2005 Steele Prizes

The 2005 Leroy P. Steele Prizes were awarded at the 111th Annual Meeting of the AMS in Atlanta in January 2005.

The Steele Prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein. Osgood was president of the AMS during 1905–06, and Birkhoff served in that capacity during 1925–26. The prizes are endowed under the terms of a bequest from Leroy P. Steele. Up to three prizes are awarded each year in the following categories: (1) Lifetime Achievement: for the cumulative influence of the total mathematical work of the recipient, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students; (2) Mathematical Exposition: for a book or substantial survey or expository-research paper; (3) Seminal Contribution to Research: for a paper, whether recent or not, that has proved to be of fundamental or lasting importance in its field or a model of important research. Each Steele Prize carries a cash award of $5,000.

The Steele Prizes are awarded by the AMS Council acting on the recommendation of a selection committee. For the 2005 prizes the members of the selection committee were: Andreas R. Blass (chair), Daniel S. Freed, John B. Garnett, Victor W. Guillemin, Craig L. Huneke, Tsit-Yuen Lam, Robert D. MacPherson, Linda P. Rothschild, and Lou P. Van den Dries.

The list of previous recipients of the Steele Prize may be found on the World Wide Web, `http://www.ams.org/prizes-awards`.

The 2005 Steele Prizes were awarded to Branko Grünbaum for Mathematical Exposition, to Robert P. Langlands for a Seminal Contribution to Research (this year restricted to the field of algebra), and to Israel M. Gelfand for Lifetime Achievement. The text that follows presents, for each awardee, the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

Mathematical Exposition: Branko Grünbaum

Citation

Branko Grünbaum's book, *Convex Polytopes*, has served both as a standard reference and as an inspiration for three and a half decades of research in the theory of polytopes. That theory is currently very active and enjoys connections with many other areas of mathematics, including optimization, computational algebra, algebraic geometry, and representation theory. Much of the development that led to the present, thriving state of polytope theory owes its existence to this book, which served as a source of information for workers in the field and as a source of inspiration for them to enter the field. Despite the passage of time, *Convex Polytopes* retains its value both as an exposition of the theory and as a reference work. Springer-Verlag's decision to issue a second edition in 2003, consisting of Grünbaum's original text plus notes by Volker Kaibel, Victor Klee, and Günter Ziegler to describe newer developments, will extend the book's influence to future generations of mathematicians.

Biographical Sketch

Branko Grünbaum was born in 1929 in what was then Yugoslavia. In 1948 he started studying mathematics at the University of Zagreb and a year later emigrated to Israel. After receiving his Ph.D. from the Hebrew University in Jerusalem in 1957 under the guidance of Aryeh Dvoretzky, he was a member of the Institute for Advanced Study in Princeton for two years. In 1961 he returned to the Hebrew University. Following a visiting appointment at Michigan State University in 1965, in 1966 he became professor at the University of Washington; he has been in Seattle ever since, from 2000 on as professor emeritus. At various times he had visiting appointments at the University of Kansas, the University of California at Los Angeles, and Michigan State University. His interests cover much of geometry and combinatorics, with the principal activity on convex sets and polytopes, and tilings. In recent

Branko Grünbaum

Robert P. Langlands

Photo of I. M. Gelfand by Tatiana Gelfand.

I. M. Gelfand

years, most of his efforts were devoted to configurations of points and lines in the Euclidean plane and to nonconvex polygons and polyhedra. He is happy to be able to give courses on these topics and to see that the material has started to attract attention after a long period of quiescence.

Response

The beginning of *Convex Polytopes* was in notes and explanations I prepared for students in my seminar at the Hebrew University in 1963. The main topic concerned the material of Klee's seminal preprints about the face vectors of convex polytopes and Steinitz's characterization of graphs of convex 3-polytopes. In time, the notes expanded and formed the core of the book. I was fortunate to have M. A. Perles contribute to the book his path-breaking results dealing with Gale diagrams and to receive the cooperation of Vic Klee and G. C. Shephard for other parts of the book. After the book went out of print, there were several attempts to publish an updated version; they foundered on the sheer quantity of the relevant new material. It took the mathematical depth and organizational ability of Günter Ziegler and the help of Volker Kaibel and Vic Klee to complete the task. I am greatly indebted to all of them. Naturally, I am deeply appreciative of the Steele Prize and greatly honored by it.

Seminal Contribution to Research: Robert P. Langlands

Citation

The Steele Prize for a Seminal Contribution to Mathematical Research is awarded to Robert Langlands for the paper "Problems in the theory of automorphic forms", Springer Lecture Notes in Math., vol. 170, 1970, pp. 18–86. This is the paper that introduced the Langlands conjectures.

The Langlands conjectures asserted deep relations among modular forms that encompassed as special cases class field theory, the Artin conjectures, and Eichler-Shimura theory, which they extended to higher dimensional varieties. The conjectures provided a unifying principle for the theory of automorphic forms, and in particular a relatively clear guide to their relation with L-functions. As a result of this paper, the systematic relation between global and local theory and the systematic use of adele groups became fixtures in the subject.

The Langlands conjectures had their origin in Langlands' theory of Eisenstein series, which was itself a major mathematical advance. The conjectures are still unproved, but many difficult cases have been established recently. It's hard to think of any other instance in the history of mathematics where conjectures gave so accurate a road map of what would turn out to be true in so many different situations. And few other conjectures have generated so much research of such high quality.

Biographical Sketch

Robert P. Langlands was born October 6, 1936, in New Westminster, British Columbia, Canada. He received his A.B. and M.A. degrees at the University of British Columbia in 1957 and 1958 respectively and his Ph.D. from Yale University in 1960. His principal speciality is the theory of automorphic forms. He is best known for the Langlands Program, which proposes deep links between algebra and analysis, having significant ramifications for number theory. Langlands held positions at Princeton University (1960–67) and at Yale University (1967– 72), and since 1972 he has been at the Institute for Advanced Study. He is the recipient of numerous honorary doctorates and awards, including the AMS Cole Prize in Number Theory in 1982, the Commonwealth Award in 1984, the National Academy of Sciences Award in Mathematics in 1988, the Wolf Prize in Mathematics (1995– 96), and La Grande Médaille d'or de l'Académie des Sciences in 2000. He is a fellow of the Royal Society of Canada (1972) and the Royal Society of London (1981); he is also a member of the American Academy of Arts and Sciences (1990), the National Academy of Sciences (1993), the American Philosophical Society (2004), the American Mathematical Society, and the Canadian Mathematical Society. Langlands is the author of numerous research papers.

Response

The pleasure of learning that one is to be awarded a Steele Prize or perhaps almost any prize in mathematics is, for anyone with a sense of proportion, soon followed by the uneasy sentiment that there are others more deserving and, at least if the prize is coveted, that they are quite aware of it. There is little to be done with the unease but to live with it and to be grateful to those unknown members of the selection committee who appreciated what you have tried to do and made an effort to persuade the other members of the committee of its merits.

The unease is, in any case, soon followed by a more troubling impulse, the desire to supplement the citation and to explain what one really had in mind. I shan't do that now, except to mention that in the paper "Problems in the theory of automorphic forms", dedicated, I recall, to Salomon Bochner, the emphasis was on what I later came to call functoriality, thus, in particular, on the Artin conjecture and a possible nonabelian class-field theory. Hasse-Weil L-functions were mentioned only in passing as a more or less obvious—once I had learned of the Taniyama-Shimura-Weil conjecture—afterthought. By the time the paper was published, I had reflected for two or three years on the "working hypotheses", as I called them, contained in it, and I no longer had any serious doubts.

