2001 Steele Prizes

The 2001 Leroy P. Steele Prizes were awarded at the 107th Annual Meeting of the AMS in January 2001 in New Orleans.

The Steele Prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein and are endowed under the terms of a bequest from Leroy P. Steele. The prizes are awarded in three categories: for expository writing, for a research paper of fundamental and lasting importance, and for cumulative influence extending over a career. The current award is $4,000 in each category (in case of multiple recipients, the amount is divided equally).

The recipients of the 2001 Steele Prizes are Richard P. Stanley for Mathematical Exposition, Leslie Greengard and Vladimir Rokhlin for a Seminal Contribution to Research (limited this year to applied mathematics), and Harry Kesten for Lifetime Achievement.

The Steele Prizes are awarded by the AMS Council acting through a selection committee whose members at the time of these selections were: Constantine M. Dafermos, Bertram Kostant, Hugh L. Montgomery, Marc A. Rieffel, Jonathan M. Rosenberg, Barry Simon, François Treves (chair), S. R. S. Varadhan, and Herbert S. Wilf. The text that follows contains, for each prize recipient, the committee's citation, a brief biographical sketch, and a response from the recipient upon receiving the prize.

Mathematical Exposition: Richard P. Stanley

Citation

The Leroy P. Steele Prize for Mathematical Exposition is awarded to Richard P. Stanley of the Massachusetts Institute of Technology in recognition of the completion of his two-volume work *Enumerative Combinatorics*. The first volume appeared in 1986, and, to quote the review of Volume 2 by Ira Gessel, "since then, its readers have eagerly awaited Volume 2. They will not be disappointed. Volume 2 not only lives up to the high standards set by Volume 1, but surpasses them. The text gives an excellent account of the basic topics of enumerative combinatorics not covered in Volume 1, and the exercises cover an enormous amount of additional material."

The field has been expanding and evolving very rapidly, and it is quite remarkable that Stanley has been able to take a still photograph of it, so to speak, that beautifully captures its subject. To appreciate the scholarly qualities of this work, one need look no further than the exercises. There are roughly 250 exercises in each volume, all graded according to difficulty, many being multipart, and all with solutions and/or references to the relevant literature being provided. There are more than 500 bibliographic citations in the two volumes.

The first volume begins with elementary counting methods, such as the sieve method, and works through the theory of partially ordered sets, ending with a beautiful treatment of rational generating functions. Volume 2 begins with an advanced, yet very clear, view of generating functions, with special attention to algebraic and D-finite ones, and concludes with a comprehensive discussion of symmetric functions.

Yet even with all of the information that is being transmitted, we never lose clarity or our view of "the big picture". As a small example, we note that the Catalan numbers seem ubiquitous in combinatorics. Every student of the subject is struck by the large number of questions that they answer and wonders if there are bijections between the various families

Richard P. Stanley

Leslie F. Greengard

Photograph by Michael Marsland, Yale Univ. Office of Public Affairs.

Vladimir Rokhlin

of objects that are counted by these numbers. In a single exercise (ex. 6.19) Stanley has collected 66 such questions and asks the reader to provide the proofs which, in each case, establish the Catalan answer. All 66 of them are worked out in the solution, which is ten pages long, and this is just one of the 500 or so exercises. The author even has time for an occasional smile-generator (e.g., ex. 6.24: "Explain the following sequence: un, dos, tres, quatre, cinc, sis,…." The solution tells us that they are the Catalan numbers.)

This is a masterful work of scholarship which is, at the same time, eminently readable and teachable. It will be the standard work in the field for years to come.

Biographical Sketch

Richard Stanley was born in New York City in 1944. He graduated from Savannah High School in 1962 and Caltech in 1966. He received his Ph.D. from Harvard University in 1971 under the direction of Gian-Carlo Rota. He was a Moore Instructor at Massachusetts Institute of Technology during 1970–71 and a Miller Research Fellow at Berkeley during 1971–73. He then returned to MIT, where he is now a professor of applied mathematics. He is a member of the American Academy of Arts and Sciences and the National Academy of Sciences, and in 1975 he was awarded the Pólya Prize in Applied Combinatorics from the Society for Industrial and Applied Mathematics. His main mathematical interest is combinatorics, especially its connections with such other branches of mathematics as commutative algebra and representation theory.

Response

I have been interested in expository writing since graduate school and have long admired such masters as Donald Knuth, George Pólya, and Jean-Pierre Serre. I think it is wonderful that the AMS awards a prize for mathematical exposition, and I am extremely pleased at having been chosen for this award. It is not just an award for me but for all of combinatorics, for which such recognition would have been unthinkable when I was starting out in the subject. I only regret that it is not possible for me to share the celebration of my prize with Gian-Carlo Rota, who inspired me throughout my career and who wrote the two forewords to *Enumerative Combinatorics*.

