUs, MAA's, etc.) will discuss their efforts to refocus college algebra courses based on their workshop experiences. Topics are expected to include visions, realities, efforts that worked, efforts that did not work, reflections on project work, hurdles encountered, suggestions on how to build support for change, etc. The session will also include discussions and exchanges of class activities, exercises, writing assignments, and tests.

Conversations with Minority Scientists, Monday 6:30 p.m.–8:00 p.m., organized by **William A. Hawkins Jr.**, University of the District of Columbia; **Robert E. Megginson**, University of Michigan; **Camille A. McKayle**, University of the Virgin Islands; and **Ivelisse M. Rubio**, University of Puerto Rico, Rio Piedras. This informal gathering sponsored by the MAA Committee on Minority Participation will provide underrepresented minority students with the opportunity to meet other students and mathematicians to share experiences and opinions on different aspects of graduate school and career paths. Participants will receive information about summer research, internships and graduate study. Everybody is welcome to attend; it will be a great opportunity for programs to recruit minority students and for student-faculty networking. This session is cosponsored by the Mathematical Sciences Research Institute (MSRI), Institute for Pure and Applied Mathematics (IPAM), Institute for Mathematics and Its Applications (IMA), American Institute for Mathematics (AIM), and Statistical and Applied Mathematical Sciences Institute (SAMSI)

Tones Are Real Functions, Rhythms Are Sequences, Monday, 7:00 p.m.–8:00 p.m., presented by **Erich Neuwirth**, University of Vienna. Musical tones (and chords) can be described mathematically as functions; the amplitude of the wave is a function of time. Therefore, real function can not only be visualized but also sonified. Rhythms, on the other hand, are discrete events and given times; therefore, a sequence of real numbers describes a rhythm. So, sequences also can be sonified. Quite a few computer tools are available to make symbolical representations of sounds and rhythms audible. In the presentation we will use some of these tools (as complex as *Mathematica* and as simple as a spreadsheet) to study some possibilities of the connection of mathematical concepts with auditory perception. One of the examples will be that the concept of partial sums is directly related to MIDI, a computer-based representation of music.

Becoming a Teacher of College Mathematics: Research on Mathematics Graduate Students' Professional Development, Tuesday, 9:00 a.m.–10:20 a.m., organized by **Kevin E. Charlwood**, Washburn University, **Larry Chrystal**, University of California Irvine, and **Natasha M. Speer**, Michigan State University. During the past several decades there has been an increase in discussion about mathematics graduate student teaching assistants' (TAs) contributions to undergraduate instruction and their needs for teaching-related professional development. In addition to publication of resources for professional development activities and programs, educational researchers with interests in TAs have begun examining the factors that shape TAs' professional lives, their teaching practices, and their development as teachers of college mathematics. In this session several mathematics education researchers will discuss their work in this area. The session will include reports on the history of research on mathematics TAs, research on TAs' experiences as teachers, and examinations of the design of PD activities. Invited speakers will include those who have published their findings in this area. Panelists include **Jason K. Belnap**, Brigham Young University; **Shandy Hauk**, University of Northern Colorado; **David E. Meel**, Bowling Green State University, and **Natasha M. Speer**. The session is sponsored by the AMS-MAA Committee on Teaching Assistants and Part-time Instructors (TA/PTI).

SIGMAAs

SIGMAA on Environmental Mathematics. A tour led by a geologist from San Diego State University is being arranged to Torrey Pines State Reserve within the San Diego city limits. For more specifics send email to Ben Fusaro, `Fusaro@math.fsu.edu`.

AWM Sessions

The Unseen AWM Opportunities, Sunday, 2:15 p.m.–3:40 p.m., organized and moderated by **Cathy Kessel**, Mathematics Education Consultant, Berkeley. The topics and panelists include The AWM Essay Contest: **Victoria E. Howle**, Sandia National Laboratories; Sonia Kovalevsky

High School Mathematics Days: **Elizabeth G. Yanik**, Emporia State University; The AWM Mentor Network: **Rachel A. Kuske**, University of British Columbia; The AWM Teacher Partnership: **Suzanne Lenhart**, University of Tennessee, Knoxville; The AWM Travel Grants Program: **Cathy Kessel**. Just before the panel discussion, AWM will recognize the Alice T. Schafer award honorees (formal announcement of the first place award is at the Joint Prize Session on Monday afternoon).

Establishing a Career in Mathematics, Wednesday, 1:00 p.m.–2:15 p.m. This AWM Workshop panel discussion is moderated by **Magnhild Lien**, California State University Northridge. Panelists are **Megan M. Kerr**, Wellesley College; **Elizabeth S. Allman**, University of Alaska, Fairbanks; and **Elana J. Fertig**, Metron, Inc.

NAM Sessions

The speaker at the **NAM Banquet** on Tuesday evening is **Earl R. Barnes**, Morgan State University.

The **Claytor-Woodard Lecture** at 1:00 p.m. on Wednesday will be given by **Scott W. Williams**, SUNY at Buffalo, on *Box Products 25 Years Later*.

Social Events

Claremont Colleges Reception, Monday, 6:00 p.m.–8:00 p.m. All alumni and friends are invited.

University of Maryland Mathematics Department Reception, Tuesday, 6:00 p.m.–8:00 p.m. All alumni and friends are invited.