In the following years various mathematicians, myself included, were able to do something with them, even some things quite striking, as with, say, base change and the Artin conjecture in the tetrahedral and octahedral case or with various general forms of the Ramanujan conjecture. Nevertheless, for lack of courage and historical perspective, I did not, as I now believe, appreciate until quite recently the real import of the suggestions and the depth one would have to attain to solve the problems posed. Unfortunately, it may now, at least for me, be too late for boldness. On the other hand, until serious inroads had been made on what the experts call the fundamental lemma, the time was not ripe for it.

Lifetime Achievement: Israel M. Gelfand

Citation

The broad and lasting impact of I. M. Gelfand on mathematics is difficult to convey in a short space. He has had a profound influence on many fields of research through his own work and through his interactions with other mathematicians, including students. Here we can only touch on a few highlights.

Gelfand's first major achievement is the theory of commutative normed rings, which he developed in the late 1930s in his thesis. His use of maximal ideals was crucial not only in harmonic analysis, but also in the subsequent development of algebraic geometry. Next, in collaboration with Naimark, he proved that noncommutative normed rings with involution may be represented as operators in Hilbert space, a cornerstone of the modern theory of C^*-algebras. In the 1940s Gelfand turned to representation theory and the theory of generalized functions. There are also foundational papers from this period on integral geometry, geodesic flows on surfaces of negative curvature, and generalized random processes.

Beginning in the mid-1940s Gelfand led many investigations on partial differential equations, and in a well-known paper published in 1960 asked for a topological classification of elliptic operators, based on the observation that the index is a homotopy invariant of the leading symbol. This led to the Atiyah-Singer index theorem, with its many profound implications and applications. We also mention his work with, among others, Levitan and Dickii on inverse spectral problems and scattering theory.

Gelfand, in collaboration with Fuks in the late 1960s, investigated the cohomology of infinite-dimensional Lie algebras, particularly those associated with a manifold. Even for the algebra of vector fields on the circle there is nontrivial and interesting cohomology. This work led to characteristic classes of foliations.

This brief account omits many fundamental results—the Bernstein-Gelfand-Gelfand resolution of representations, work on integral geometry and the Radon transform, combinatorial characteristic classes, etc.—as well as recent work on such topics as determinants, noncommutative polynomials, etc. Gelfand has also had a parallel career working on applied problems, ranging from computation to biology.

Gelfand's mathematical influence has spread not only through his many research papers, but also through his books, lectures, and seminars. His series of five books (with various coauthors) on *Generalized Functions* dates from the late 1950s and has been a classic for 50 years. A recent book with Kapranov and Zelevinski entitled *Discriminants, Resultants, and Multidimensional Determinants* is also a major work. In between are monographs on many other topics. Gelfand's seminar, which began in Moscow and continues in Piscataway, has long been a training ground for participants and speakers. His educational activities extend to younger mathematicians as well, including a cor-

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respondence school in both Russia and the United States as well as many books on elementary mathematics.

Biographical Sketch

Israel M. Gelfand was born on September 2, 1913, in Krasnye Okny, Ukraine; he received his Ph.D. and D.Sc. in mathematics from Moscow State University in 1935 and 1940 respectively. For almost fifty years (1941–90) Gelfand served as professor of mathematics at Moscow State University; he has held visiting professor positions at Harvard University and the Massachusetts Institute of Technology (1989–90). Since 1990 he has served as professor of mathematics at Rutgers University. Gelfand is the author of more than 800 articles and 30 books in mathematics, applied mathematics, and theoretical biology. He has worked chiefly in the area of functional analysis and representation, but he has significantly contributed to many other areas of mathematics as well.

Gelfand is the recipient of many awards and honors, including the State Prize of the U.S.S.R. (1953), the Lenin Prize (1956), the Wolf Foundation Prize (1978), the Kyoto Prize (1989), and a MacArthur Foundation Fellowship (1994). He was elected a member of the American Academy of Arts and Sciences (1964), the Royal Irish Academy (1970), the National Academy of Sciences (1970), the Royal Swedish Academy (1974), the Académie des Sciences of France (1976), the Royal Society of Britain (1977), the Academia dei Lincei of Italy (1988), the Japan Academy of Sciences (1989), and the European Academy of Sciences (2004). In 2000 he was made a Lifetime Member of the New York Academy of Sciences. A corresponding member of the U.S.S.R. Academy of Sciences since 1953, Gelfand was elected to full membership in 1984. He is also the recipient of many honorary degrees.

Response

I am very touched to receive this award from the American Mathematical Society. For me it is a confirmation that everything that I have worked for through my entire life was not in vain. This recognition of my work from my peers, colleagues, and friends from the American Mathematical Society is especially meaningful for me. Mathematics for me is a universal and adequate language of sciences, and it is an example of how people of different cultures and backgrounds can communicate and work together. This is extremely important in our times.

2005 Bôcher Prize

The 2005 Maxime Bôcher Memorial Prize was awarded at the 111th Annual Meeting of the AMS in Atlanta in January 2005.

Established in 1923, the prize honors the memory of Maxime Bôcher (1867-1918), who was the Society's second Colloquium Lecturer in 1896 and who served as AMS president during 1909-10. Bôcher was also one of the founding editors of *Transactions of the AMS*. The original endowment was contributed by members of the Society. The prize is awarded for a notable paper in analysis published during the preceding six years. To be eligible, the author should be a member of the American Mathematical Society or the paper should have been published in a recognized North American journal. Currently, this prize is awarded every three years. The prize carries a cash award of $5,000.

The Bôcher Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2005 prize the members of the selection committee were: Charles L. Fefferman, Leon Simon (chair), and Daniel I. Tataru.

Previous recipients of the Bôcher Prize are: G. D. Birkhoff (1923), E. T. Bell (1924), Solomon Lefschetz (1924), J. W. Alexander (1928), Marston Morse (1933), Norbert Wiener (1933), John von Neumann (1938), Jesse Douglas (1943), A. C. Schaeffer and D. C. Spencer (1948), Norman Levinson (1953), Louis Nirenberg (1959), Paul J. Cohen (1964), I. M. Singer (1969), Donald S. Ornstein (1974), Alberto P. Calderón (1979), Luis A. Caffarelli (1984), Richard B. Melrose (1984), Richard M. Schoen (1989), Leon Simon (1994), Demetrios Christodoulou (1999), Sergiu Klainerman (1999), Thomas Wolff (1999), Daniel Tataru (2002), Terence Tao (2002), and Fanghua Lin (2002).

The 2005 Bôcher Prize was awarded to FRANK MERLE. The text that follows presents the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

Frank Merle

Citation

The Bôcher Prize is awarded to Frank Merle (Cergy-Pontoise, France) for his fundamental work in the analysis of nonlinear dispersive equations, represented most recently by his joint work "Stability of blow-up profile and lower bounds for blow-up rate for the critical generalized KdV equation" (with Y. Martel), *Annals of Math.* 155 (2002), 235-280; "Blow up in finite time and dynamics of blow up solutions for the L^2-critical generalized KdV equation" (with Y. Martel), *J. Amer. Math. Soc.* 15 (2002), 617-664; and "On universality of blow-up profile for L^2 critical nonlinear Schrödinger equation" (with P. Raphael), *Invent. Math.* 156 (2004), no. 3, 565-672.

Biographical Sketch

Frank Merle was born November 22, 1962, in Marseille, France. He received his Ph.D. at the École Normale Supérieure in 1987 and held a Centre National de la Recherche Scientifique (CNRS) research position there from 1988 to 1991. From 1989 to 1990 he was assistant professor at the Courant Institute. Since 1991 he has been professor of mathematics at the Université de Cergy-Pontoise. From 1998 to 2003 he was a member of the Institut Universitaire de France and in 1996 and from 2003 to 2004, a member of the Institute for Advanced Study in Princeton.

