2002 Steele Prizes

The 2002 Leroy P. Steele Prizes were awarded at the 108th Annual Meeting of the AMS in San Diego in January 2002.

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) Mathematical Exposition: for a book or substantial survey or expository-research paper; (2) 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; and (3) 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. 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 2002 prizes, the members of the selection committee were: M. S. Baouendi, Sun-Yung A. Chang, Michael G. Crandall, Constantine M. Dafermos, Daniel J. Kleitman, Hugh L. Montgomery, Barry Simon, S. R. S. Varadhan (chair), and Herbert S. Wilf.

The list of previous recipients of the Steele Prize may be found in the November 2001 issue of the *Notices*, pages 1216–20, or on the AMS website at `http://www.ams.org/prizes-awards/`.

The 2002 Steele Prizes were awarded to Yitzhak Katznelson for Mathematical Exposition, to Mark Goresky and Robert MacPherson for a Seminal Contribution to Research, and to Michael Artin and Elias Stein 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: Yitzhak Katznelson

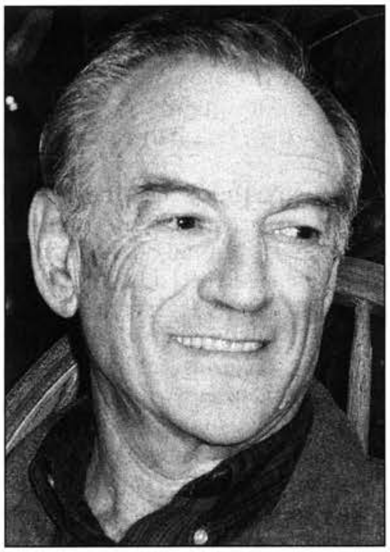
Citation

Although the subject of harmonic analysis has gone through great advances since the sixties, Fourier analysis is still its heart and soul. Yitzhak Katznelson's book on harmonic analysis has withstood the test of time. Written in the sixties and revised later in the seventies, it is one of those "classic" Dover paperbacks that has made the subject of harmonic analysis accessible to generations of mathematicians at all levels.

The book strikes the right balance between the concrete and the abstract, and the author has wisely chosen the most appropriate topics for inclusion. The clear and concise exposition and the presence of a large number of exercises make it an ideal source for anyone who wants to learn the basics of the subject.

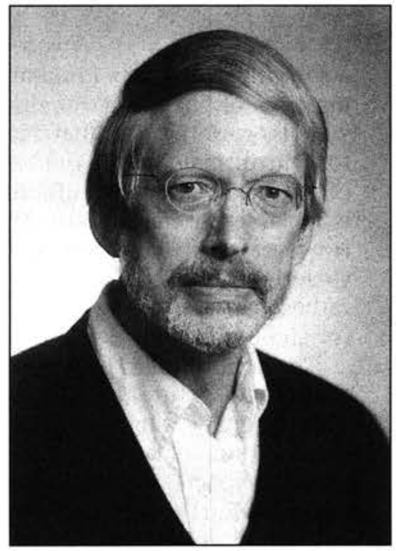
Biographical Sketch

Yitzhak Katznelson was born in Jerusalem in 1934. He graduated from the Hebrew University with a



Yitzhak Katznelson

Mark Goresky



Robert MacPherson

master's degree in 1956 and obtained the Dr. és Sci. degree from the University of Paris in 1959.

After a year as a lecturer at the University of California, Berkeley, and a few more at the Hebrew University, Yale University, and Stanford University, he settled in Jerusalem in 1966. Until 1988 he taught at the Hebrew University, while making extended visits to Stanford and Paris. He is now a professor of mathematics at Stanford University.

Katznelson's mathematical interests include harmonic analysis, ergodic theory (and in particular its applications to combinatorics), and differentiable dynamics.

Response

What a pleasant surprise!

I am especially gratified by the committee's approval of "the balance between the concrete and the abstract," which was one of my main concerns while teaching the course and while developing the notes into a book.

How should one look at things, and in what generality? If a statement and its proof apply equally in an abstract setup, should it be introduced in the most general or the most familiar terms?

When I came to Paris in 1956 I heard a rumor that the old way of doing mathematics was being replaced by a new, "abstract" fashion which was the only proper way of doing things. The rumor was spread mostly by younger students—typically hugging a freshly-purchased volume of Bourbaki—but seemed confirmed also by the way some courses were taught.

As late as 1962, Kahane and Salem found the need to apologize (undoubtedly tongue-in-cheek) in the preface to their exquisite book *Ensembles Parfaits et Séries Trigonométriques* for dealing with subject matter that might be considered too concrete.

The balance I tried to strike in the book—and I believe that I was strongly influenced by Kahane and Salem—was to set up the subject matter in the most concrete terms and allow as much generality and abstraction as needed for development, methods, and solutions.

Seminal Contribution to Research: Mark Goresky and Robert MacPherson

Citation

In two closely related papers, "Intersection homology theory", *Topology* 19 (1980), no. 2, 135–62 (IH1) and "Intersection homology. II", *Invent. Math.* 72 (1983), no. 1, 77–129 (IH2), Mark Goresky and Robert MacPherson made a great breakthrough by discovering how Poincaré duality, which had been regarded as a quintessentially manifold phenomenon, could be effectively extended to many singular spaces. Viewed topologically, the key difficulty had been that Poincaré duality reflects the transversality property that holds within a manifold but which fails in more general spaces. IH1 introduced "intersection chain complexes", which are the subcomplexes of usual chain complexes consisting of those chains which satisfy a transversality condition with respect to the natural strata of a space. More precisely, by introducing a kind of measure, called a "perversity", of the amount of variation from transversality a chain would be allowed, Goresky and MacPherson actually introduced a parametrized family of intersection chain complexes. Each of these yielded a corresponding sequence of intersection homology groups, and these theories intermediated between homology and cohomology. Starting with methods of local piecewise-linear transversality that had been developed by investigations of M. Cohen, E. Akin, D. Stone, and C. McCrory, IH1 showed that its intersection homology theories were related to each other by a version of Poincaré duality; in particular, the intersection homology theory which was positioned midway between homology and cohomology satisfied, when defined, a self-duality, as was familiar for manifolds. This immediately yielded a signature invariant for many singular varieties, and that, in turn, was used in IH1 to yield, in analogy with the Thom-Milnor treatment of piecewise linear manifolds, rational characteristic classes for many triangulated singular varieties. However, these characteristic classes of singular varieties naturally were elements in homology rather than cohomology groups, a distinction which for singular varieties was significant.

The continuation paper, IH2, reformulated this theory in a natural and powerful sheaf language. This language, suggested by Deligne, gave local formulations of a version of Poincaré duality for singular spaces in terms of a Verdier duality of sheaves. Furthermore, IH2 presented beautiful axiomatic characterizations of its intersection chain sheaves. These were all the more valuable as the achievement of duality for nonsingular spaces came at the cost of giving up the familiar functorial and homotopy properties that characterized usual homology theories; in particular, intersection homology theory is not a "homology theory" in the sense of homotopy theory.

IH1 and IH2 made possible investigations across a great spectrum of mathematics which further extended key classical manifold phenomena and methods to singular varieties and used these to solve well-known problems. While it is impossible to list all of these, a few important ones in 1) differential geometry, 2) algebraic geometry and representation theory, 3) geometrical topology, and 4) geometrical combinatorics will be indicated.

1) An immediate question was the relation of intersection homology theory to an analytic theory of L^2 differential forms and L^2 cohomology on suitable singular varieties with metrics that J. Cheeger had concurrently developed. In fact, for many metrics the resulting groups were seen to be isomorphic by a generalization of the classical de Rham isomorphism of manifold theory. Questions about when and how this can be generalized to various natural metrics have since occupied many investigators.