Reception for Mathematicians in Business, Industry, and Government, Monday, 5:45 p.m.–6:45 p.m., organized by **Michael Monticino**, University of North Texas. This welcome reception is open to all meeting participants and in particular, those interested in the mathematics of business, industry, and government (BIG). The reception provides a great opportunity to interact with BIG mathematicians and learn more about BIG mathematics, and is sponsored by the BIG SIGMAA.

University of Michigan Alumni and Friends Get-Together, Tuesday, 5:30 p.m.–7:00 p.m.

National Math Circle Reception and Meeting, Tuesday, 7:00 p.m.–9:00 p.m. All current and potential Math Circle (and similar programs) organizers are invited to this first annual NMC reception. Come be a part of creating the NMC mission and program structure and learn more about upcoming Math Circle projects including Circle-in-a-Box.

North Carolina State University Department of Mathematics Reception, Monday, 5:45 p.m.–7:00 p.m. All alumni, family, spouses, and friends are invited to meet old friends and to hear about recent events in the department.

University of Oregon Mathematics Department Reception, Tuesday, 5:30 p.m.–7:00 p.m. All alumni and friends are invited.

University of Wisconsin Department of Mathematics Reception, Monday, 5:45 p.m.–7:30 p.m. All alumni and friends are invited to visit with old and new friends.

Ancillary Conferences

Introducing Concepts of Statistical Inference, Saturday, 8:30 a.m.–5:00 p.m., presented by **Allan Rossman** and **Beth Chance**, California Polytechnic University-San Luis Obispo; **George Cobb**, Mount Holyoke College; and **John Holcomb**, Cleveland State University. We present ideas and activities for helping students to learn fundamental concepts of statistical inference. These ideas and activities are centered around a randomization-based curriculum rather than normal-based inference; they rely heavily on simulations, both tactile and computer-based. Our goals with this curriculum are to develop students' understanding of the process of statistical investigations and of key concepts of inference, rather more covering a litany of specific methods based on normal approximations. We propose that this approach leads to deeper conceptual understanding, makes a clear connection between study design and scope of conclusions, and provides a powerful and generalizable analysis framework. This hands-on workshop will feature participants working directly with student activities, which they can then implement in their own classrooms. We will also discuss ideas for assessing student understanding and invite participants to contribute to an ongoing assessment/evaluation project. The intended audience for this workshop is teachers of introductory statistics in colleges (including two-year colleges) and high schools.

For registration and additional details go to `http://www.causeway.org/workshop/inference_jmm08/`. Participants will be notified of the exact meeting room in the San Diego Convention Center. There is no registration fee for this workshop. Lunch will be provided. Enrollment is limited to 30. This workshop is sponsored by MAA Special Interest Group on Statistics Education and the Consortium for the Advancement of Undergraduate Statistics Education (CAUSE).

Building (UP) an Undergraduate Statistics Program, 8:30 a.m.–5:00 p.m., presented by **Julie Legler**, St. Olaf College, and **Robin Lock**, St. Lawrence University. Many colleges and universities are recognizing that this is an opportune time to establish or invigorate an Undergraduate Statistics Program or USP (i.e., programs that offer majors in statistics as well as those offering statistics minors, concentrations, or tracks within other majors). Is this a good time for your department to strengthen its statistics program? This workshop will explore this question and provide some useful information with respect to enhancing your USP. The workshop takes a two-pronged approach to USP planning. First, participants will use resources to assess the potential and to facilitate planning for a USP at their institution. The resources will include ASA Undergraduate Statistics Education Initiative (USEI) which provides valuable, thoughtful guidance for institutions creating or developing USPs. In addition to examining the USEI guidelines, the workshop will include sharing the experience of a number of successful undergraduate statistics programs, identifying issues your department may face, discussing and proposing solutions, and constructing a plan for your own department. This workshop will address issues related to curriculum and course development, especially beyond the introductory level, as well as some of the many practical, administrative issues institutions face when considering initiating or enhancing

a USP. The intended audience for this workshop is faculty and chairs/representatives of mathematics departments looking to establish or invigorate an undergraduate statistics program.

For registration and additional details go to http://www.causeway.org/workshop/inference_jmm08/. Participants will be notified of the exact meeting room in the San Diego Convention Center. There is no registration fee for this workshop. Enrollment is limited to 30. Lunch will be provided. This workshop is sponsored by MAA Special Interest Group on Statistics Education and the Consortium for the Advancement of Undergraduate Statistics Education (CAUSE).

New York, New York

Courant Institute of New York University

March 15–16, 2008

Saturday – Sunday

Meeting #1036

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: January 2008
Program first available on AMS website: January 31, 2008
Program issue of electronic *Notices*: March 2008
Issue of *Abstracts*: Volume 29, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: November 27, 2007
For abstracts: January 22, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Weinan E, Princeton University, *Title to be announced.*

Ilya Kapovich, University of Illinois at Urbana-Champaign, *Title to be announced.*

Ovidiu Savin, Columbia University, *Title to be announced.*

Ravi Vakil, Stanford University, *Title to be announced.*

Special Sessions

Algebraic Combinatorial Geometry (Code: SS 3A), **Julianna Tymoczko**, University of Iowa, and **Linda Chen**, Ohio State University.

Buckminster Fuller's Synergetics and Mathematics (Code: SS 5A), **Christopher J. Fearnley** and **Joe Clinton**, Synergetics Collaborative.

Geometric Topology (Code: SS 7A), **Marco Varisco**, Binghamton University, SUNY, and **David Rosenthal**, St. John's University.