Over the years he has held various visiting positions at the University of Chicago, Rutgers University, Stanford University, the Courant Institute, the Institute for Advanced Study in Princeton, the Mathematical Sciences Research Institute in Berkeley, the University of Tokyo, the CNRS, and Leiden University.

Merle's awards and honors include the Institut Poincaré Prize in Theoretical Physics (1997), the Charles-Louis de Saulse de Freycinet Prize of the Académie des Sciences de Paris (2000), and an invitation to speak at the International Congress of Mathematicians in 1998.

Response

It is a great honor to be awarded the Bôcher Memorial Prize. I am grateful to the prize committee and to the American Mathematical Society for their recognition of this research. I am also deeply grateful to Jean Bourgain and Carlos Kenig for their constant support and early recognition of this work, and to George Papanicolaou, who introduced me to these problems and supported me. I would like to thank people who influenced me early in my career and over the years, such as Henri Berestycki; Haïm Brezis; Louis Nirenberg (who was a role model); Hiroshi Matano; Robert V. Kohn; Abbas Bahri; Jean Ginibre; my close collaborators Yvan Martel, Pierre Raphael, and Hatem Zaag; and family and friends.

The cited work is concerned with the Critical Generalized Korteweg-de Vries (CGKdV) and Critical Schrödinger (CNLS) equations. We considered the existence and description of solutions which break down (or blow up) in finite time and related qualitative properties of the equations such as long-time behavior of global solutions. Such problems were proposed as models for understanding breakdown in the Hamiltonian context. A number of people, including Ya. G. Sinai and V. E. Zakharov, first investigated these problems in the 1970s using formal asymptotics combined with numerical methods. Initial work led to less-than-clear results for CGKdV and to a controversial blow-up rate for CNLS. In 1988, for the generic behavior of the breakdown, Papanicolaou and coauthors suggested a rate equal to the scaling rate corrected by $\sqrt{Loglog(t)}$, but this rate is different from that of the explicit blow-up solution.

In the last decade, from Bourgain's seminal work; from the work of Kenig, Gustavo Ponce, Luis Vega; and now from the work of a large mathematical community, a huge breakthrough has arisen out of analytical methods based on frequency localization properties of the solution of dispersive equations. This approach extends linear-type behavior (in particular global existence results) to various nonlinear contexts. For nonlinear-type behavior (in particular for the qualitative study of breakdown), little is known apart from stability results of the 1980s based on global energy arguments by P.-L. Lions and M. Weinstein.

The approach we took for these problems was not to justify possible formal asymptotics and construct one solution with a given behavior; instead, we looked for properties of these equations that were rigid enough to classify different blow-up and dynamical behaviors. Since the 1980s this geometrical approach has had great success in elliptic theory and in geometry. Earlier research on the nonlinear heat equation (Merle and Zaag) suggested that this approach might also be successful for evolution equations. Using the Hamiltonian structure, we were able to localize in physical space dispersive effects which occur naturally at infinity. By their local nature, these effects give a new set of estimates and provide a dynamical rigidity for the asymptotic behavior of solutions (by way of a monotonicity formula, or by local quantities which do not oscillate in time or which satisfy a maximum principle).

For the CGKdV problem, a mechanism of balance between local dispersive effects and Hamiltonian constraints on the solutions allows us to prove and describe blow-up. In the process, we also eliminate the formally expected candidate. Nevertheless, getting a sharp lower bound for the blow-up rate remains an open problem. In the subcritical case, these techniques give asymptotic stability in the energy space of a soliton or finite sum of solitons.

For the CNLS problem, an exact description of blow-up is given (at least for solutions with a single blow-up point). It confirms that the remarkable conjecture of Papanicolaou (along with M. Landman, C. Sulem, and P.-L. Sulem) is the only generic behavior. Additional rigidities for the global behavior of solutions are also exhibited.

In the future, I think three directions should be investigated. The first is to extend this approach to other dispersive problems. Bearing in mind the qualitative elliptic theory of the 1980s and 1990s, the second direction is to carry out a similar program in the context of oscillatory integral problems. In particular, I think questions from the dynamical systems viewpoint should be considered, such as classification of connections between critical points. The last direction is to develop techniques using localization in both space and frequency to investigate a new set of questions.

Again, I thank the prize committee for honoring these lines of research, and I look forward to continued work on them.

2005 Cole Prize in Number Theory

The 2005 Frank Nelson Cole Prize in Number Theory was awarded at the 111th Annual Meeting of the AMS in Atlanta in January 2005.

The Cole Prize in Number Theory is awarded every three years for a notable research memoir in number theory that has appeared during the previous five years (until 2001, the prize was usually awarded every five years). The awarding of this prize alternates with the awarding of the Cole Prize in Algebra, also given every three years. These prizes were established in 1928 to honor Frank Nelson Cole (1861–1926) on the occasion of his retirement as secretary of the AMS after twenty-five years of service and as editor-in-chief of the *Bulletin* for twenty-one years. The endowment was made by Cole, contributions from Society members, and his son, Charles A. Cole. The Cole Prize carries a cash award of $5,000.

The Cole Prize in Number Theory is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2005 prize the members of the selection committee were: Andrew J. Granville, Richard L. Taylor (chair), and Marie France Vigneras.

Previous recipients of the Cole Prize in Number Theory are: H. S. Vandiver (1931), Claude Chevalley (1941), H. B. Mann (1946), Paul Erdős (1951), John T. Tate (1956), Kenkichi Iwasawa (1962), Bernard M. Dwork (1962), James B. Ax and Simon B. Kochen (1967), Wolfgang M. Schmidt (1972), Goro Shimura (1977), Robert P. Langlands (1982), Barry Mazur (1982), Dorian M. Goldfeld (1987), Benedict H. Gross and Don B. Zagier (1987), Karl Rubin (1992), Paul Vojta (1992), Andrew J. Wiles (1997), Henryk Iwaniec (2002), and Richard Taylor (2002).

The 2005 Cole Prize in Number Theory was awarded to PETER SARNAK. The text that follows presents the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

Peter Sarnak

Citation

The Frank Nelson Cole Prize in Number Theory is awarded to Peter Sarnak of New York University and Princeton University for his work relating the distribution of zeros of L-functions in certain families to the distribution of eigenvalues in a large compact linear group of a type that depends on the family of L-functions one is considering. In particular it is awarded for the book *Random Matrices, Frobenius Eigenvalues, and Monodromy* (with N. Katz) in which this Katz-Sarnak philosophy is introduced and in which it is extensively verified in the function field case. This philosophy has had a major impact on the direction of work in analytic number theory. In addition the prize is awarded for the papers "The non-vanishing of central values of automorphic L-functions and Landau-Siegel zeros" (with H. Iwaniec) and "Low lying zeros of families of L-functions" (with H. Iwaniec and W. Luo) in which this philosophy is tested in the much harder number field case. For example, the second paper shows, subject to suitable Riemann hypotheses, that the low lying zeros of the L-functions of modular forms with root number 1 (resp.-1) are distributed like the low lying eigenvalues of a random matrix in $SO(2N)$ (resp. $SO(2N+1)$) as N gets large.

Biographical Sketch

Peter Sarnak was born on December 18, 1953, in Johannesburg, South Africa. He received his Ph.D. from Stanford University in 1980. Sarnak began his academic career at the Courant Institute of Mathematical Sciences, advancing from assistant professor (1980–83) to associate professor (1983). He moved to Stanford University as a professor of mathematics (1987–91). Sarnak has been a professor of mathematics at Princeton University since 1991 and at the Courant Institute since 2001. Since 2002, Sarnak has held the position of Eugene Higgins Professor of Mathematics at Princeton, having served as the H. Fine Professor (1995–96) and as department chair (1996–99).