2) The work of IH2 led to the discovery of the important category $P(X)$ of perverse sheaves on an algebraic variety X. In the case when X is a smooth algebraic variety over a field of characteristic zero the [generalized] Riemann-Hilbert theorem says that the category $P(X)$ is equivalent to the category of D-modules on X. This equivalence made possible the applications of Grothendieck's yoga to the theory of D-modules and, in particular, to the formulation and proof of the Kazhdan-Lusztig conjecture, which gives a formula for characters of reducible representations of Lie groups in terms of intersection homology of the closures of Schubert cells. In the case when X is an algebraic variety over a finite field F, $P(X)$ is used in investigating "good" functions on the points $X(F)$ of X over F. This is the basic ingredient in the geometrization of representation theory which has had remarkable successes in recent years.

3) Paul Segal used the methods of Goresky and MacPherson and a cobordism theory of singular varieties to show that their rational characteristic classes could in many cases be lifted, after inverting 2, to a KO-homology class. Intersection chain sheaves were extensively used in various collaborations of Cappell, Shaneson, and Weinberger which extended results of classical Browder-Novikov-Sullivan-Wall surgery theory of manifolds to yield topological classifications of many singular varieties, which developed new invariants for singular varieties and their transformation groups, which gave methods of computing the characteristic classes of singular varieties, and which related these to knot invariants.

4) In investigations of the geometrical combinatorics of convex polytopes, the intersection homology groups of their associated toric varieties have become a fundamental tool. This began with R. Stanley's investigations of the face vectors of polytopes. A calculation of the Goresky-MacPherson characteristic classes of toric varieties was used by Cappell and Shaneson in obtaining an Euler-MacLaurin formula with remainder for lattice sums in polytopes. Recent works of MacPherson and T. Braden on flags of faces of polytopes used results on the intersection chain sheaves of toric varieties. The already astonishing range of research areas influenced by this seminal work continues to grow.

Biographical Sketch: Mark Goresky

Mark Goresky received his B.Sc. from the University of British Columbia in 1971 and attended graduate school at Brown University. He spent the 1974–75 academic year at the Institut des Hautes Études Scientifiques and received his Ph.D. in 1976. He was a C. L. E. Moore Instructor at the Massachusetts Institute of Technology (1976-78) and an assistant professor at UBC (1978-81). In 1981 he moved to Northeastern University, where he eventually attained the rank of professor with a joint appointment in mathematics and computer science. Since 1995 he has lived in Princeton, New Jersey, where he is currently a member at the Institute for Advanced Study. He has held other visiting positions at the University of Chicago, the Max-Planck-Institut für Mathematik, the IHÉS, and the University of Rome.

Goresky received a Sloan Fellowship in 1981. He is a fellow of the Royal Society of Canada, and he received the Coxeter-James Award (1984) and the Jeffrey-Williams Prize (1996) from the Canadian Mathematical Society.

Biographical Sketch: Robert MacPherson

Robert MacPherson received a B.A. from Swarthmore College and a Ph.D. from Harvard University.

He held faculty positions at Brown University from 1970 to 1987, at MIT from 1987 to 1994, and at the Institute for Advanced Study since then. Over the years, he has held visiting positions at the Institut des Hautes Études Scientifiques in Paris, Université de Paris VII, Steklov Institute in Moscow, IAS in Princeton, Università di Roma I, University of Chicago, Max-Planck-Institut für Mathematik in Bonn, and Universiteit Utrecht. He received the National Academy of Sciences Award in Mathematics and honorary doctorates from Brown University and Université de Lille. He served as chair of the National Research Council's Board on Mathematical Sciences from 1997 to 2000. He is a member of the American Academy of Arts and Sciences, the National Academy of Sciences, and the American Philosophical Society.

Response

We are very grateful to the American Mathematical Society for awarding us the Steele Prize. We are particularly pleased to receive a joint prize for our joint research. We know of no other mathematical prize that is awarded jointly to the participants of a collaboration. Given the increasing role of collaborative research in mathematics, this policy on the part of the AMS seems particularly enlightened to us.

In September 1974 we began a year at the Institut des Hautes Études Scientifiques with a pact to try to understand what intersection theory should mean for singular spaces. We thought the question might have importance for several areas of mathematics, given the ubiquity with which singular spaces naturally arise. By late autumn, we had found intersection homology and Poincaré duality. Jeff Cheeger, Pierre Deligne, Clint McCrory, John Morgan, and Dennis Sullivan played significant roles in the early stages of this research.

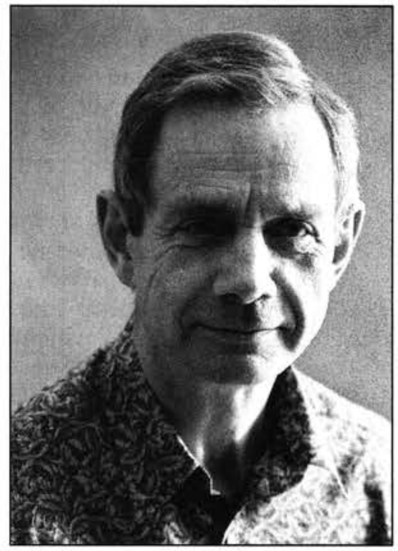
Starting around 1980, an explosion of activity surrounding intersection homology occurred. Our dream that the subject would find applications suddenly became true. Many mathematicians contributed a remarkable collection of ideas to this activity, and our collaboration was swept along with this flow into new fields such as combinatorics and automorphic forms.

Today, extensions and applications of the theory are pursued by a new generation of highly talented mathematicians, some of whom have already received mathematical awards in Europe (where prizes for younger mathematicians are more common). It is gratifying to see that these ideas, in whose discovery we participated, are now in such capable hands.

Lifetime Achievement: Michael Artin

Citation

Michael Artin has helped to weave the fabric of modern algebraic geometry. His notion of an algebraic space extends Grothendieck's notion of scheme. The point of the extension is that Artin's theorem on approximating formal power series solutions allows one to show that many moduli spaces are actually algebraic spaces and so can be studied by the methods of algebraic geometry. He showed also how to apply the same ideas to the algebraic stacks of Deligne and Mumford. Algebraic stacks and algebraic spaces appear everywhere in modern algebraic geometry, and Artin's methods are used constantly in studying them.



Michael Artin

He has contributed spectacular results in classical algebraic geometry, such as his resolution (with Swinnerton-Dyer in 1973) of the Shafarevich-Tate conjecture for elliptic $K3$ surfaces. With Mazur, he applied ideas from algebraic geometry (and the Nash approximation theorem) to the study of diffeomorphisms of compact manifolds having periodic points of a specified behavior.

For the last twenty years he has worked to create and define the new field of noncommutative algebraic geometry.

Artin has supervised thirty doctoral students and influenced a great many more. His undergraduate algebra course was for many years one of the special features of an MIT education; now some of that insight is available to the rest of the world through his textbook.

Biographical Sketch

I have departed from the usual format here to write a bit about my early life and the origins of my interest in mathematics.

When I was nearly forty years old I had a revelation: A recurring dream that I'd had since age twelve was an allegory of my birth! In the dream, I was stuck in a secret passage in our house but eventually worked my way out and emerged into a sunlit cupola. After my revelation, the dream went away.

My mother says that I was a big baby and it was a difficult birth, although I don't know what I weighed. The conversion from German to English pounds adds ten percent, and I suspect that my mother added another ten percent every few years. She denies this, of course. Anyway, I'm convinced that a birth injury caused my left-handedness and some seizures, which, fortunately, are under control.