Isoperimetric Problems and PDE (Code: SS 6A), **Bernd Kawohl**, University of Cologne, and **Marcello Lucia**, City University of New York.

L-Functions and Automorphic Forms (Code: SS 1A), **Alina Bucur**, Institute for Advanced Study, **Ashay Venkatesh**, Courant Institute of Mathematical Sciences, **Stephen D. Miller**, Rutgers University, and **Steven J. Miller**, Brown University.

Mathematics of Multiscale Phenomena (Code: SS 4A), **Peter McCoy** and **Reza Malek-Madani**, U.S. Naval Academy.

Nonlinear Elliptic Equations and Geometric Inequalities (Code: SS 2A), **Fengbo Hang**, Princeton University, and **Xiaodong Wang**, Michigan State University.

Nonlinear Waves and their Applications (Code: SS 8A), **Edward D. Farnum**, Kean University, and **Roy Goodman**, New Jersey Institute of Technology.

Northeast Hyperbolic Geometry (Code: SS 9A), **Ara Basmajian**, Hunter College and Graduate Center of the City University of New York, and **Ed Taylor**, Wesleyan University.

Baton Rouge, Louisiana

Louisiana State University, Baton Rouge

March 28–30, 2008

Friday – Sunday

Meeting #1037

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: February 2008
Program first available on AMS website: February 14, 2008
Program issue of electronic *Notices*: March 2008
Issue of *Abstracts*: Volume 29, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 11, 2007
For abstracts: February 5, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Maria Chudnovsky, Columbia University, *Title to be announced.*

Soren Galatius, Stanford University, *Title to be announced.*

Zhongwei Shen, University of Kentucky, *Title to be announced.*

Mark Shimozono, Virginia Polytechnic Institute & State University, *Title to be announced.*

Special Sessions

Actions of Quantum Algebras (Code: SS 8A), **Lars Kadison**, University of Pennsylvania, and **Alexander Stolin**, University of Gothenburg/Chalmers University of Technology.

Algebraic Geometry of Matrices and Determinants (Code: SS 14A), **Zachariah C. Teitler**, Texas A&M University, and **Kent M. Neuerburg**, Southeastern Louisiana University.

Arrangements and Related Topics (Code: SS 15A), **Daniel C. Cohen**, Louisiana State University.

Current Challenges in Financial Mathematics (Code: SS 10A), **Arkadev Chatterjea**, Kenan-Flagler Business School, The University of North Carolina at Chapel Hill, and **Ambar Sengupta**, Louisiana State University.

Elementary Mathematics from an Advanced Perspective (Code: SS 11A), **James J. Madden**, Louisiana State University, and **Kristin L. Umland**, University of New Mexico.

Gauge Theory in Smooth and Symplectic Topology (Code: SS 21A), **Scott J. Baldridge** and **Brendan E. Owens**, Louisiana State University.

Geometric Group Theory (Code: SS 13A), **Noel Brady**, University of Oklahoma, **Tara E. Brendle**, Louisiana State University, and **Pallavi Dani**, University of Oklahoma.

Geometric and Combinatorial Representation Theory (Code: SS 7A), **Pramod N. Achar** and **Daniel S. Sage**, Louisiana State University.

Harmonic Analysis and Partial Differential Equations in Real and Complex Domains (Code: SS 3A), **Loredana Lanzani**, University of Arkansas, and **Zhongwei Shen**, University of Kentucky.

Knot and 3-Manifold Invariants (Code: SS 6A), **Oliver T. Dasbach** and **Patrick M. Gilmer**, Louisiana State University.

Lie Groups and Holomorphic Function Spaces: Analysis, Geometry, and Mathematical Physics (Code: SS 20A), **Brian C. Hall**, University of Notre Dame, and **Jeffrey J. Mitchell**, Robert Morris University.

Lie Groups, Lie Algebras, and Their Representations (Code: SS 18A), **Mark C. Davidson**, Louisiana State University, and **Ronald Stanke**, Baylor University.

Mathematical Modeling in Biology (Code: SS 9A), **Hongyu He**, Louisiana State University, **Sergei S. Pilyugin**, University of Florida, and **Jianjun Tian**, College of William and Mary.

Matroid Theory (Code: SS 17A), **Bogdan S. Oporowski** and **James G. Oxley**, Louisiana State University.

Nonlinear Evolution Equations of Mathematical Physics (Code: SS 5A), **Jerry L. Bona**, University of Illinois at Chicago, and **Michael M. Tom**, Louisiana State University.

Number Theory and Applications in Other Fields (Code: SS 12A), **Jorge Morales**, Louisiana State University, **Robert Osburn**, University College Dublin, and **Robert V. Perlis** and **Helena Verrill**, Louisiana State University.

Radon Transforms, Tomography, and Related Geometric Analysis (Code: SS 16A), **Fulton B. Gonzalez**, Tufts University, **Isaac Pesenson**, Temple University, **Todd Quinto**, Tufts University, and **Boris S. Rubin**, Louisiana State University.

Recent Advances in Knot Theory: Quandle Theory and Categorified Knot Invariants (Code: SS 4A), **Sam Nelson**, Pomona College, and **Alissa S. Crans**, Loyola Marymount University.

Recent Trends in Partial Differential Equations (Code: SS 23A), **Wai Yuen Chan**, Southeast Missouri State University.