Sarnak was a Sloan Fellow (1983–85) and a Presidential Young Investigator (1985–90). In 1991 he was elected to the American Academy of Arts and Sciences. With P. Deift and X. Zhou, he received the Pólya Prize of the Society for Industrial and Applied Mathematics in 1998. Sarnak was elected to membership in the National Academy of Sciences (2002), won the AMS's Levi L. Conant Prize (jointly with N. Katz) in 2003, and held the Rothschild Chair of the Isaac Newton Institute in Cambridge, UK, and the Aisenstadt Chair of the Centre de Recherches Mathématiques in Montreal in 2004. He has sat on numerous editorial boards, oversight committees, and advisory committees, and he has published extensively in the areas of number theory and automorphic forms.

Response

It is a great honor for me to receive this prize. I have mostly worked in collaboration with others. Not only has this allowed me to achieve things I could never have done by myself, but it is also more fun (especially when you are stuck, which, of course, is most of the time). This recognition belongs as much to my coworkers as to me.

In my work with Nick Katz cited above, our original aim was to determine if there was a function field analogue of the phenomenon (due to Montgomery and Odlyzko) that the local fluctuations of the distribution of the zeros of the Riemann zeta function are governed by the distributions of the eigenvalues for the Gaussian Unitary Ensemble in random matrix theory. After a lot of false starts and misunderstandings, we found such an analogue. Its source lay in the analysis of the large n limit of monodromy groups associated with families of such zeta functions. This led naturally to the possibility that the distribution of low lying zeros of a family of automorphic L-functions might also be governed in a decisive way by a symmetry type associated with the family. The extensive numerical computations of zeros of such L-functions by Mike Rubinstein, who was a graduate student at Princeton at that time, gave us valuable evidence for this belief.

The paper with Henryk Iwaniec and Wenzhi Luo, cited above, developed methods to study these questions for L-functions of automorphic forms. The paper with Iwaniec does the same for the related problem of the quantitative study of nonvanishing of such L-functions at special points on the critical line and its arithmetical applications. This allowed for the verification of aspects of the conjectured distribution of zeros as dictated by the symmetry.

One of my greatest pleasures in connection with these works has been to see how others have picked up on these ideas and run with them, far beyond what I had anticipated. Let me mention in particular the remarkable conjectures for the moments of central values of families of L-functions (Keating, Snaith, Conrey, Farmer, and Rubinstein) and the determination of some of these moments as well as far-reaching quantitative nonvanishing results for such central values (Kowalski, Michel, Soundararajan, and VanderKam).

Finally, it was Paul Cohen who many years ago, when I was a student at Stanford, pointed me to Montgomery's work on the pair-correlation of the zeros of zeta and its connection to random matrix theory and asked, why is it so?

My efforts to try to answer that question began with a paper with Zeev Rudnick on the higher correlations for zeros of the zeta function and led eventually to the works cited above.

2005 Satter Prize

The 2005 Ruth Lyttle Satter Prize in Mathematics was awarded at the 111th Annual Meeting of the AMS in Atlanta in January 2005.

The Satter Prize is awarded every two years to recognize an outstanding contribution to mathematics research by a woman in the previous five years. Established in 1990 with funds donated by Joan S. Birman, the prize honors the memory of Birman's sister, Ruth Lyttle Satter. Satter earned a bachelor's degree in mathematics and then joined the research staff at AT&T Bell Laboratories during World War II. After raising a family, she received a Ph.D. in botany at the age of forty-three from the University of Connecticut at Storrs, where she later became a faculty member. Her research on the biological clocks in plants earned her recognition in the U.S. and abroad. Birman requested that the prize be established to honor her sister's commitment to research and to encourage women in science. The prize carries a cash award of $5,000.

The Satter Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2005 prize the members of the selection committee were: Karen E. Smith, Jean E. Taylor (chair), and Chuu-Lian Terng.

Previous recipients of the Satter Prize are: Dusa McDuff (1991), Lai-Sang Young (1993), Sun-Yung Alice Chang (1995), Ingrid Daubechies (1997), Bernadette Perrin-Riou (1999), Karen E. Smith (2001), Sijue Wu (2001), and Abigail Thompson (2003).

The 2005 Satter Prize was awarded to Svetlana Jitomirskaya. The text that follows presents the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

Svetlana Jitomirskaya

Citation

The Ruth Lyttle Satter Prize in Mathematics is awarded to Svetlana Jitomirskaya for her pioneering work on non-perturbative quasiperiodic localization, in particular for results in her papers (1) "Metal-insulator transition for the almost Mathieu operator", *Ann. of Math.* (2) 150 (1999), no. 3, 1159–1175, and (2) with J. Bourgain, "Absolutely continuous spectrum for 1D quasiperiodic operators", *Invent. Math.* 148 (2002), no. 3, 453–463. In her *Annals* paper, she developed a non-perturbative approach to quasiperiodic localization and solved the long-standing Aubry-Andre conjecture on the almost Mathieu operator. Her paper with Bourgain contains the first general non-perturbative result on the absolutely continuous spectrum.

Biographical Sketch

Svetlana Jitomirskaya was born on June 4, 1966, and raised in Kharkov, Ukraine, in a family of two accomplished mathematicians (later three, counting her older brother). She received her undergraduate degree (1987) and Ph.D. (1991) from Moscow State University. Since 1990 she has held a research position at the Institute for Earthquake Prediction Theory in Moscow. In 1991 she came with her family to southern California. She was employed by the University of California, Irvine, as a

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part-time lecturer (1991–92) and rose through the ranks to become a visiting assistant professor (1992–94) and then a regular faculty member (since 1994). She took a leave from UCI to spend nine months at Caltech (1996). She was a Sloan Fellow (1996–2000) and a speaker at the International Congress of Mathematicians in 2002. She is married and has three children ranging in age from one to seventeen.

Response

I am very grateful to the AMS for this honor and to the members of the Ruth Lyttle Satter Prize Committee for identifying and selecting me. It is humbling to be on the same list with the past recipients of this prize.

I must say that I have never felt disadvantaged because of being a woman mathematician; in fact, the opposite is true to some extent. However, compared to most others, I did have a unique advantage: a fantastic role model from early on—my mother, Valentina Borok, who would have been much more deserving of such a prize than I am now, had it been available in her time. I see my receiving this prize as a special tribute to her memory.

It is a pleasure to use this opportunity to say some thanks. It was great to be raised by my parents, and I was lucky to be a student of Yakov Sinai, who was both my undergraduate (since 1984) and graduate advisor. I am also very grateful to Abel Klein, whose support and encouragement in the postdoctoral years were crucial for my career. I had many wonderful collaborators, from each of whom I learned a lot. Three of those particularly stand out, as they have influenced my work in a major way. They are, in chronological (for me) order: Barry Simon, Yoram Last, and Jean Bourgain. Each of them has not only introduced new techniques to me and had a visible influence on my style and choice of topics but also provided a special inspiration and changed the way I think about mathematics. I am also grateful to Jean for entering, with his methods and ideas, the area of quasiperiodic operators. That certainly brought this field to a new level and changed how it is perceived by many others.

Finally, special thanks go to my family, as I wouldn't have accomplished a fraction of what I did without patience, support, and a lot of sacrifice on their part.

2005 Book Prize

The AMS Book Prize was awarded at the Joint Mathematics Meetings in Atlanta in January 2005.

The Book Prize was established in 2003 to recognize a single, relatively recent, outstanding research book that makes a seminal contribution to the research literature, reflects the highest standards of research exposition, and promises to have a deep and long-term impact in its area. The book must have been published within the six calendar years preceding the year in which it is nominated. Books may be nominated by members of the Society, by members of the selection committee, by members of AMS editorial committees, or by publishers. The prize amount is $5,000. This is the first time the prize has been given.