The name Artin comes from my great-grandfather, an Armenian rug merchant who moved to Vienna in the nineteenth century.

Armenians were declared "Aryan" by the Nazis, but one side of my mother's Russian family was Jewish, and because of this, my father Emil was fired from the university in Hamburg. We came to America in 1937, when I was three years old.

My father loved teaching as much as I do, and he taught me many things: sometimes mathematics, but also the names of wild flowers. We played music and examined pond water. If there was a direction in which he pointed me, it was toward chemistry. He never suggested that I should follow in his footsteps, and I never made a conscious decision to become a mathematician.

I had decided to study science when I began college, but fields such as chemistry and physics gradually fell away, until biology and mathematics were the only ones left. I loved them both, but decided to major in mathematics. I told myself that changing out of mathematics might be easier, since it was at the theoretical end of the science spectrum, and I planned to switch to biology at age thirty when, as everyone knew, mathematicians were washed up. By then I was too involved with algebraic geometry. My adviser Oscar Zariski had seen to that.

Response

I thank the AMS and the prize committee for choosing to award me the Steele Prize for Lifetime Achievement, and I congratulate my fellow recipient Eli Stein. This award gives me great pleasure.

I also want to thank the many inspiring people who have surrounded me throughout my career. It has been a privilege to teach at MIT, where the students are gifted and motivated, and where my colleagues are as deserving of an award for lifetime achievement as I am. My thesis students there have been a constant source of inspiration. The financial support provided by the National Science Foundation for my work has been invaluable.

Alexander Grothendieck, Barry Mazur, John Tate, and of course my thesis adviser Oscar Zariski, are among the people who influenced me the most during the 1950s and 1960s. Those were exciting times for algebraic geometry. The crowning achievement of the Italian school, the classification of algebraic surfaces, was just entering the mainstream of mathematics. The sheaf theoretic methods introduced by Jean-Pierre Serre were being absorbed, and Grothendieck's language of schemes was being developed. Zariski's dynamic personality, and the explosion of activity in the field, persuaded me to work there. I became his student along with Peter Falb, Heisuke Hironaka, and David Mumford. Later, in the 1960s, I visited the Institut des Hautes Études Scientifiques several times to work with Grothendieck and Jean-Louis Verdier.

My interest in noncommutative algebra began with a talk by Shimshon Amitsur and a visit to Chicago, where I met Claudio Procesi and Lance Small. They prompted my first foray into ring theory, and in subsequent years noncommutative algebra gradually attracted more of my attention. I changed fields for good in the mid-1980s, when Bill Schelter and I did experimental work on quantum planes using his algebra package, Affine.

My early training has led me to concentrate on dimension two, or noncommutative surfaces. They display many interesting phenomena which remain to be explained, and I've come to understand that two is a critical dimension. Thanks to recent work of people such as Johan de Jong, Toby Stafford, and Michel Van den Bergh, the methods of algebraic geometry are playing a central role in this area too, and I hope to see it absorbed into the mainstream in the near future.

Lifetime Achievement: Elias Stein

Citation

During a scientific career that spans nearly half a century, Eli Stein has made fundamental contributions to different branches of analysis.

In harmonic analysis, his Interpolation Theorem is a ubiquitous tool. His result about the relation between the Fourier transform and curvature revealed a deep and unsuspected property and has far reaching consequences. His work on Hardy spaces has transformed the subject. He has made important contributions to the representation theory of Lie groups as well.

Elias Stein

His work on several complex variables is equally striking. His explicit approximate solutions for the $\bar{\partial}$-problems made it possible to prove sharp regularity results for solutions in strongly pseudoconvex domains. In this connection he also obtained subelliptic estimates which sharpened and quantified Hörmander's hypoellipticity theorem for second order operators.

Besides his contributions through his own research and excellent monographs, Stein has worked with and influenced many students, who have gone on to make profound contributions of their own.

Biographical Sketch

Elias M. Stein was born in Belgium in 1931 and came to the U.S. at the age of ten. He received his Ph.D. from the University of Chicago in 1955. Since 1963 he has taught at Princeton University, where he has served twice as chair of the mathematics department (1968–71 and 1985–87).

Stein's many fellowships and awards include a National Science Foundation Postdoctoral Fellowship (1955–56), an Alfred P. Sloan Foundation Fellowship (1961–63), Guggenheim Fellowships (1976–77 and 1984–85), membership in the National Academy of Sciences (1974) and the American Academy of Arts and Sciences (1982), the von Humboldt Award (1989–90), the Schock Prize from the Swedish Academy of Sciences (1993), and the Wolf Prize (1999). He was awarded the AMS Steele Prize in 1984 for his book *Singular Integrals and the Differentiability Properties of Functions* published in 1970 by Princeton University Press. Stein received an honorary Ph.D. from Peking University and an honorary D.Sc. from the University of Chicago.

Response

I want to express my deep appreciation to the American Mathematical Society for the honor represented by this award. At this occasion I am mindful of the great debt I owe others for my present good fortune. Beginning with my teachers and mentors and continuing with my peers, colleagues, and students, I have had the advantage of their warm support and encouragement and the indispensable benefit of their inspiration and help. To all of them I am very grateful.

I would like also to say something about the area of mathematics of which I am a representative. For more than a century there has been a significant and fruitful interaction between Fourier analysis, complex function theory, partial differential equations, real analysis, as well as ideas from other disciplines such as geometry and analytic number theory, etc. That this is the case has become increasingly clear, and the efforts and developments involved have, if anything, accelerated in the last twenty or thirty years. Having reached this stage, we can be confident that we are far from the end of this enterprise and that many exciting and wonderful theorems still await our discovery.

2002 Bôcher Prize

The 2002 Maxime Bôcher Memorial Prize was awarded at the 108th Annual Meeting of the AMS in San Diego in January 2002.

The Bôcher Prize is awarded every three years for a notable research memoir in analysis that has appeared during the previous five years in a recognized North American journal (until 2001, the prize was usually awarded every five years). 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 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 2002 prize, the members of the selection committee were: Luis Caffarelli, Sergiu Klainerman (chair), and Linda Preiss Rothschild.

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), and Thomas Wolff (1999).

The 2002 Bôcher Prize was awarded to Daniel Tataru, Terence Tao, and Fanghua Lin. 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.

Daniel Tataru

Citation

The Bôcher Memorial Prize in 2002 is awarded to Daniel Tataru for his fundamental paper "On global existence and scattering for the wave maps equations", *Amer. Jour. of Math.* 123 (2001) no. 1, 37–77. The paper introduces a remarkable functional framework which has played an important role in the recent breakthrough of T. Tao on the critical regularity for wave maps in two and three dimensions. The work of Tataru and Tao opens up exciting new possibilities in the study of nonlinear wave equations.

The prize also recognizes Tataru's important work on Strichartz estimates for wave equations with rough coefficients and applications to quasilinear wave equations, as well as his many deep contributions to unique continuation problems.

Biographical Sketch

Daniel Tataru was born on May 6, 1967, in a small city in the northeast of Romania. He received his undergraduate degree in 1990 from the University of Iasi, Romania, and his Ph.D. in 1992 from the University of Virginia. He was assistant, associate, and then full professor at Northwestern University (1992–2001) with a two year interruption when he visited the Institute for Advanced Study and Princeton University (1995–97). Since 2001 he has been a professor of mathematics at the University of California at Berkeley.