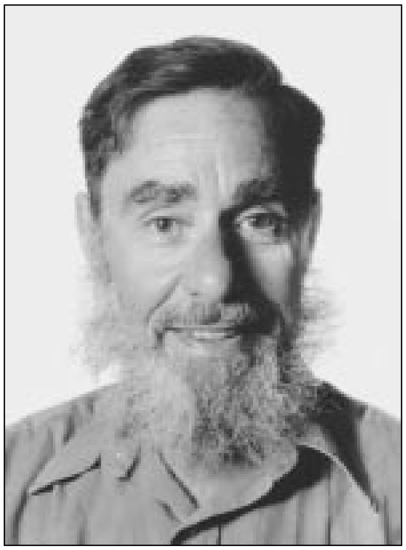
Seminal Contribution to Research: Leslie F. Greengard and Vladimir Rokhlin

Citation

For the paper by L. Greengard and V. Rokhlin "A fast algorithm for particle simulations", *J. Comput. Phys.* **73**, no. 2 (1987), 325–348.

This is one of the most important papers in numerical analysis and scientific computing in the last two decades. This paper introduces an algorithm, the fast multipole method (FMM), that speeds up the computation of certain types of sums. It showed that several ideas in harmonic analysis, far field expansions, and multiscale analysis based on dyadic decompositions of space, together with some further innovations, such as so-called "translation operators", could be combined to produce a practical algorithm that would make possible scientific and engineering computations that would have been impossible before. While the paper itself treats a very special case, it contains the fundamental ideas for a vast variety of generalizations and applications. The paper combines both the elegance and originality of the algorithm itself and the "hard" analysis of the proofs. These sums arise in a variety of applications, ranging from computational astronomy (computing the gravitational interaction of stars in a galaxy), to molecular dynamics (the Coulomb interaction of charges in a large molecule), to engineering computations of radar scattering, to

Photograph by Nicola Kountoupes, Cornell University Photography.



Harry Kesten

anything related to solutions of the Laplace equation (vortex methods for incompressible flow). The FMM has been enormously influential not just because of its basic scientific applications, but also because it forms the basis of commercial software for electronic packaging analysis, semiconductor design, and electro-magnetic applications. It has brought previously intractable computational problems within reach.

Biographical Sketch: Leslie F. Greengard

Leslie Greengard was born in London, England, and grew up in New York, Boston, and New Haven. He received his B.A. in mathematics from Wesleyan University in 1979, his Ph.D. in computer science from Yale University in 1987, and his M.D. from Yale University in 1987. From 1987–89 he was a National Science Foundation Postdoctoral Fellow at Yale University in the Department of Computer Science. He is presently a professor of mathematics at the Courant Institute of New York University, where he has been a faculty member since 1989. Much of his work has been in the development of "analysis-based" fast algorithms such as the Fast Multipole Method for gravitation and electromagnetics and the Fast Gauss Transform for diffusion.

Response: Leslie Greengard

I am deeply honored to be the recipient of a 2001 Steele Prize together with Vladimir Rokhlin. The work for which the prize has been awarded lies at the interface of mathematics, physics, and computer science. It is a pleasure to have this kind of interdisciplinary effort recognized by my mathematical colleagues.

As the field of computational mathematics begins to mature, we need a long-term view; short-term results are inadequate, and intermediate results may have no practical application or immediate impact. Mathematics is uniquely positioned as a field to promote this kind of work. There are many open problems, and it's a lot of fun to go after them.

I was fortunate to have met Rokhlin when I was an M.D./Ph.D. student at Yale, working on a tree-based algorithm (a primitive fast multipole method) to evaluate electrostatic interactions in three dimensions. When Rokhlin arrived in 1985, he had already developed an early version of the full fast multipole method for accelerating the solution of boundary integral equations in two dimensions. Martin Schultz, then chair of the department, introduced us. The analytic structure introduced by Rokhlin was richer than that of the simple tree-based codes. He became my thesis advisor, and we have been collaborating ever since.

Biographical Sketch: Vladimir Rokhlin

Vladimir Rokhlin was born in Russia in 1952. He received his M.S. in mathematics in 1973 from the University of Vilnius, Lithuania, and his Ph.D. in applied mathematics from Rice University in 1983. From 1973 to 1976 he worked at the Leningrad Institute of Arctic Geology and from 1976 to 1985, at the Exxon Production Research Company in Houston, Texas. He is currently a professor of mathematics and computer science at Yale University, where he has been working since 1985. He is a member of the National Academy of Sciences.