Structural Graph Theory (Code: SS 2A), **Maria Chudnovsky**, Columbia University.

Wavelets, Frames, and Multi-Scale Constructions (Code: SS 22A), **Palle E. T. Jorgensen**, University of Iowa, **David R. Larson**, Texas A&M University, **Gestur Olafsson**, Louisiana State University, and **Darrin Speegle**, Saint Louis University.

White Noise Distribution Theory and Orthogonal Polynomials (Code: SS 1A), **Jeremy J. Becnel**, Stephen F. Austin State University, and **Aurel I. Stan**, The Ohio State University at Marion.

Bloomington, Indiana

Indiana University

April 5–6, 2008

Saturday – Sunday

Meeting #1038

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2008
Program first available on AMS website: February 21, 2008
Program issue of electronic *Notices*: April 2008
Issue of *Abstracts*: Volume 29, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 18, 2007
For abstracts: February 12, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Shi Jin, University of Wisconsin, *Title to be announced.*

Michael J. Larsen, Indiana University, *Title to be announced.*

Mircea Mustata, University of Michigan, *Title to be announced.*

Margaret H. Wright, New York University-Courant Institute, *Title to be announced.*

Special Sessions

Algebraic Aspects of Coding Theory (Code: SS 5A), **Heide Gluesing-Luerssen**, University of Kentucky, and **Roxana Smarandache**, San Diego State University.

Algebraic K-theory and Nil groups in Algebra and Topology (Code: SS 20A), **James F. Davis**, Indiana University, and **Christian Haesemeyer**, University of Illinois at Chicago.

Applications of Ring Spectra (Code: SS 16A), **Randy McCarthy**, University of Illinois at Urbana-Champaign, and **Ayelet Lindenstrauss**, Indiana University.

Birational Algebraic Geometry (Code: SS 3A), **Mircea I. Mustata**, University of Michigan, and **Mihnea Popa**, University of Illinois at Chicago.

Combinatorial Representation Theory, Topological Combinatorics, and Interactions Between Them (Code: SS 13A), **Patricia Hersh**, Indiana University, **Cristian P. Lenart**, State University of New York at Albany, and **Michelle Wachs**, University of Miami.

Combinatorial and Geometric Aspects of Commutative Algebra (Code: SS 1A), **Juan Migliore**, University of Notre Dame, and **Uwe Nagel**, University of Kentucky.

D-modules (Code: SS 14A), **Mathias Schulze**, Oklahoma State University, and **Hans Ulrich Walther**, Purdue University.

Discrete Structures in Conformal Dynamics and Geometry (Code: SS 11A), **Kevin M. Pilgrim**, Indiana University, and **William J. Floyd**, Virginia Polytech Institute & State University.

Financial Mathematics (Code: SS 22A), **Victor Goodman**, Indiana University, and **Kiseop Lee**, University of Louisville.

Finite Element Methods and Applications (Code: SS 9A), **Nicolae Tarfulea**, Purdue University Calumet, and **Sheng Zhang**, Wayne State University.

Geometry and Dynamics (Code: SS 7A), **Chris Connell**, **David M. Fisher**, and **Marlies Gerber**, Indiana University.

Graph Theory (Code: SS 17A), **Jozsef Balogh**, University of Illinois at Urbana-Champaign, **Hemanshu Kaul**, Illinois Institute of Technology, and **Tao Jiang**, Miami University.

Harmonic Analysis Methods in Mathematical Fluid Dynamics (Code: SS 21A), **Zoran Grujic** and **Irina Mitrea**, University of Virginia.

Harmonic Analysis and Related Topics (Code: SS 8A), **Ciprian Demeter**, Institute for Advance Study, and **Nets Katz**, Indiana University.

Hyperbolic and Kinetic Equations (Code: SS 2A), **Shi Jin**, University of Wisconsin, and **Marshall Slemrod**, University of Wisconsin.

Mathematical Modeling of Cell Motility: From Molecular Events to Mechanical Movement (Code: SS 18A), **Anastasios Matzavinos**, Ohio State University, and **Nicoleta Eugenia Tarfulea**, Purdue University Calumet.

Minimal and CMC Surfaces (Code: SS 19A), **Bruce Michael Solomon** and **Matthias Weber**, Indiana University, and **Adam Weyhaupt**, Southern Illinois University.

Operator Algebras and Applications (Code: SS 12A), **Hari Bercovici**, Indiana University, **Marius Dadarlat**, Purdue University, and **Mihai Popa**, Indiana University.

Probability and Spatial Systems (Code: SS 10A), **Russell D. Lyons**, Indiana University, and **Alexander Holroyd**, University of British Columbia.

Recent Advances in Classical and Geophysical Fluid (Code: SS 15A), **Roger Temam** and **Shouhong Wang**, Indiana University.

Some Mathematical Problems in Biology, from Macromolecules to Ecosystems (Code: SS 6A), **Santiago David Schnell**, Indiana University, and **Roger Temam**, Indiana University.

Weak Dependence in Probability and Statistics (Code: SS 4A), **Richard C. Bradley** and **Lahn T. Tran**, Indiana University.