Response

I feel very honored to receive the 2002 Bôcher Prize, for which I am grateful to the selection committee and the American Mathematical Society. I would like to take this opportunity to acknowledge several people who have significantly influenced my work. My undergraduate mentor, Viorel Barbu, provided a model and an inspiration for me on what it means to be a mathematician. Later, my thesis advisors, Irena Lasiecka and Roberto Triggiani, through their professional support as well as their warmth, helped me grow, move on confidently, and adjust successfully here in the U.S. From them I learned control theory, which subsequently served both as a motivation and as a source of good problems in unique continuation. Sergiu Klainerman is the one who introduced me to nonlinear hyperbolic equations. I thank him for his constant support and for a fruitful collaboration during my years in Princeton. I am also grateful for the help and the encouragement that I received earlier in my career from M. G. Crandall, J. L. Lions, and P. L. Lions, as well as for the support of my friends and former colleagues at Northwestern. In addition, I continue to learn from my collaborators Herbert Koch and Hart Smith.

The wave maps equation is a semilinear second order hyperbolic equation which models the evolution of "waves" which take values into a Riemannian manifold. The starting point of the work in the citation was an earlier article of Klainerman and Machedon. At the time it was clear that bridging the gap between their result and the main wave maps conjecture required two distinct improvements of their argument. One was the so-called "division problem", which is related to controlling the bilinear interaction of waves at a fixed size of the frequency; the second was to control the interaction of low and high frequency waves in order to prevent the migration of the energy toward high frequency (which could lead to blow-up). These two problems correspond to two separate logarithmic divergencies in the work of Klainerman and Machedon, but, more importantly, they also correspond to the difference between a local and a global (in time) result. In the article cited I solved the first of these two problems; the second one was later solved by Tao. This was not an easy problem. Part of the difficulty lies in the construction of an appropriate functional framework. However, one does not have a good starting point for this, since the main condition this framework has to satisfy is a self-consistency condition. The solution was to start with a "reasonable" framework, proceed with the proof, and then backtrack and readjust the initial set-up whenever the argument did not work. While fairly intuitive, my approach is quite technical and I hope it can be simplified in the future. After the recent work of Tao there are still some finishing touches to be put on the study of the wave-maps equation. However, the more interesting problems which are still open are the other unsolved critical problems for the Yang-Mills equation, the nonlinear Schrödinger equation, and others.

My work on second order nonlinear hyperbolic equations was initially a byproduct of my attempt to use a phase space localization technique called the FBI transform for the analysis of partial differential operators with rough coefficients. Originally the FBI transform had been employed by Sjöstrand for the study of partial differential operators with analytic coefficients; as I learned later, it has also been used by physicists under the name of the Bergman transform. This approach produced sharp Strichartz type (dispersive) estimates for linear second order hyperbolic equations with rough coefficients, which in turn led to considerable progress in the local theory for second order nonlinear hyperbolic equations. At the same time an alternate approach for the nonlinear equations was pursued by Bahouri and Chemin, with comparable success. Later on, using Klainerman's vector fields method, Klainerman and Rodnianskii were able to improve my results. Around that time it became clear that the FBI transform is not robust enough for the study of nonlinear hyperbolic equations. My recent joint work with Hart Smith is based on another way of constructing a parametrix for the wave equation, using wave packets (which are highly localized solutions that stay coherent on a given time scale). The idea of constructing approximate solutions as superpositions of wave packets goes back to Fefferman, but its first effective use for second order hyperbolic equations is due to Smith. The joint work of myself and Smith largely completes the local theory for general second order nonlinear hyperbolic equations. The main open problem that remains is to understand whether the results can be improved for equations which have a special structure such as the Einstein equations, nonlinear elasticity, and other related problems.

Daniel Tataru

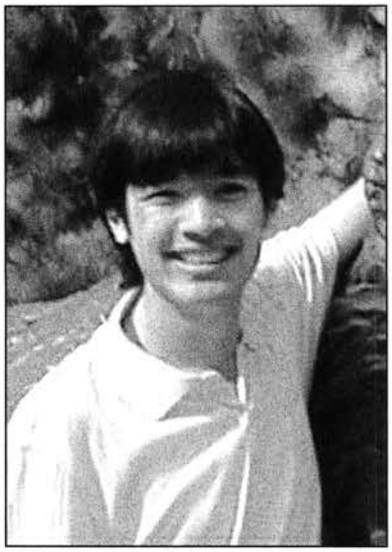
Unique continuation problems for PDEs have long been on my list of favorite topics. Originally my interest was motivated by problems in control theory, but later it took a life of its own. My view of the subject was influenced by the work of several mathematicians: L. Hörmander, G. Lebeau, L. Robbiano, C. Zuily, and others. Initially I worked on unique continuation problems which, up to that time, had received little or no attention: for boundary value problems, for operators with partially analytic coefficients, for anisotropic operators. Later on, in an ongoing joint project with Herbert Koch, I have returned to some of the more classical problems, but with a new twist: rough coefficients and/or unbounded potentials. The starting point for us was the seminal work of D. Jerison, C. Kenig, and T. Wolff.

Terence Tao

Citation

The Bôcher Memorial Prize in 2002 is awarded to Terence Tao for his recent fundamental breakthrough on the problem of critical regularity in Sobolev spaces of the wave maps equations, "Global regularity of wave maps I. Small critical Sobolev norm in high dimensions", *Int. Math. Res. Notices* (2001), no. 6, 299–328 and "Global regularity of wave maps II. Small energy in two dimensions", to appear in *Comm. Math. Phys.* (2001 or early 2002).

The committee also recognizes his remarkable series of papers, written in collaboration with J. Colliander, M. Keel, G. Staffilani, and H. Takaoka, on global regularity in optimal Sobolev spaces for KdV and other equations, as well as his many deep



Terence Tao

contributions to Strichartz and bilinear estimates.

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 (1996–1998), 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 Australian National University (2001). He is currently on leave from UCLA as a Clay Prize Fellow.

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.

Tao's research is divided into three areas: real-variable harmonic analysis (especially estimates for rough operators and connections with geometric combinatorics); nonlinear evolution equations (especially the global behavior of rough solutions); and algebraic combinatorics (specifically the understanding of the Littlewood-Richardson rule and its generalizations, and its applications to linear algebra, algebraic geometry, and representation theory).

Response

I am deeply flattered and honored to be nominated for the Bôcher Prize, and I am grateful to the prize committee for their recognition of this research. I have been extremely fortunate to have been supported, encouraged, and taught by many wonderful people and collaborated with many more. For the papers cited above I was particularly influenced by many invaluable conversations with Elias Stein, Tom Wolff, Jean Bourgain, Sergiu Klainerman, Chris Sogge, Daniel Tataru, Michael Christ, and my collaborators Mark Keel, Jim Colliander, Gigliola Staffilani, Hideo Takaoka, Ana Vargas, and Luis Vega. I am particularly grateful to Mark Keel and Sergiu Klainerman for giving me a thorough and expert introduction to the field of nonlinear wave and dispersive equations.

In the analysis of nonlinear dispersive equations, the tools used can be roughly divided into "analytical" tools and "algebraic" ones. By analytic tools I mean the use of function spaces such as Sobolev or Lebesgue spaces, coupled with linear, bilinear, multilinear, or nonlinear estimates in these spaces (which are often proven by harmonic analysis techniques). These estimates can allow one to apply perturbation theory and approximate a nonlinear equation by the linear analogue, at least for short times. By algebraic tools I refer to the use of conservation laws, symmetries, monotonicity formulae, special transformations, integrability, and explicit solutions. These algebraic identities give some partial control on the global development of solutions to the nonlinear PDE. To obtain satisfactory global control of solutions, one often combines the partial global control coming from the algebraic identities, with the more detailed but local control coming from the analytic techniques. For instance, perturbation theory might show that smooth solutions exist as long as the energy remains finite, while algebraic identities (i.e., integration by parts) might show that the energy remains constant. Combining the two one would then be able to show that smooth solutions exist globally in time, so that no singularities can ever form if the initial energy is finite.