The Book Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2005 prize the members of the selection committee were: Rodrigo Banuelos, Steven G. Krantz (chair), H. W. Lenstra, Dale P. Rolfsen, and Bhama Srinivasan.

The 2005 Book Prize was awarded to WILLIAM P. THURSTON. The text that follows presents the selection committee's citation and a brief biographical sketch.

Citation

Three-Dimensional Geometry and Topology by William P. Thurston, edited by Silvio Levy.

William P. Thurston's "Geometrization Program" is one of the big events of modern mathematics. The main thrust of the program is to prove a classification of all 3-manifolds by showing that each such manifold can be broken up into pieces, each of which admits a geometric structure which is hyperbolic, Euclidean, spherical, or one of five other model 3-dimensional geometries. A corollary of the program would be the Poincaré conjecture.

More than twenty years ago, Thurston wrote an extensive set of notes explaining the key ideas of his program. These notes were circulated informally by the Princeton Mathematics Department—a copy could be had for the cost of the photocopying—and today the book is in most mathematics libraries. The contents of these notes cannot be considered to be a proof of the geometrization conjecture. They are instead a manifest, laying out all the key ideas and explaining how things fit together. The book, *Three-Dimensional Geometry and Topology*, is the first volume of a multi-volume work projected to provide all the details of the proof of Thurston's program. It begins at a quite elementary level, but takes the reader to a rather sophisticated stage of classifying the uniformizing geometries of a compact 3-manifold. This result is a major step of the geometrization program. Even though the geometrization program remains unproved, this is exciting and vital mathematics.

William P. Thurston

Thurston's book is nearly unique in the intuitive grasp of subtle geometric ideas that it provides. It has been enormously influential, both for graduate students and seasoned researchers alike. Certainly the army of people who are working on the geometrization program regard this book as "the touchstone" for their work. A book that has played such an important and dynamic role in modern mathematics is eminently deserving of the AMS Book Prize.

Biographical Sketch

William P. Thurston was born October 30, 1946, in Washington, D.C. He received his Ph.D. in mathematics from the University of California at Berkeley in 1972. He held positions at the Institute for Advanced Study in Princeton (1972–73) and the Massachusetts Institute of Technology (1973–74) before joining the faculty of Princeton University in 1974. Thurston returned to Berkeley, this time as a faculty member, in 1991, and became director of the Mathematical Sciences Research Institute in 1993. He moved to UC Davis in 1996 and in

2003 accepted his current position at Cornell University, where he holds joint appointments in the Department of Mathematics and the Faculty of Computing and Information Science.

Thurston held an Alfred P. Sloan Foundation Fellowship from 1974 to 1975. In 1976 he was awarded the AMS Oswald Veblen Geometry Prize for his work on foliations. In 1979 he became the second mathematician ever to receive the Alan T. Waterman Award, and in 1982 he was awarded the Fields Medal. He is a member of the American Academy of Arts and Sciences and the National Academy of Sciences.

Response

I feel especially honored to receive the AMS Book Prize for *Three-Dimensional Geometry and Topology*, because I invested so much of myself in it.

This book grew from a portion of lecture notes that I distributed to a large mailing list in the olden days before the Web, now available electronically at `http://www.msri.org/publications/books/gt3m/`. At the time, I had grown dissatisfied with the usual vehicles for recording and communicating mathematics. One issue has been that the informal drawings and diagrams that mathematicians often use when talking with each other are quite often missing from papers and books. When I was an undergraduate and graduate student, I enjoyed learning to study mathematics in a slow, laborious, step-by-step process, but as my study of mathematics progressed, I went through many experiences of struggling to digest laborious sequential arguments, finally catching on to whole-brain, instantaneous ways to understand the concepts and saying to myself, "Oh, is *that* what they were talking about? Why didn't they say so?" I started to realize that written mathematics is usually a highly denatured rendition of what sits inside mathematicians' heads. It's a hard task that often never happens to translate a detailed step-by-step proof or description into a conceptual understanding, far harder than to translate from concept to details. We've all also noticed that in seminar talks and even in informal one-on-one explanations of mathematics, it's common for one person to talk completely past another. Why is it so hard to communicate mathematics effectively?

I had the ambition to try to communicate on a more conceptual level, paying attention not only to the logical aspects of what is correct but also to the psychological aspects of how we can hold it in our heads and understand it. The geometric modules of our brains are the parts most severely neglected in most mathematical writing. Many papers, even about geometry and topology, lack the figures, or they have figures that are poor or mistaken. I was determined to include all the figures that would be natural to sketch if I were explaining things one-on-one to someone interested in understanding.

This was all much harder than I anticipated. The process of writing lecture notes flowed reasonably smoothly: I just wrote what I thought were good conceptual explanations, later filling in pencil sketches in spaces left by the typist. But as I started to hear of the arduous efforts people went through to digest the material, I realized that it wasn't as easy as I had thought to communicate mathematics more directly on a conceptual plane. Concepts that sit easily in the brain are often surprisingly hard to build up or to communicate. There is a big difference between proofs that are easy to follow but are hard to hold in mind vs. proofs that may be hard to get straight but that you see in a glance once you have them.

In writing the book, my goal was to make the ideas more accessible by filling in more of the unspoken assumptions. In doing so, I found it hard to avoid switching over to different brain modes that are centered more on language and symbols. At the time I started, the hardest problem was to find a workable system for reasonable renditions of the many figures. None of the artists or graphics professionals I tried seemed to be able to get the mathematical relationships correct, and I had neither the time nor the skill to draw professional-looking versions myself. Now, of course, there are computer drawing programs that make the job much easier although still laborious.

Personally, my mind always used to turn to jelly when it came time to do homework in school, and I have similar difficulties when I try to correct and edit something left over from past efforts. I would have given up in despair except for the support and hard work of many people, most notably the editing by Silvio Levy, who devoted many hours of his multifaceted talents and in particular solved the figure issue by developing good ways to do almost all the figures using Mathematica, in addition to working out the language and fixing up many mathematical issues. The other really remarkable contribution was through Al Marden, who organized several bookwriting workshops involving many colleagues to help with a task much larger than I had foreseen. I owe a huge debt to all these people.

In the end, I haven't discovered a solution to the problem of how to communicate mathematics effectively, but I have a better grasp of the problem than when I started. In any case, I am tremendously gratified to receive this recognition for my efforts and the efforts of all the people who helped.

2005 Whiteman Prize

The 2005 Albert Leon Whiteman Memorial Prize was awarded at the 111th Annual Meeting of the AMS in Atlanta in January 2005.

The Whiteman Prize is awarded every four years to recognize notable exposition and exceptional scholarship in the history of mathematics. The prize was established in 1998 using funds donated by Mrs. Sally Whiteman in memory of her husband, the late Albert Leon Whiteman. The prize carries a cash award of $4,000.

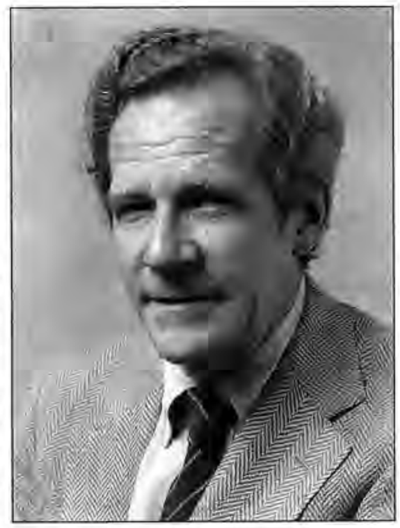
The Whiteman Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2005 prize the members of the selection committee were: Thomas W. Hawkins (chair), Victor J. Katz, and Robert Osserman.