Claremont, California

Claremont McKenna College

May 3–4, 2008

Saturday – Sunday

Meeting #1039

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: March 2008
Program first available on AMS website: March 20, 2008
Program issue of electronic *Notices*: May 2008
Issue of *Abstracts*: Volume 29, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: January 15, 2008
For abstracts: March 11, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael Bennett, University of British Columbia, *Title to be announced.*

Chandrashekhar Khare, University of Utah, *Title to be announced.*

Huaxin Lin, University of Oregon, *Title to be announced.*

Anne Schilling, University of California Davis, *Title to be announced.*

Special Sessions

Diophantine Problems and Discrete Geometry (Code: SS 3A), **Matthias Beck**, San Francisco State University, and **Lenny Fukshansky**, Texas A&M University.

Dynamical Systems and Differential Equations (Code: SS 1A), **Adolfo Rumbos**, Pomona College, **Mario Martelli**, Claremont McKenna College, and **Alfonso Castro**, Harvey Mudd College.

Hopf Algebras and Quantum Groups (Code: SS 5A), **Gizem Karaali**, Pomona College, **M. Susan Montgomery**, University of Southern California, and **Serban Raianu**, California State University Dominguez Hills.

Operators, Functions and Linear Spaces (Code: SS 2A), **Asuman G. Aksoy**, Claremont McKenna College, **Stephan R. Garcia**, Pomona College, **Michael Davlin O'Neill**, Claremont McKenna College, and **Winston C. Ou**, Scripps College.

Recent Developments in Riemannian and Kaehlerian Geometry (Code: SS 4A), **Hao Fang**, University of Iowa, **Zhiqin Lu**, University of California, Irvine, **Dragos-Bogdan Suceava**, California State University Fullerton, and **Mihaela B. Vajiac**, Chapman University.

Rio de Janeiro, Brazil

Instituto Nacional de Matemática Pura e Aplicada (IMPA)

June 4–7, 2008

Wednesday – Saturday

Meeting #1040

First Joint International Meeting between the AMS and the Sociedade Brasileira de Matemática.
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: February 2008
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: Expired
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

AMS Invited Addresses

Ruy Exel, University Federal de Santa Catarina, *Noncommutative dynamics.*

Velimir Jurdjevic, University of Toronto, *Title to be announced.*

Andre Nachbin, Institute for Pure-Applied Mathematics, Rio de Janeiro, *Wave dynamics: Asymptotics with differential operators and solutions.*

Richard M. Schoen, Stanford University, *Title to be announced.*

Ivan P. Shestakov, University of Sao Paulo, *Automorphisms of free algebras.*

Amie Wilkinson, Northwestern University, *Title to be announced.*

Vancouver, Canada

University of British Columbia and the Pacific Institute of Mathematical Sciences (PIMS)

October 4–5, 2008

Saturday – Sunday

Meeting #1041

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2008
Program first available on AMS website: August 21, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines

For organizers: March 9, 2008
For consideration of contributed papers in Special Sessions: June 17, 2008
For abstracts: August 12, 2008

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Freeman Dyson, Institute for Advanced Study, *Birds and Frogs* (Einstein Public Lecture in Mathematics).

Richard Kenyon, University of British Columbia, *Title to be announced.*

Alexander S. Kleshchev, University of Oregon, *Title to be announced.*

Mark Lewis, University of Alberta, *Title to be announced.*

Audrey A. Terras, University of California San Diego, *Title to be announced.*

Special Sessions

Combinatorial Representation Theory (Code: SS 1A), **Sara C. Billey**, University of Washington, **Alexander S. Kleshchev**, University of Oregon, and **Stephanie Jane Van Willigenburg**, University of British Columbia.

Middletown, Connecticut

Wesleyan University

October 11–12, 2008
Saturday – Sunday

Meeting #1042
Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2008
Program first available on AMS website: August 28, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines
For organizers: March 11, 2008
For consideration of contributed papers in Special Sessions: June 24, 2008
For abstracts: August 19, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Special Sessions
Algebraic Geometry (Code: SS 1A), **Eyal Markman** and **Jenia Tevelev**, University of Massachusetts, Amherst.

Kalamazoo, Michigan

Western Michigan University

October 17–19, 2008
Friday – Sunday

Meeting #1043
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2008
Program first available on AMS website: September 4, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines
For organizers: March 17, 2008
For consideration of contributed papers in Special Sessions: July 1, 2008
For abstracts: July 26, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses
M. Carme Calderer, University of Minnesota, *Title to be announced.*
Alexandru Ionescu, University of Wisconsin, *Title to be announced.*
Boris S. Mordukhovich, Wayne State University, *Title to be announced.*
David Nadler, Northwestern University, *Title to be announced.*

Huntsville, Alabama

University of Alabama, Huntsville

October 24–26, 2008
Friday – Sunday

Meeting #1044
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: August 2008
Program first available on AMS website: September 11, 2008
Program issue of electronic *Notices*: October 2008
Issue of *Abstracts*: Volume 29, Issue 4

Deadlines
For organizers: March 24, 2008
For consideration of contributed papers in Special Sessions: July 8, 2008
For abstracts: September 2, 2008

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses
Mark Behrens, Massachusetts Institute of Technology, *Title to be announced.*
Anthony Michael Bloch, University of Michigan, Ann Arbor, *Title to be announced.*
Roberto Camassa, University of North Carolina, Chapel Hill, *Title to be announced.*
Mark V. Sapir, Vanderbilt University, *Title to be announced.*

Shanghai, People's Republic of China

Fudan University

December 17–21, 2008

Wednesday – Sunday

Meeting #1045

First Joint International Meeting Between the AMS and the Shanghai Mathematical Society
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: June 2008
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: February 1, 2008
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

L. Craig Evans, University of California Berkeley, *Title to be announced.*

Zhi-Ming Ma, Chinese Academy of Sciences, *Title to be announced.*

Richard Schoen, Stanford University, *Title to be announced.*

Richard Taylor, Harvard University, *Title to be announced.*

Xiaoping Yuan, Fudan University, *Title to be announced.*

Weiping Zhang, Chern Institute, *Title to be announced.*

Special Sessions

Harmonic Analysis and Partial Differential Equations with Applications, **Yong Ding**, Beijing Normal University, and **Guo-Zhen Lu**, Wayne State University.