Both the algebraic and analytic tools have been under development for many decades, the groundwork being laid by many excellent mathematicians. In the last ten years there has been immense progress, particularly in the analytic side of things, thanks to the efforts of Bourgain, Klainerman-Machedon, Kenig-Ponce-Vega, and many, many other authors. Indeed, our understanding of the local theory of nonlinear wave and dispersive equations has become quite satisfactory. Unfortunately, even when this local theory is completely understood, it does not always match up with the algebraic tools needed to create good global results; for instance, the local theory may need control of the solution in the Sobolev space H^2, but the conserved quantities might only control the solution in H^1.

One interesting development in recent years is that hybrid techniques, combining both analytical and algebraic ideas, have started to bridge some of the above gaps. In particular, the use of cutoff functions (in space, or in frequency, or in both), together with the latest linear and multilinear estimates, have been used to obtain "localized" conservation laws, "localized" evolution equations, "localized" gauge transforms, etc., which are more flexible than their global algebraic counterparts, and have had some recent successes. Notable applications of this type of philosophy include Bourgain's series of papers on nonlinear Schrödinger equations; the work by Martel and Merle on the stability of solitons for the generalized Korteweg de Vries equations; the many papers on global solutions below the energy norm (starting with work of Bourgain, and also including the papers by Colliander, Keel, Staffilani, Takaoka, and myself); the recent breakthroughs on quasilinear wave equations by Bahouri-Chemin, Tataru-Smith, and Klainerman-Rodnianski; and the recent series of papers on wave maps. For instance, one effective technique for constructing global solutions when the energy is infinite is to construct a smoothing operator, define the associated smoothed out energy, and show an approximate conservation law for the smoothed out energy. For wave maps, one new technique has been to localize the wave map to different frequency modes, and then gauge transform each frequency mode independently. The work on quasilinear wave equations is also interesting in that it seems to bring geometric optics back into the cutting edge of the theory. (Intriguingly, this has also occurred in the theory of oscillatory integrals, thanks to the work of Bourgain, Wolff, and others.)

In the future I believe we will see a more systematic synthesis of the analytic and algebraic techniques, perhaps ultimately leading to a unified theory for treating the development of nonlinear PDE; at present there are only tantalizing hints of such a theory. The end result should be a more powerful and flexible theory, allowing for much more detailed control on the global behavior of nonlinear PDE. (In particular, I hope to see finer control on the possible cascade of energy between frequencies, and on tracking particle-like behavior of solutions.)

Fanghua Lin

Citation

The Bôcher Memorial Prize in 2002 is awarded to Fanghua Lin for his fundamental contributions to our understanding of the Ginzburg-Landau (GL) equations with a small parameter. In a remarkable series of papers, among which we single out his pioneering work "Some dynamical properties of the GL vortices", *Comm. Pure Appl. Math.* (1996), 323–59, he has established, both in the stationary and evolutionary cases of GL equations, that the limiting phenomenon is governed by a finite dimensional system associated to the BBH renormalized energy.

The prize also recognizes his many deep contributions to harmonic maps and liquid crystals. Of particular note is his paper "Gradient estimates and blow-up analysis for stationary harmonic maps", *Annals of Math.* (2), 149 (1999), no. 3, 785–829.

Biographical Sketch

Fanghua Lin was born in China in 1959. He received a Ph.D. from the University of Minnesota (1985). He has held faculty positions at the Courant Institute (1985–88) and the University of Chicago (1988–89; 1996–97). Since 1989 he has been a professor of mathematics at New York University. Over the years, he has held numerous visiting positions, including those at MSRI, IAS, University of Paris-Sud, the Max Planck Institute, Academia Sinica, Hong Kong University of Science and Technology, and the University of Minnesota.

Fanghua Lin

Lin's awards and honors include an Alfred P. Sloan Fellowship (1989–91), a Presidential Young Investigator Award (1989–94), and the Chang Jiang Professorship (1999). He has served on the editorial committees of twelve mathematics journals, published over 110 research articles, and given numerous invited addresses.

Response

It is a great honor to be awarded the Bôcher Prize, and I am grateful to the members of the Bôcher Prize selection committee and the American Mathematical Society for their recognition of my work and this kind citation.

The Ginzburg-Landau (GL) equations with a small parameter were used to model superconductivity. They are also among the standard equations used to describe various phase transition phenomena. Many people have contributed to the study of these equations, and I interpret my receipt of this prize as a tribute to all of them.

My first paper on this subject established the connection between the critical points of the Bethuel, Brezis, Hélein (BBH) renormalized energy and the static solutions of the GL equations, one of many open problems posed in the seminal work of BBH. Soon after that, I learned the importance of various dynamical issues, particularly those concerned with vortex dynamics, and the scientific views of several of my colleagues at the Courant Institute (Weinan E and Andy Majda) and also of my collaborator Jack Xin have greatly influenced me. I had a lot of fun learning and solving some of these problems related to the vortex dynamics in 2-D.

The study of the GL equations in high dimensions is more subtle and involved. The analytical method that I developed jointly with T. Rivière can also be applied to study similar problems for the Seiberg-Witten and Yang-Mills equations. Nevertheless, many difficulties remain, especially those concerned with dynamical issues.

Much of my work relies on ideas from geometric measure theory, and I take this opportunity to thank my Ph.D. advisor, my long-time friend and collaborator, R. Hardt, for introducing me to this fascinating subject. I have been extremely lucky to have been at the Courant Institute, and I thank my colleagues there for their advice, support, and friendship during these past years. I also want to thank friends at the University of Chicago who have been very kind and offered a great deal of help during my career.

2002 Cole Prize in Number Theory

The 2002 Frank Nelson Cole Prize in Number Theory was awarded at the 108th Annual Meeting of the AMS in San Diego in January 2002.

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 on the occasion of his retirement as secretary of the AMS after twenty-five years of service. He also served as editor-in-chief of the *Bulletin* for twenty-one years. 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 2002 prize, the members of the selection committee were: Benedict Gross, Carl Pomerance, and Paul Vojta (chair).

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), and Andrew J. Wiles (1997).

The 2002 Cole Prize in Number Theory was awarded to Henryk Iwaniec and Richard Taylor. 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.

Henryk Iwaniec

Citation

The Frank Nelson Cole Prize in Number Theory is awarded to Henryk Iwaniec of Rutgers University for his fundamental contributions to analytic number theory. In particular, the prize is awarded for his paper (with J. Friedlander) "The polynomial $X^2 + Y^4$ captures its primes", in *Ann. Math.*, which is the first paper ever to show that an integer polynomial with "sparse" range takes on infinitely many prime values. The method is robust, and already D. R. Heath-Brown has extended the method to certain cubic polynomials. In addition, the prize is awarded for the series of papers (with W. Duke and J. Friedlander) "Bounds for automorphic L-functions, I, II, III", in *Invent. Math.*, and the paper (with B. Conrey) "The cubic moment of central values of automorphic L-functions", in *Ann. Math.* In these papers, critical-line bounds for L-functions associated to certain modular forms were greatly improved by novel methods, including an amplification technique that provided the starting point for J. W. Cogdell, I. Piatetskii-Shapiro, and P. Sarnak to finally resolve Hilbert's eleventh problem (on representation by quadratic forms in a number field). And, the prize is awarded for the paper (with P. Sarnak) "The nonvanishing of central values of automorphic L-functions and Landau-Siegel zeros", *Israel J. Math.*, for the introduction of far-reaching averaging and mollification techniques for families of automorphic L-functions.