The first recipient of the Whiteman Prize was Thomas Hawkins (2001).

The 2005 Whiteman Prize was awarded to HAROLD EDWARDS. The text that follows presents the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

Citation

In awarding the Albert Leon Whiteman Prize to Harold Edwards, the American Mathematical Society pays tribute to his many publications over several decades that have fostered a greater understanding and appreciation of the history of mathematics, especially the theory of algebraic numbers. Edwards' historical work has all been related to the theory of numbers and has been presented mainly in two forms: mathematical expositions that are organized in the historical order of development so as to convey a genetic understanding of the relevant mathematical theory, and traditional scholarly historical papers. Both forms combine clear and careful historical scholarship with an attendant mastery of the underlying mathematics and together constitute a major contribution to our understanding of the history of mathematics in the spirit of the guidelines set for the Whiteman Prize.



Harold Edwards

The first of Edwards' several major genetic expositions was presented in his book *Riemann's Zeta Function* (1974), which provides the reader with a deep mathematical understanding of Riemann's seminal paper and the many investigations that were more or less inspired by it. His second book, *Fermat's Last Theorem: A Genetic Introduction to Algebraic Number Theory* (1977), was also of this type, its goal being to introduce the reader to algebraic number theory by retracing some of the crucial discoveries in their original contexts and with their original motivations. In particular, the careful 177-page exposition of the work of Kummer that it contains provides the reader with a solid understanding of the theory of algebraic numbers as it was perceived by one of the principal founders of the theory. In 1984 Edwards published his third book-length genetic exposition. Bearing the title *Galois Theory*, it focused on a clear exposition of the somewhat cryptic work of Galois, thereby providing the reader with a deeper understanding of the mathematical considerations that gave birth to present-day Galois theory. Any historian or mathematician interested in exploring some aspect of the history of the Riemann zeta function, the theory of algebraic numbers, or Galois theory would be wise to begin by a careful study of one of Edwards' books.

Edwards' more traditional scholarly historical papers have an evident symbiotic relation with his genetic expositions. This is especially true of his book on Fermat's Last Theorem. The masterful account of Kummer's mathematics that it contains has its roots in two important, purely historical papers on "The background of Kummer's proof of Fermat's Theorem for regular primes" (1975, 1977). Based on a careful reading of the relevant publications and the use of unpublished documents, these papers present a clear, accurate, and illuminating account of an important—and previously poorly understood—episode in the history of algebraic number theory. Among the many insights contained in these papers is a critique of the widely accepted view that it was Fermat's conjectured theorem that formed the primary motivation for Kummer's revolutionary theory of ideal factorization. A cogent historical case is made for the view that it was actually the loftier quest for higher reciprocity laws that inspired Kummer.

Much of Edwards' subsequent historical research focuses upon the two men, Kronecker and Dedekind, who in quite different ways sought to develop Kummer's ideas beyond the special number fields he had considered. The first fruits of these efforts are contained in his paper "The genesis of ideal theory" (1980). In his publications Edwards is frank about his preference for Kummer's approach over the now-familiar approach eventually developed by Dedekind. His awareness of his own prejudices and their potential for misrepresentation has resulted in remarkably objective and illuminating accounts of the work of both mathematicians.

Indeed, it is perhaps because the final set-theoretic form of Dedekind's theory is neither as obvious nor as natural to Edwards as it is to most present-day mathematicians that he has succeeded so well in delineating the gradual changes Dedekind made to his theory of ideals, which, as he has shown, actually resembled Kummer's in its initial versions. His paper "Dedekind's invention of ideals" (1982) summarizes cogent historical arguments for the radical nature of Dedekind's eventual approach to ideal theory and for the likely sources of his inspiration.

That Dedekind's theory of ideals won out over the rival generalization of Kummer's theory, namely Kronecker's theory of divisors, is due at least in part to Dedekind's superior expository skill in presenting his work. Kronecker, on the other hand, withheld his ideas on divisor theory from publication for decades as he sought to work them out in a suitable form. Then in a paper of 1882, as a Festschrift in honor of Kummer, Kronecker finally put something into print, but, much to the disappointment of his contemporaries, he did no more than present a sketch of his ideas that was difficult even for experts such as Dedekind to penetrate. One of Edwards' signal achievements has been to reconstruct and expound Kronecker's theory (as well as Dedekind's reaction to it). He began this process in "The genesis of ideal theory" and completed it in his book *Divisor Theory* (1990), which provides the sort of systematic and coherent exposition of divisor theory that Kronecker himself was never able to achieve. Edwards has also used the resultant insights into Kronecker's actual practice of algebraic number theory to provide a more informed interpretation of his scattered—and often misrepresented—remarks on the philosophy of mathematics. (His forthcoming paper "Kronecker's Fundamental Theorem of General Arithmetic" is a good example.) Although Edwards' personal sympathy for an intuitionist view of mathematics seems to have been the motivation for much of his historical work relating to Kronecker, the final products of his efforts are characterized by their studied objectivity. They have laid to rest many unfounded anecdotes about Kronecker and his views that had been promulgated by other historians.

Edwards' combination of historical insights and sound mathematical scholarship make him a worthy recipient of the Whiteman Prize.

Biographical Sketch

Harold M. Edwards was born in Champaign, Illinois, in 1936. He received a B.A. from the University of Wisconsin in 1956, an M.A. from Columbia in 1957, and a Ph.D. from Harvard in 1961. After teaching at Harvard (1961–62) and Columbia (1962–66), he went to New York University in 1966, where he has remained. He is now an emeritus professor. He has published seven books: *Advanced Calculus* (1969, 1980, 1993), *Riemann's Zeta Function* (1974, 2001), *Fermat's Last Theorem* (1977), *Galois Theory* (1984), *Divisor Theory* (1990), *Linear Algebra* (1995), and *Essays in Constructive Mathematics* (2005).

Response

I am deeply grateful to be awarded the Whiteman Prize, especially so because I am only the second recipient, the first having been my esteemed colleague Thomas Hawkins.

I must echo the pleasure Tom Hawkins expressed in his response four years ago at this "manifestation of the importance the AMS attaches to the historical study of mathematics" as well as his recollection that "when I committed myself to a career in history of mathematics, there was in this country no such recognition of historical work by professional mathematical societies."

Hawkins's phrase, "the historical study of mathematics," strikes me as particularly apt. I have always felt that my study was mathematics, not the history of mathematics, but the study of the history has always been for me the easiest—and often the only—point of entry into the study of a given mathematical topic. My book on the zeta function began thirty-five years ago with a wish to understand and, I admit, a wish to prove the Riemann hypothesis. For me, the natural approach was to read Riemann's own words, and after I had studied his cryptic eight-page paper in some detail, I thought that others might profit from an exposition of what I had learned. Publishing a work of this sort did not appear then to be a very promising career choice, but it came from a deeply felt attitude toward the study of mathematics and was more an expression of a need than a career choice. How gratifying it is to have the value of the work done for such a reason confirmed by this prize!

I would like to take advantage of this opportunity to express my gratitude to three individuals who have not been mentioned in the acknowledgements in any of my books, because their influence on any one book was so indirect, but who were each immensely important to my career.

First, to Raoul Bott, who was my thesis advisor more than forty years ago. His plain-spoken, common-sense approach to mathematics has inspired all who have ever heard him lecture, not to mention those of us who had the good luck to start our research careers with him.

Second, to Morris Kline, who would certainly be a prime candidate for this prize if he were still alive. He hired me at NYU, and, being a historian himself, he furthered my historical work in many ways.

And third, to Uta Merzbach, a valued colleague who took a very helpful interest in my work and whose sharing with me of her expertise and experience in historical research was my only education in such work.