Integral and Convex Geometric Analysis, **Deane Yang**, Polytechnic University, and **Jiazu Zhou**, Southwest University.

Nonlinear Systems of Conservation Laws and Related Topics, **Gui-Qiang Chen**, Northwestern University, and **Shuxing Chen** and **Yi Zhou**, Fudan University.

Quantum Algebras and Related Topics, **Naihuan N. Jing**, North Carolina State University, **Quanshui Wu**, Fudan University, and **James J. Zhang**, University of Washington.

Recent Developments in Nonlinear Dispersive Wave Theory, **Jerry Bona**, University of Illinois at Chicago, **Bo Ling Guo**, Institute of Applied Physics and Computational Mathematics, **Shu Ming Sun**, Virginia Polytech Institute and State University, and **Bingyu Zhang**, University of Cincinnati.

Washington, District of Columbia

Marriott Wardman Park Hotel and Omni Shoreham Hotel

January 5–8, 2009

New Dates!!!

Monday – Thursday

Meeting #1046

Joint Mathematics Meetings, including the 115th Annual Meeting of the AMS, 92nd 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: Bernard Russo
Announcement issue of *Notices*: October 2008
Program first available on AMS website: November 1, 2008
Program issue of electronic *Notices*: January 2009
Issue of *Abstracts*: Volume 30, Issue 1

Deadlines

For organizers: April 1, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Urbana, Illinois

University of Illinois at Urbana-Champaign

March 27–29, 2009

Friday – Sunday
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 29, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Special Sessions

Geometric Group Theory (Code: SS 2A), **Sergei V. Ivanov**, **Ilya Kapovich**, **Igor Mineyev**, and **Paul E. Schupp**, University of Illinois at Urbana-Champaign.

q-Series and Partitions (Code: SS 1A), **Bruce Berndt**, University of Illinois at Urbana-Champaign.

Raleigh, North Carolina

North Carolina State University

April 4–5, 2009

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 4, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

San Francisco State University

April 25–26, 2009

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 25, 2008
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Waco, Texas

Baylor University

October 16–18, 2009

Friday – Sunday
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 17, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Boca Raton, Florida

Florida Atlantic University

October 30 – November 1, 2009

Friday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 30, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Riverside, California

University of California

November 7–8, 2009

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 6, 2009

For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 6–9, 2010

Wednesday – Saturday
Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd 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 of Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2009
Program first available on AMS website: November 1, 2009
Program issue of electronic *Notices*: January 2010
Issue of *Abstracts*: Volume 31, Issue 1

Deadlines

For organizers: April 1, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lexington, Kentucky

University of Kentucky

March 27–28, 2010

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 28, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011

Wednesday – Saturday
Joint Mathematics Meetings, including the 117th Annual Meeting of the AMS, 94th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: October 2010
Program first available on AMS website: November 1, 2010
Program issue of electronic *Notices*: January 2011
Issue of *Abstracts*: Volume 32, Issue 1

Deadlines

For organizers: April 1, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Boston, Massachusetts

John B. Hynes Veterans Memorial Convention Center, Boston Marriott Hotel, and Boston Sheraton Hotel

January 4–7, 2012

Wednesday – Saturday
Joint Mathematics Meetings, including the 118th Annual Meeting of the AMS, 95th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2011
Program first available on AMS website: November 1, 2011
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 33, Issue 1

Deadlines

For organizers: April 1, 2011
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 9–12, 2013, *Wednesday – Saturday*

Joint Mathematics Meetings, including the 119th Annual Meeting of the AMS, 96th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Lesley M. Sibner
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, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center

January 15–18, 2014, *Wednesday – Saturday*

Joint Mathematics Meetings, including the 120th Anual Meeting of the AMS, 97th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Matthew Miller
Announcement issue of *Notices*: 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

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Joint Meetings Advance Registration/Housing Form

Note: Write your name as you would like it to appear on your badge (no titles, please). Badges and programs can only be mailed to home addresses. If you would like your registration materials mailed to you on December 13, please register by November 15, provide your home address, and check this box: ☐ **I want my materials mailed to the following address on 12/13/07.**
☐ **I do not want my materials mailed. I will pick them up onsite.**

Name _____

Mailing Address _____

_____

Telephone: _____ Fax: _____

In case of emergency (for you) at the meeting, call: Day #: _____ Evening #: _____

Email Address _____

Affiliation for name badge _____

Nonmathematician guest badge name _____ (please note charge below)

Acknowledgment of this registration will be sent to the email address listed, unless you check this box: Send by U.S. Mail ☐

Membership
✓ all that apply. First column is eligible for member registration fee