Biographical Sketch

Henryk Iwaniec was born in Elblag, Poland, on October 9, 1947. He graduated from Warsaw University in 1971, and he received his Ph.D. there in 1972. From 1971 until 1983 he held various positions in the Institute of Mathematics of the Polish Academy of Sciences. In 1976 he defended his *habilitation* thesis. In the year 1976–77 he enjoyed a fellowship of the Accademia Nazionale dei Lincei at the Scuola Normale Superiore di Pisa. In 1979–80 he visited the University of Bordeaux. In 1983 he was promoted to professor. The same year he became member correspondent of the Polish Academy of Sciences.

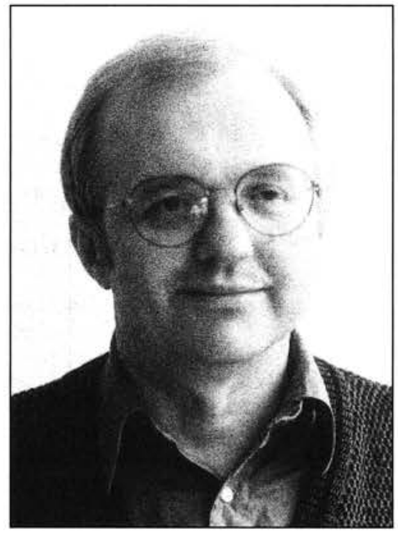
Iwaniec left Poland in 1983 to take visiting positions in the USA at the Institute for Advanced Study in Princeton (1983–84 and 1985–86) and the University of Michigan at Ann Arbor (summer 1984), and he was the Ulam Distinguished Visiting Professor at Boulder (fall 1984). In January 1987 he assumed his present position as New Jersey State Professor of Mathematics at Rutgers University. He was elected to the American Academy of Arts and Sciences in 1995. He spent the year 1999–2000 as a distinguished visiting professor at IAS. Recently he became a citizen of the USA.

Iwaniec received first prizes in the Marcinkiewicz contests for student works in the academic years 1968–69 and 1969–70. In 1978 he received the State Prize from the Polish Government, in 1991 he received the Jurzykowski Award from the Alfred Jurzykowski Foundation in New York, and in 1996 he received the Sierpinski Medal. Iwaniec was an invited speaker at the International Congress of Mathematicians in Helsinki (1978) and in Berkeley (1986).

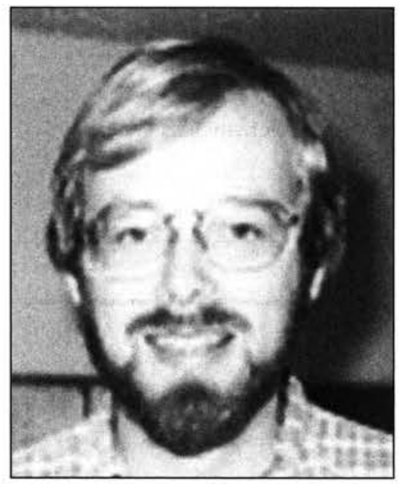
Response from Professor Iwaniec

I thank from my heart the American Mathematical Society and the committee of the Cole Prize for selecting me for this award. My joy is even greater when I think that this is a significant award for professional accomplishments from beyond my native country, and in particular that this is coming from my new homeland in the USA. Less emotional, nevertheless important for me, is also the feeling of larger recognition of analytic number theory which the Cole Prize manifests in this case. Indeed, all the works cited for the prize are joint with many of my colleagues. Without their collaboration I cannot imagine how could I get that far. Yes, working together offers an immediate satisfaction from sharing ideas, but above all it is the only way we can cultivate in depth the modern analytic number theory.

Analytic number theory pursues hard classical problems of an arithmetical nature by means of best available technologies from any branch of mathematics, and that is its beauty and strength. Analytic number theory is not driven by one concept; consequently it has no unique identity. Fourier analysis was always present, but in the last two decades it has been expanded to nonabelian harmonic analysis by employing the spectral theory of automorphic forms. For example, applying this analysis implicitly we have established the asymptotic distribution of primes in residue classes in the range beyond the capability of the Grand Riemann Hypothesis. Moreover, along these lines, we were able to produce primes in polynomial sequences. To this end one needs to enhance the Dirichlet characters by more powerful cusp forms on congruence groups. In a different direction we performed amplified spectral averaging from which to deduce important estimates for individual values of L-functions and to apply the latter to questions of equidistribution of many arithmetical objects. Other fruitful resources for solving problems in analytic number theory were uncovered by exploiting the Riemann hypothesis for varieties. Connections of these problems with the profound theory of Deligne are by no means straightforward. Perhaps these brief words may give some idea of what the trends are in the subject today, or at least what we are doing there.



Henryk Iwaniec



Richard Taylor

There are many colleagues to whom I owe my gratitude for inspiration and joint research over the last years; among them I would like to mention Enrico Bombieri, Brian Conrey, Jean-Marc Deshouillers, William Duke, John Friedlander, Etienne Fouvry, Philippe Michel, and Peter Sarnak.

Richard Taylor

Citation

The Frank Nelson Cole Prize in Number Theory is awarded to Richard Taylor of Harvard University for several outstanding advances in algebraic number theory. He led an effort to extend his earlier work with Wiles, to show that all elliptic curves over Q are modular, i.e., are factors of the Jacobians of modular curves. In his book with M. Harris, he established the local Langlands conjecture, giving a complete parametrization of the n-dimensional representations of a

Galois group of a local field. He has also made important progress on 2-dimensional Galois representations, establishing the Artin conjecture for an infinite class of nonsolvable cases, and increasing our understanding of the conjectures of Fontaine-Mazur and Serre.

Biographical Sketch

Richard Taylor was born on May 19, 1962, in Cambridge, England. At the age of two he moved to Oxford, where he grew up. In 1980 he went back to Cambridge for his undergraduate studies. In 1984 he moved to Princeton University for his graduate studies, receiving his Ph.D. in 1988 for a thesis on congruences between modular forms. His advisor was Andrew Wiles, who had a very great influence on Taylor's mathematical development.

After graduating Richard Taylor spent a postdoctoral year at the Institut des Hautes Études Scientifiques outside Paris. Encouraged and supported by John Coates, he then moved back to Cambridge University for six years. Following his marriage in 1995, he left Cambridge first for the Savilian chair of geometry at Oxford University, and a year later moved to Harvard University, where he is still employed. In 1990 he was awarded a junior Whitehead Prize by the London Mathematical Society, in 1992 he was awarded the Prix Franco-Brittanique by the French Académie des Sciences, and in 1995 he was elected a fellow of the Royal Society.

Richard Taylor is an algebraic number theorist working on the interconnections between automorphic forms and representations of Galois groups. In 1994 he collaborated with Andrew Wiles to repair the gap in Wiles' proof of Fermat's last theorem.

Response from Professor Taylor

It is a great honour and pleasure for me to receive the Frank Nelson Cole Prize. It is also an honour to share the prize with a mathematician I admire as much as Henryk Iwaniec. The citation mentions three papers and one book, on which I have worked with a total of seven collaborators. I would like to thank them all, above all for the enjoyment I have had working on these various projects.

2002 Award for Distinguished Public Service

The 2002 Award for Distinguished Public Service was presented at the 108th Annual Meeting of the AMS in San Diego in January 2002.

The Award for Distinguished Public Service is presented every two years to a research mathematician who has made a distinguished contribution to the mathematics profession during the preceding five years. The purpose of the award is to encourage and recognize those individuals who contribute their time to public service activities in support of mathematics. The award carries a cash prize of $4,000.

The Award for Distinguished Public Service is made by the AMS Council, acting on the recommendation of a selection committee. For the 2002 award, the members of the selection committee were: Frederick W. Gehring (chair), Peter D. Lax, D. J. Lewis, Calvin C. Moore, and William Y. Velez.