Thank you to the AMS, to the selection committee, and to Mrs. Sally Whiteman, who established the prize in memory of her husband, Albert Leon Whiteman.

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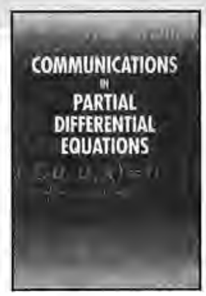

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2005 Conant Prize

The 2005 Levi L. Conant Prize was awarded at the 111th Annual Meeting of the AMS in Atlanta in January 2005.

The Conant Prize is awarded annually to recognize an outstanding expository paper published in either the *Notices of the AMS* or the *Bulletin of the AMS* in the preceding five years. Established in 2000, the prize honors the memory of Levi L. Conant (1857–1916), who was a mathematician at Worcester Polytechnic University. The prize carries a cash award of $1,000.

The Conant Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2005 prize the members of the selection committee were: Anthony W. Knapp, Carl Pomerance (chair), and M. B. Ruskai.

Previous recipients of the Conant Prize are: Carl Pomerance (2001), Elliott Lieb and Jakob Yngvason (2002), Nicholas Katz and Peter Sarnak (2003), and Noam D. Elkies (2004).

The 2005 Conant Prize was awarded to Allen Knutson and Terence Tao. The text that follows presents the committee's citation, brief biographical sketches, and the awardees' responses upon receiving the prize.

Citation

The Levi L. Conant Prize in 2005 is awarded to Allen Knutson and Terence Tao for their stimulating article "Honeycombs and Sums of Hermitian Matrices", *Notices of the AMS* **48** (2001), no. 2, 175–186.

In 1912 Hermann Weyl raised the problem of characterizing the possible sets of eigenvalues of the sum $A+B$ of two Hermitian matrices A, B in terms of the sets of eigenvalues of each of them. This is a very natural problem with applications to many areas, particularly to quantum theory. In particular, it allows one to describe the possible results of measurements of the sum of two observables in terms of those of the individual observables. Yet surprisingly little progress was made until a full solution was found in 1998. Soon after, Knutson and Tao introduced the concept of "honeycombs" and used them to simplify the solution and prove some related conjectures.

In eminently readable and unpretentious style, the authors give an account of their approach to Weyl's problem. After a brief introduction to the 1962 conjecture of Alfred Horn, which recasts the Weyl problem in terms of a conjectured series of inequalities for the eigenvalues of the sum matrix $A+B$, the authors introduce honeycombs, a type of diagram reminiscent of a beehive. Using 15 clearly explained figures that help one to picture various combinatorial nuances, the authors expertly lead the reader through the intricacies of their work. They gently transport us from Weyl's classical problem to a "quantum" analog, involving the Littlewood-Richardson formula for multiplicities of representations of unitary groups within tensor products. They then explain the key "saturation conjecture", which connects the classical and quantum problems to each other and implies the validity of Horn's conjecture. Having shown that the saturation conjecture can be reduced to a problem about honeycombs, they sketch its proof, all the while playing strongly to the reader's intuition. The story that is recounted brushes against symplectic geometry, invariant theory, combinatorics, and computational complexity, but the authors deftly keep the reader from getting overwhelmed by technicalities.

By skillfully combining honeycomb diagrams with a high level of exposition, Knutson and Tao make this fascinating subject accessible to a wide mathematical audience.

Allen Knutson

Biographical Sketch

Allen Knutson did his graduate work in symplectic geometry, overlapping with Terence Tao at Princeton, where their common love of linear algebra brought them together to work on Horn's conjecture. He finished up at the Massachusetts Institute of Technology, his third graduate school, the first being the University of California, Santa Cruz, thus equalling his number of undergraduate institutions: Caltech, New York University, and the Budapest Semesters in Mathematics Program.

In addition to the *Notices* article concerning his and Tao's combinatorial work together, Knutson has another one solely on "The symplectic and algebraic geometry of Horn's problem", *Linear Algebra Appl.* **319** (2000), nos. 1-3, 61-81.

After a National Science Foundation postdoc at Brandeis with Gerald Schwarz, Knutson moved in 1999 to the University of California, Berkeley, where he is now associate professor. His awards include a Clay research summer fellowship, a Sloan Fellowship, and the International Jugglers' Association world record in two-person ball juggling from 1990 to 1995. (The record was for 12 balls; nowadays the record is 13.)

Response

I am extremely honored and gratified to receive the Conant Prize—almost as much as to receive the initial invitation to write the article!

One of the most mysterious aspects of the original conjecture of Horn was a sort of continuous/discrete schizophrenia, in which real eigenvalues were occasionally required to be natural numbers. This already suggested that there should be other related, naturally discrete, mathematical fields in which the "eigenvalues" would be automatically integral. Three of these have come up: dominant weights of representations of $GL(n)$, Schubert classes on Grassmannians, and integral honeycombs.

The work of Totaro and Helmke-Rosenthal, and its more difficult converse by Klyachko, went back and forth between the Hermitian matrices and the Schubert classes. Ours is pretty much entirely in the combinatorial realm, with honeycombs, hives, and puzzles. Belkale's proof is entirely in the Schubert domain and is being given a very pretty generalization by Purbhoo and Sottile, beyond Grassmannians to other "minuscule flag varieties". It still seems amazing that Horn could guess a recursive statement completely within the Hermitian framework!

The saturation problem (as distinct from Horn's conjecture) seems most naturally stated and studied purely within representation theory and has received a solution recently for general groups by Kapovich and Millson, "A path model for geodesics in Euclidean buildings and its applications to representation theory", math.RT/0411182.

Terence Tao

Biographical Sketch

Terence Tao was born in Adelaide, Australia, in 1975. He received his Ph.D. in mathematics from Princeton University in 1996 under the advisorship of Elias Stein. He has been at the University of California, Los Angeles, as a Hedrick assistant professor (1996–98), assistant professor (1999–2000), and professor (2000–). He has also held visiting positions at the Mathematical Sciences Research Institute (1997), the University of New South Wales (1999–2000), and the Australian National University (2001–03).

Tao has been supported by grants from the National Science Foundation and fellowships from the Sloan Foundation, Packard Foundation, and the Clay Mathematics Institute. He received the Salem Prize in 2000 and the Bôcher Prize in 2002.

Tao's research concerns a number of areas, including harmonic analysis, geometric and arithmetic combinatorics, analytic number theory, nonlinear evolution equations, and algebraic combinatorics.

Allen Knutson

Response

I am deeply touched and honoured, and perhaps even a little surprised, to receive this award. Allen and I were fascinated by this problem of summing Hermitian matrices ever since we were graduate students, and we were always struck by just how much geometric, algebraic, and combinatorial structure underlies this innocuous-sounding problem.

Terence Tao

This area of mathematics is highly interdisciplinary, benefitting from ideas in fields as diverse as algebraic geometry, symplectic geometry, representation theory, enumerative combinatorics, linear algebra, and the geometry and combinatorics of convex polytopes; this topic seems to draw the interest of mathematicians from many other fields (for instance, I myself was drawn to this problem despite being primarily in analysis). I hope our article helps popularize this topic further. (An excellent survey of the field can be found in the reference [F2] in the cited article.)

Some further progress has been achieved since the publication of the *Notices* article. For instance, we now understand that while honeycombs (and the closely related Littlewood-Richardson rule) "solve" the Hermitian matrix and $U(n)$ tensor product problems, they are in fact much more tightly connected with the "infinite negative curvature" or "zero temperature" variants of those problems.