❑ AMS	❑ ASA
❑ MAA	❑ AWM
❑ ASL	❑ NAM
❑ CMS	❑ YMN
❑ SIAM	

Registration Fees

Joint Meetings	**by Dec 14**	**at mtg**	**Subtotal**
❑ Member AMS, ASL, CMS, MAA, SIAM	US $214	US $279	
❑ Nonmember	US $332	US $431	
❑ Graduate Student	US $ 44	US $ 54	
❑ Undergraduate Student	US $ 23	US $ 29	
❑ High School Student	US $ 5	US $ 10	
❑ Unemployed	US $ 43	US $ 53	
❑ Temporarily Employed	US $172	US $200	
❑ Developing Countries Special Rate	US $ 43	US $ 53	
❑ Emeritus Member of AMS or MAA	US $ 43	US $ 53	
❑ High School Teacher	US $ 43	US $ 53	
❑ Librarian	US $ 43	US $ 53	
❑ Nonmathematician Guest	US $ 15	US $ 15	

$ _____

AMS Short Course: *Applications of Knot Theory (1/4–1/5)*

❑ Member of AMS or MAA	US $ 94	US $125	
❑ Nonmember	US $125	US $155	
❑ Student, Unemployed, Emeritus	US $ 42	US $ 63	

$ _____

MAA Short Course: *Combinatorics: Past, Present, Future. (1/4–1/5)*

❑ Member of MAA or AMS	US $125	US $140	
❑ Nonmember	US $175	US $190	
❑ Student, Unemployed, Emeritus	US $ 50	US $ 60	

$ _____

MAA Minicourses (see listing in text)
I would like to attend: ❑ One Minicourse ❑ Two Minicourses
Please enroll me in MAA Minicourse(s) #_____ and/or #_____
In order of preference, my alternatives are: #_____ and/or #_____
Price: US $60 for each minicourse.
(For more than 2 minicourses, call or email the MMSB.) $ _____

Employment Center
Applicant résumé forms and employer job listing forms will be on the AMS website at www.ams.org/emp-reg/.

Employer—First Table		US $245	US $325
❑ Computer-scheduled ❑ Self-scheduled ❑ Combination Interview			
Employer— Each Additional Table		US $ 95	US $125
❑ Computer-scheduled ❑ Self-scheduled ❑ Combination Interview			
❑ Employer—Posting Job Description Only		US $ 50	N/A
❑ Applicant (all services)		US $ 44	US $ 82
❑ Applicant (Winter List & Message Ctr only)		US $ 22	US $ 22

$ _____

Events with Tickets

MER Banquet (1/7)	US $50.00	#____Regular	#____Veg	#____Kosher
NAM Banquet (1/8)	US $49.00	#____Regular	#____Veg	#____Kosher
AMS Banquet (1/9)	US $52.00	#____Regular	#____Veg	#____Kosher

$ _____

Other Events
❑ AMS Workshop on Grant Writing (1/6) (no charge)
❑ Graduate Student/First Time Attendee Reception (1/6) (no charge)

Total for Registrations and Events $ _____

Registration for the Joint Meetings is not required for the Short Courses, but it is required for the Minicourses and the Employment Center

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 are not 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.
❑ Credit Card. VISA, MasterCard, AMEX, Discover (no others accepted)

Card number: _____

Exp. date: _____ Zipcode of credit card billing address: _____

Signature: _____

Name on card: _____

❑ Purchase order # _____ (please enclose copy)

Other Information

Mathematical Reviews field of interest # _____

How did you hear about this meeting? Check one: ❑ Colleague(s) ❑ *Notices* ❑ *Focus* ❑ Internet

❑ This is my first Joint Mathematics Meeting.
❑ 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 ✓ this box if you have a disability requiring special services.
❑ **Please do not include my name on any promotional mailing list.**

Mail to:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887 Fax: 401-455-4004
Questions/changes call: 401-455-4143 or 1-800-321-4267 x4143; mmsb@ams.org

Deadlines *Please register by the following dates for:*

Résumés/job descriptions printed in the *Winter Lists*	**Oct. 24, 2007**
To be eligible for the room lottery and the raffle:	**Oct. 31, 2007**
For housing reservations, badges/programs mailed:	**Nov. 15, 2007**
For housing changes/cancellations through MMSB:	**Dec. 7, 2007**
For advance registration for the Joint Meetings, Employment Center, Short Courses, MAA Minicourses, & Tickets:	**Dec. 14, 2007**
For 50% refund on banquets, cancel by:	**Dec. 21, 2007***
For 50% refund on advance registration, Minicourses & Short Courses, cancel by:	**Dec. 28, 2007***

***no refunds after this date**

San Diego Joint Meetings Hotel Reservations

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 a ranked or unranked hotel at a comparable rate. Participants are urged to call the hotels directly for details on suite configurations, sizes, and availability; however, suite reservations can be made only through the MMSB to receive the convention rates listed. Reservations at the following hotels must be made through the MMSB to receive the convention rates listed. Reservations made directly with the hotels may be changed to a higher rate. All rates are subject to a 10.6% sales 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 Card Number _____ Exp. Date _____ Signature _____

Date and Time of Arrival _____ **Date and Time of Departure** _____

Name of Other Room Occupant _____ **Arrival Date** _____ **Departure Date** _____ **Child (give age(s)**_____