Previous recipients of the award are: Kenneth M. Hoffman (1990), Harvey B. Keynes (1992), I. M. Singer (1993), D. J. Lewis (1995), Kenneth C. Millett (1998), and Paul J. Sally Jr. (2000).

The 2002 Award for Distinguished Public Service was presented to MARGARET H. WRIGHT. The text that follows presents the selection committee's citation, a brief biographical sketch, and the recipient's response upon receiving the award.

Citation

The 2002 American Mathematical Society Award for Distinguished Public Service is presented to Professor Margaret H. Wright, newly appointed chair of computer science at New York University after fourteen years with the Computing Sciences Research Center at Bell Laboratories.

Margaret H. Wright

Professor Wright was elected to the National Academy of Engineering in 1997 and was chosen Emmy Noether Lecturer by the Association for Women in Mathematics and Forsythe Lecturer by the Computer Science Department at Stanford University in 2000.

Among her notable contributions to the federal government are service as chair of the Advisory Committee for the Directorate of Mathematical and Physical Sciences at the National Science Foundation, as current chair of the Advanced Scientific Computing Advisory Committee for the Department of Energy, and recently as a member of committees of the National Research Council.

Professor Wright's contributions to the scientific community include service as president of SIAM in 1995–96, as cochair of the Scientific Advisory Committee of the MSRI at Berkeley, California, as the current editor-in-chief of the *SIAM Review* and as an associate editor of the *SIAM Journal on Scientific Computation*, the *SIAM Journal on Optimization*, and the IEEE/AIP journal *Computation in Science and Engineering*.

Finally, Professor Wright has been active for many years in encouraging women and minority students, for example, by means of programs that brought them together with leaders and researchers from industry to discuss opportunities outside academia.

Biographical Sketch

Margaret H. Wright is professor of computer science and mathematics and chair of the Computer Science Department in the Courant Institute, New York University. From 1988–2001 she was with the Computing Sciences Research Center at Bell Laboratories, Lucent Technologies (formerly AT&T Bell Laboratories), where she was named a Distinguished Member of Technical Staff in 1993 and a Bell Labs Fellow in 1999. She served as head of the Scientific Computing Research Department from 1997–2000. From 1976–1988 she was a research staff member in the Systems Optimization Laboratory, Department of Operations Research, Stanford University.

She received her B.S. in mathematics and her M.S. and Ph.D. in computer science from Stanford University. Her research interests include optimization, linear algebra, numerical and scientific computing, and scientific and engineering applications.

She was elected to the National Academy of Engineering in 1997 and to the American Academy of Arts and Sciences in 2001. During 1995–1996 she served as president of the Society for Industrial and Applied Mathematics (SIAM), and she is now a member of the Board of Trustees; she was previously a member of the SIAM Council and Vice-President at Large. She is chair of the Advisory Committee on Advanced Scientific Computing for the Department of Energy's Office of Science and is currently chair of the peer committee in computer science and engineering at the National Academy of Engineering. She is also a member of the National Science Foundation Blue Ribbon Panel on Cyberinfrastructure. From 1996–2001 she served on the Scientific Advisory Committee of the Mathematical Sciences Research Institute (MSRI) and was cochair during 1999–2001.

In 2000 she was chosen as the Noether Lecturer by the Association for Women in Mathematics and as the Forsythe Lecturer by the Computer Science Department, Stanford University; she also received the Award for Distinguished Service to the Profession from SIAM.

Wright is editor-in-chief of *SIAM Review*, as well as an associate editor of the *SIAM Journal on Scientific Computing*, the *SIAM Journal on Optimization*, *Mathematical Programming*, and *Computing in Science and Engineering*.

Response

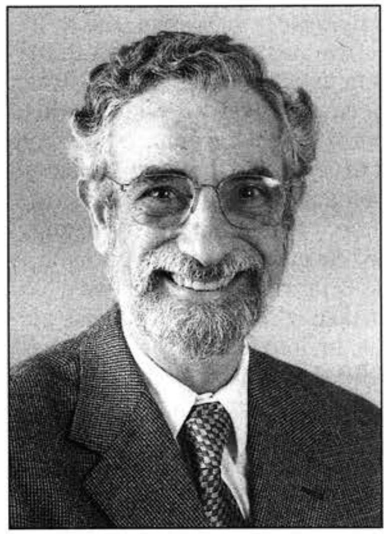
It is a great privilege for me to receive the 2002 Award for Distinguished Public Service, and I am deeply grateful to the selection committee and the American Mathematical Society.

Thinking about public service, I would like to echo some thoughts of Don Lewis, the 1995 recipient of this award and one of my heroes. In his response, Don stressed a point that deserves frequent repetition: Mathematical sciences research will thrive only if constant attention is paid to the multiple environments in which we work and live. Because mathematical scientists function in many different contexts, some broad, some narrow, it follows that public service takes many forms—improving education, encouraging students to pursue careers in mathematics, supporting young people in the mathematical sciences, arguing for funding, sustaining the vitality of scientific societies, and conveying the excitement and importance of scientific research.

Some of the activities mentioned in my citation involve service on committees, and I want to offer a plug for the joys of committee service. Despite the stereotype (undeniably true at times!) that the way not to get something done is to form a committee, being in the room when decisions are made—and they are often made by a committee—does matter. Since our community needs to be involved in discussions at all levels about science policy and education, we also need to be on committees at all levels. Happily, the best committees provide an opportunity to meet fascinating people and to appreciate and understand other points of view.

In everything that I have done, it has been a privilege to work with many outstanding, dedicated individuals. I thank them for providing irrefutable proof that public service can make a difference.

2002 Conant Prize



Elliott Lieb

Jakob Yngvason

The 2002 Levi L. Conant Prize was awarded at the 108th Annual Meeting of the AMS in San Diego in January 2002.

The Conant Prize is awarded annually to recognize the best 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 2002 prize, the members of the selection committee were: Brian J. Parshall, Anthony V. Phillips (chair), and Joseph H. Silverman.

The previous recipient of the Conant Prize is Carl Pomerance (2001).

The 2002 Conant Prize was awarded to Elliott H. Lieb and Jakob Yngvason. The text that follows presents the committee's citation, a brief biographical sketch, and the awardees' response upon receiving the prize.

Citation

The Levi L. Conant Prize in 2002 is granted to Elliott H. Lieb and Jakob Yngvason for their appealing and thought-provoking article "A Guide to Entropy and the Second Law of Thermodynamics", *Notices of the AMS* **45**, no. 5 (1998), 571–581.

"This article is intended for readers who, like us, were told that the second law of thermodynamics is one of the major achievements of the nineteenth century...but who were unsatisfied with the 'derivations' of the entropy principle as found in textbooks and in popular writings." Thus do Lieb and Yngvason begin their article. They proceed to take the reader on a tour of the second law of thermodynamics as seen through an axiomatic-mathematical lens, without ever losing the friendly and conversational tone of the start.

Abstractly, there is only a set G and a preorder $<$ on G. Interpreted physically, the elements of G represent states of a system, and the preorder $<$ is required to satisfy certain natural axioms that characterize when one state can "lead to" another state (specifically, when the second is adiabatically accessible from the first, in a precise sense that the authors make clear). The second law of thermodynamics is then formulated in terms of an entropy function on $(G, <)$, that is, a real-valued function S on G that characterizes $<$ and has certain additivity and scaling properties. The authors detail the search for simple, elegant, and mathematically precise axiom systems that allow the construction of an entropy function and, thus, that capture the powerful predictive capabilities of thermodynamics. In doing so, they illuminate a fascinating trail between the "pure" world of mathematical abstraction and the "real" world of physics, chemistry, and engineering.