Indeed, recent work of Speyer has connected honeycombs to a variant of the Hermitian matrix problem in which the underlying field C is replaced by the field $C\{t\}$ of Pusieux series, while recent work of Henriques and Kamnitzer has also connected honeycombs to GL_n crystal representations. Meanwhile, there have now been several alternative proofs of the Horn and saturation conjectures (in very different settings) which use completely different techniques, such as Derksen and Weyman's proof of the saturation conjecture via quiver representations, Kapovich-Leeb-Millson's proof of the saturation conjecture via the theory of modules over discrete valuation rings, or Belkale's geometric proof of the Horn and saturation conjectures via the transversality analysis of Schubert varieties.

There are clearly some very rich interconnections between very distinct areas of mathematics here, and there is much that is still left to be done; we are nowhere close to uncovering the underlying theory which explains all of these connections. For instance, the situation when the underlying group $U(n)$ (or GL_n) is replaced by another Lie group is still only partially understood. Another completely open question is how these honeycombs "converge" in the large dimensional limit (as n goes to infinity), as there should definitely be some connection with free probability and free convolution.

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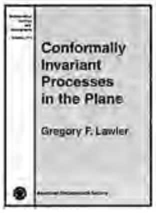

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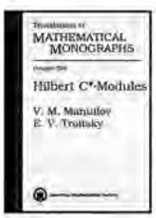

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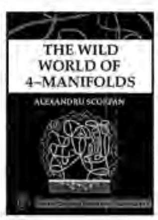

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2004 Morgan Prize

The 2004 AMS-MAA-SIAM Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student was awarded at the Joint Mathematics Meetings in Atlanta in January 2005.

The Morgan Prize is awarded annually for outstanding research in mathematics by an undergraduate student (or students having submitted joint work). Students in Canada, Mexico, and the United States or its possessions are eligible for consideration for the prize. Established in 1995, the prize was endowed by Mrs. Frank Morgan of Allentown, Pennsylvania, and carries the name of her late husband. The prize is given jointly by the AMS, the Mathematical Association of America (MAA), and the Society for Industrial and Applied Mathematics (SIAM) and carries a cash award of $1,000.

Recipients of the Morgan Prize are chosen by a joint AMS-MAA-SIAM selection committee. For the 2004 prize the members of the selection committee were: Svetlana R. Katok, Herbert A. Medina, Kris Stewart, Philippe M. Tondeur (chair), and Paul Zorn.

Previous recipients of the Morgan Prize are: Kannan Soundararajan (1995), Manjul Bhargava (1996), Jade Vinson (1997), Daniel Biss (1998), Sean McLaughlin (1999), Jacob Lurie (2000), Ciprian Manolescu (2001), Joshua Greene (2002), and Melanie Wood (2003).

The 2004 Morgan Prize was awarded to Reid W. Barton. Receiving an honorable mention was Po-Shen Loh. The text that follows presents the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize. The same information is provided for the honorable mention.

Reid W. Barton

Citation

The winner of the 2004 Morgan Prize for Outstanding Research in Mathematics by an Undergraduate is Reid W. Barton. The award is based on the research paper "Packing densities of patterns".

Packing densities were introduced by Herb Wilf in 1992–93. Some of the early questions were settled by Alkes Price, Fred Galvin, and Walter Stromquist. Recent contributions were made by M. H. Albert, M. D. Atkinson, C. C. Handley, D. A. Holton, W. Stromquist, A. Burstein, P. Hästö, and T. Mansour. The main goal of Barton's paper is to extend the theory of packing densities of permutations to that of patterns, i.e. words allowing repetition of letters. After resolving the basic conceptual issues elegantly, Barton delves into the study of packing densities for specific families of layered patterns. He proves several important results, some generalizing earlier results by the above-mentioned authors, some opening up new vistas. Barton also outlines a possible program to tackle open questions and formulates new conjectures. This is all in all a remarkable debut paper in the area of pattern research in combinatorics, an area of considerable current interest. Commentators consider Barton's paper the best paper so far on packing densities and praise it for its clarity, new techniques, and new results.

Biographical Sketch

Reid W. Barton is a senior at the Massachusetts Institute of Technology majoring in mathematics. A resident of Arlington, Massachusetts, Reid began his formal studies in mathematics at Tufts University while in middle school. As a high school student, he earned four gold medals at the International Mathematical Olympiad, placing first with a perfect score in 2001. That year he also placed first at the International Olympiad in Informatics, earning his second IOI gold medal. As an undergraduate, he has been designated a Putnam Fellow the past three years and has been a member of MIT's Putnam team, which placed first in 2003 and second in 2001. Reid has also competed on MIT's ACM International Collegiate Programming Contest team, finishing fifth and second at the 2003 and 2001 World Finals respectively. An accomplished pianist, Reid performs in

MIT Chamber Music Society groups. He is an avid bridge player and also enjoys playing intramural soccer, hockey, and ultimate.

Response

I am very honored to receive the 2004 Frank and Brennie Morgan Prize. I would like to thank the AMS-MAA-SIAM Morgan Prize Committee for selecting me for this award. I would also like to thank Joe Gallian, director of the Duluth REU [Research Experiences for Undergraduates], for providing the opportunity to do research on a challenging problem in a stimulating environment, and all those affiliated with the Duluth REU who gave me feedback on my research.

Honorable Mention: Po-Shen Loh

Citation

The Morgan Prize Committee is pleased to award honorable mention for the 2004 Morgan Prize for Outstanding Research in Mathematics by an Undergraduate to Po-Shen Loh. This recognition is based on his senior thesis at Caltech on "Random graphs and the second eigenvalue problem".

His result is a probabilistic estimate. It extends the work of Alon and Roichman involving the second-largest eigenvalue of the Cayley graph of a sufficiently large group with respect to a subset of a certain size. The improvement upon the Alon/Roichman result comes from replacing the order of the group by the sum of degrees of its irreducible representations. This is considerably smaller for nonabelian groups in general.

The second-largest eigenvalue of a graph is a characterization of the expansion of the graph, which is an important concept in combinatorics and the theory of computation. Graphs with large expansion are used in the derandomization of algorithms, the design of error correcting codes, and other applications. Their investigations have been an active research area for two decades. Po-Shen Loh's contribution is a nice result and the promise of great things to come.

Biographical Sketch

Po-Shen Loh received his mathematics degree from Caltech in 2004 and is currently studying mathematics at the University of Cambridge on a one-year Winston Churchill Foundation Scholarship. This fall he will start his Ph.D. at Princeton University, aided by fellowships from the Hertz Foundation and the National Science Foundation. As a grade-school student in Madison, Wisconsin, Po-Shen first developed his dual interests in mathematics and computer science through competitions, representing the United States at the international level in both subjects. At Caltech these interests migrated to research, thanks to many supportive faculty in the mathematics, applied mathematics, and computer science departments and to Caltech's Summer Undergraduate Research Fellowship program.

Po-Shen's research interests, combinatorics and its applications, are the product of this varied background. In his spare time at Cambridge, Po-Shen explores topics in other fields, tinkers with computers, and enjoys the British countryside with his wife, a fellow Caltech graduate.

Response

I feel very honored to be designated Honorable Mention for this award, and I am very grateful to all of the people involved in organizing this prize competition. I would like to mention several institutions and individuals who contributed significantly to this final result. Caltech provided a special close-knit academic and social atmosphere that allowed my creativity and imagination to flourish, and its Summer Undergraduate Research Fellowship program gave me the opportunity to explore various fields of research during the summers of 2000, 2001, 2002, and 2003. During those summers I worked for three wonderful Caltech advisors: Alain Martin and Leonard Schulman from computer science, and Emmanuel Candes from applied mathematics. Leonard Schulman supervised my 2003 project, which evolved into the senior thesis that won this Honorable Mention. His guidance was essential. I would also like to recognize the mathematics department at Caltech, in whose supportive company I developed the bulk of my mathematical knowledge. Finally, thank you to Debbie, my family, and my friends for your consistent support and encouragement.