Order of choice	Hotel	Single	Double 1 bed	Double 2 beds	Triple 2 beds	Triple 2 beds w/cot	Triple - king or queen w/cot	Quad 2 beds	Quad 2 beds w/cot	Suites Starting rates
	San Diego Marriott Hotel & Marina (hqtrs)									
	Cityview	US $172	US $172	US $172	US $192	US $192	US $192	US $212	US $212	N/A
	Bayview	US $192	US $192	US $192	US $212	US $212	US $212	US $232	US $232	US $685
	Student	US $138	US $138	US $138	US $158	US $158	US $158	US $178	US $178	N/A
	Horton Grand Hotel	US $155	US $155	US $155 (very limited)	US $175 (very limited)	N/A	N/A	US $195 (very limited)	N/A	US $215
	Student	US $145	US $145	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Hilton San Diego Gaslamp Quarter	US $150	US $150	US $150	US $170	N/A	US $190	US $190	N/A	US $489
	Student	US $140	US $140	US $140	US $160	N/A	US $180	US $180	N/A	N/A
	Embassy Suites-Cityview Suites	US $149	US $149	US $149	US $169	No rollaways; have sleeper sofa	No rollaways; have sleeper sofa	US $189	N/A	all suites
	Bayview Suites	US $169	US $169	US $169	US $189	No rollaways; have sleeper sofa	No rollaways; have sleeper sofa	US $209	N/A	all suites
	Student Suites	US $135	US $135	US $135	US $145	No rollaways; have sleeper sofa	No rollaways; have sleeper sofa	US $155	N/A	all suites
	Omni San Diego	US $140	US $140	US $140	US $160	N/A	US $185	US $180	N/A	Jr. Suite: US $399; 1BR US $499
	Student	US $125	US $125	US $125	US $145	N/A	US $170	US $165	N/A	N/A
	Holiday Inn on the Bay-Cityview	US $135	US $135	US $135	US $150	N/A	US $160	US $165	N/A	N/A
	Bayview	US $165	US $165	US $165	US $180	N/A	US $190	US $195	N/A	US $338
	Student	US $125	US $125	US $125	US $140	N/A	US $150	US $155	N/A	N/A
	Holiday Inn Express	US $129	US $129	US $129	US $144	N/A	N/A	US $159	N/A	US $239
	Student	US $119	US $119	US $119	US $134	N/A	N/A	US $149	N/A	N/A
	Courtyard Marriott Downtown	US $109	US $109	US $109	US $119	N/A	King only-US $119	US $129	N/A	US $169
	Rodeway Inn and Suites	US $91	US $91	US $91	US $101	$121	US $121	US $111	US $131	N/A
	500 West Hotel	US $49	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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:_____

Email confirmations (no paper) will be sent by the Hilton, Embassy Suites, Holiday Inns, Horton, Marriott (hqtrs), Omni & Rodeway Inn. **Please provide your email address:**_____

If you are not making a reservation, please check off 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

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: susan@math.nwu.edu; telephone: 312-996-3041.

Eastern Section: Lesley M. Sibner, Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: lsibner@duke.poly.edu; telephone: 718-260-3505.

Southeastern Section: Matthew Miller, Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001, e-mail: miller@math.sc.edu; telephone: 803-777-3690.

2009 Washington, DC, Meeting: Bernard Russo, Department of Mathematics, University of California, Irvine, CA 92697-3875, e-mail: brusso@math.uci.edu; telephone: 949-824-5505.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at** www.ams.org/meetings/.

Meetings:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 78 in the the January 2007 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 abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

IMA INSTITUTE FOR MATHEMATICS AND ITS APPLICATIONS

Membership opportunities

in connection with the 2008-2009 thematic program on

MATHEMATICS AND CHEMISTRY

IMA NEW DIRECTIONS RESEARCH PROFESSORSHIPS provide an extraordinary opportunity for established mathematicians–typically mid-career faculty at US universities–to branch into new directions and increase the impact of their research by spending the 2008-2009 academic year immersed in the thematic program at the IMA. Research Professors will enjoy an excellent research environment and stimulating scientific program connecting Mathematics and Chemistry and related areas of mathematics with a broad range of fields of application. New Directions Research Professors are expected to be resident and active participants in the program, but are not assigned formal duties. Deadline January 15, 2008.

IMA POSTDOCTORAL FELLOWSHIPS provide an excellent opportunity for mathematical scientists near the beginning of their career who have a background in and/or an interest in learning about applied and computational aspects of Mathematics and Chemistry. IMA postdoctoral fellowships run one to two years, at the option of the holder, starting September 1, 2008. Deadline January 4, 2008.

IMA INDUSTRIAL POSTDOCTORAL FELLOWSHIPS are designed to prepare mathematicians for research careers in industry or involving industrial interaction. IMA industrial postdoctoral fellowships run two years starting September 1, 2008. They are funded jointly by the IMA and an industrial sponsor, and holders devote 50% effort to their own research and the IMA program and 50% effort working with industrial scientists. Deadline January 4, 2008.

IMA GENERAL MEMBERSHIPS provide an opportunity for mathematicians and scientists employed elsewhere to spend a period of one month to one year in residence at the IMA, and to participate in the 2008-2009 thematic program. The residency should fall in the period September 2008 through June 2009 (in special cases extending into the summer months). Logistic support such as office space, computer facilities, and secretarial support will be provided, and local expenses may be provided.

For more information and application materials see
www.ima.umn.edu/docs/membership.html or phone 612-624-6066.

Notices of the American Mathematical Society
Volume 54, Number 11, Pages 1449–1592, December 2007
0002-9920(200712)54:11;1-8