Biographical Sketch: Elliott H. Lieb

Elliott H. Lieb was born in Boston, Massachusetts, in 1932. He received his B.Sc. degree from MIT in 1953 and his Ph.D. degree in mathematical physics from the University of Birmingham (UK) in 1956 under the direction of S. F. Edwards. He holds honorary doctorates from Copenhagen University and the École Polytechnique Fédérale de Lausanne. After a Fulbright postdoc in Kyoto, he held positions in Illinois, Cornell, IBM, Sierra Leone, Yeshiva, Northeastern, and MIT. From 1975 he has been a professor in the mathematics and physics departments of Princeton University.

He has received a number of prizes for his work in mathematics and mathematical physics, including the Birkhoff Prize of the AMS and the Society for Industrial and Applied Mathematics, the Rolf Schock Prize in mathematics of the Swedish Academy, the Heinemann Prize in mathematical physics of the American Physical Society, the Boltzmann Prize in statistical mechanics of the International Union of Pure and Applied Physics, and the Max-Planck Medal of the German Physical Society. He is a member of the U.S., Austrian, and Danish Academies of Science, and the American Academy of Arts and Sciences. He served twice as president of the International Association of Mathematical Physics. Invited lectures include the AMS Gibbs Lecture and the Hedrick Lecture of the Mathematical Association of America.

Biographical Sketch: Jakob Yngvason

Jakob Yngvason was born in Reykjavik, Iceland, in 1945. He studied physics at the University of Göttingen, Germany, receiving his Ph.D. there in 1973 under the direction of H. J. Borchers. He was assistant professor at the University of Göttingen from 1973 to 1978, and from 1978 to 1985 he was senior research scientist at the Science Institute of the University of Iceland in Reykjavik. From 1985 to 1996 he was professor of theoretical physics at the University of Iceland. Since 1996 he has been professor of mathematical physics at the University of Vienna, Austria. He is also president of the Erwin Schrödinger Institute for Mathematical Physics in Vienna and vice president of the International Association of Mathematical Physics. He has held visiting positions at many research institutions, including the Universities of Göttingen and Leipzig, Rutgers University, the Institut des Hautes Études Scientifiques in Bures-sur-Yvette, DESY in Hamburg, NORDITA in Copenhagen, and the Max Planck Institute for Physics in Munich.

His main research interests are in quantum field theory and rigorous quantum many-body theory. He was plenary speaker at the 13th International Congress on Mathematical Physics in Paris, 1994. He received the Olafur Danielsson Prize for Mathematics in 1993.

Response from Lieb and Yngvason

This award was a pleasant surprise to us. We had worked for many years to try to formulate the second law of thermodynamics—the law of increasing entropy—in a mathematically precise, yet accessible, way and were not sure to what extent we had succeeded in communicating our enthusiasm for the subject to our colleagues. It is a very much appreciated honor to have our *Notices* article counted as "the best expository paper published in the *Notices* or the *Bulletin* in the preceding five years."

Our article is based on a long and detailed analysis (in *Physics Reports* **310** (1999), 1–96) of one of the most precise laws of physics. It was discovered in the first half of the nineteenth century and by the beginning of the twentieth century had attracted the attention of mathematicians, notably Carathéodory. To this day many schools of thought continue this interest.

The twentieth century, however, tended to see the law as an "easy" consequence and "incomplete expression" of statistical mechanics (Gibbs). This is an overstatement since the "derivation" from statistical mechanics is, after more than a century, still in a rudimentary phase, and because the law itself makes no reference to statistical mechanics. That is to say, the second law could well hold even if the world were made of vortices in a seamless fluid instead of being made of atoms. Statistical mechanics is a beautiful and important subject, but it is essential to understand the second law in its own right if we are ever going to derive it from statistical mechanics. Beginning in the fifties some people (e.g., P. Landsberg, H. Buchdahl, G. Falk and H. Jung, and, most notably, R. Giles) advocated an approach to the law based on an order relation among equilibrium states. We built on this structure. The earlier work introduced a basic new axiom which we call "comparison"; one of our main contributions was to convert this from an axiom to a theorem.

The subject is not, and may never be, finished. Also, the logical structure may have use in other fields, such as economics. We would be delighted if our article motivated other mathematicians to take up the thread.

Our sincere thanks go to Beth Ruskai for urging us to write this article; to the editor, Tony Knapp, for patience and much helpful criticism; and to Sandy Frost for essential help with editing.

Mathematics People

Prizes of the Mathematical Society of Japan

Several annual prizes are awarded to mathematicians by the Mathematical Society of Japan (MSJ) at the autumn meeting of the Society.

The Autumn Prize of the MSJ is awarded for outstanding contributions to mathematics, in the highest and broadest sense, in the past five years. The Autumn Prize in the year 2001 is awarded to Atsushi Moriwaki of Kyoto University for his distinguished contributions to Arakelov geometry.

The Geometry Prize is awarded to a maximum of two geometers in recognition of major fundamental research in geometry. This prize was established with funds donated to the MSJ. The Geometry Prize in the year 2001 is awarded to Reiko Miyaoka of Sophia University for her outstanding contributions to the theories of Dupin hypersurfaces and minimal surfaces.

The Takebe Prize for outstanding research was established to encourage young mathematicians. The Takebe Senior Prize is awarded to recipients chosen from nominations by members of the MSJ. The Takebe Junior Prize is awarded to self-nominated recipients. The Takebe Prize in the year 2001 is awarded to the recipients listed below.

Takebe Senior Prize: Yukari Ito of Tokyo Metropolitan University for the study of crepant resolutions and the McKay correspondence; Yoshihide Kakizawa of Hokkaido University for the study of the asymptotic theory of statistics in time series analysis; Masanori Hino of Kyoto University for the study of stochastic analysis in infinite dimensional spaces; and Hideo Takaoka of Hokkaido University for the study of nonlinear dispersive equations by the high and low frequency method.

Takebe Junior Prize: Osamu Iyama of Kyoto University for the study of representation theory of orders; Akira Ushijima of the Tokyo Institute of Technology for the study of standard division of hyperbolic manifolds; Ken-ichi Kawarabayashi of Keio University for the study of circuits and chromatic numbers in graph theory; and Kanetomo Sato of Nagoya University for the study of cycle maps for varieties over arithmetic fields.

—MSJ announcement

Siemens Westinghouse Competition Winners Announced

Six high school mathematics students were among the winners in the Siemens Westinghouse Science and Technology National Competition. Individual prizes were awarded to the following students. Alexandra Ovetsky (Central High School, Philadelphia, Pennsylvania) won second place overall in the competition for her project "Surreal Dimensions and their Applications". She was awarded a \$50,000 scholarship. Jacob Licht (William H. Hall High School, West Hartford, Connecticut) won fourth place overall with his project "Rainbow Ramsey Theory: Rainbow Arithmetic Progressions and Anti-Ramsey Results". He received a \$30,000 scholarship. Peter Behroozi (Malcolm Price Laboratory School, Cedar Falls, Iowa) was awarded fifth place and a \$20,000 scholarship for his project "A Proof of the Collatz Conjecture for Rational Patterns". Fourth place in the team competition went to Rebecca Williams (North Lamar High School, Paris, Texas), Cynthia Chi (William P. Clements High School, Sugar Land, Texas), and Charles Hallford (Texas Academy of Mathematics and Science, Denton, Texas) for their joint project "The Generalization of the deBruijn Edge Sums". They will receive scholarships worth \$30,000.

The annual competition, administered by the College Board and funded by the Siemens Foundation, recognizes outstanding talent among high school students in science, mathematics, and technology.

—From a College Board announcement