Response: Vladimir Rokhlin

It is hard to express my delight at being a co-recipient of the 2001 Steele Prize. I have always viewed myself as an applied mathematician, with the emphasis on the "applied". When dealing with a problem, I tend to be interested in its computational aspects; when things work out, the beauty of the resulting mathematics takes me by surprise. It is truly nice to see that this sense of wonder is shared by other mathematicians.

I met Leslie Greengard in 1985. At that point I was convinced that the future belonged to "fast" methods; I had constructed a rudimentary fast scheme for the solution of the Laplace equation in two dimensions and was not quite sure what the next step should be. When I encountered Leslie, he was thinking along very similar lines, but was motivated by biology and chemistry. We have been collaborating ever since.

Steele Prize for Lifetime Achievement: Harry Kesten

Citation

The Leroy P. Steele Prize for Lifetime Achievement is awarded to Harry Kesten, professor of mathematics at Cornell University, for his many and deep contributions to probability theory and its applications. Much of Kesten's work has revolved around random walks on graphs, and his exceptional expertise in this field has led him, and his numerous collaborators, to a wealth of results. To mention only a few of Kesten's achievements: his work on percolation and on first-passage percolation (late 1970s to present), the solution of Chung's problem with the proof of necessary and sufficient conditions for processes with independent increments to hit points with positive probability (late 1960s), the generalization and sharpening of central limit theorems (of Lévy's and Kolmogorov's lineage). Among "applied" areas in which interesting problems have been successfully tackled by Kesten are models for population growth, river networks, and the distinguishing of scenery along a random walk path. Statistical mechanics has been an especially fruitful area of application of the results and methods developed by Kesten: percolation was introduced in the late 1950s by Broadbent and Hammersley as a model for the spread of a fluid or gas through a random medium; it is now viewed by physicists as a prototype of a system with a phase transition. Kesten's analysis near the critical probability p_c provided for the first time rigorous proofs of bounds for significant quantities associated with the percolation and of the equations relating the exponents in those quantities, bounds, and equations that had been-heuristically found by physicists. It gave him the means of completing the proof that $p_c = 1/2$ in two-dimensional percolation; it led him to a mathematical definition of the physicist's "incipient cluster at criticality" and helped him get some hold on this fractal, again by studying random walks on various graphs.

Biographical Sketch

In 1933 when the Nazis came to power, Harry Kesten was one and a half years old. That year his family moved to The Netherlands, where he grew up and received his university education. In 1956 he obtained a fellowship to attend Cornell University, where he earned his Ph.D. under the supervision of Mark Kac. Kesten then held a one-year instructorship at Princeton University and a two-year instructorship at the Hebrew University. He returned to Cornell in 1961 and has been there ever since, except for various leaves.

Kesten has delivered several special lectures during his career: the Mathematical Association of America Earle Raymond Hedrick Lectures in 1970, an Invited Address at the 1971 AMS Winter Meeting, a Rietz Lecture to the Institute of Mathematical Statistics in 1971, a Brouwer Memorial Lecture in 1981, lectures at the International Congress of Mathematicians in Nice (1970) and Warsaw (1983), and the Wald Lectures to the Institute of Mathematical Statistics in 1986. He is a member of the National Academy of Sciences and the American Academy of Arts and Sciences, is a Correspondent of the Royal Dutch Academy of Sciences, and has served on numerous editorial boards internationally. Kesten has been the recipient of Sloan and Guggenheim Fellowships, as well as of the Brouwer Medal and the George Pólya Prize of the Society for Industrial and Applied Mathematics.

Response

I feel very honored by the award of the Leroy P. Steele Prize for Lifetime Achievement. Of course I accept the prize with great pleasure. I am extremely grateful to the Selection Committee and the AMS for giving me this recognition.

Like most other mathematicians I have had much help and stimulation from teachers and colleagues. My thesis adviser, Mark Kac, started me on random walks on groups, which was virgin territory at that time. Ever since then I have been fascinated by random walks, be they of the classical kind on the integers and real line or on more exotic objects such as trees and percolation clusters. I am amazed that people continue to find interesting new problems and angles in this oldest branch of probability theory. I have profited immensely from working on random walks with Frank Spitzer. The years when he was alive and we were colleagues at Cornell were some of the most exciting and inspiring of my career. It was under Frank's influence that I started my investigations of properties which hold for general random walks on the real line without any moment conditions.

The many contributions of Mark Kac to statistical physics, as well as the work of Frank Spitzer on interacting particle systems and the questions which Mark and Frank raised, attracted me to problems related to statistical mechanics. This led me to work on self-avoiding walks, percolation and first-passage percolation and diffusion-limited aggregation. The beautiful conjectures of physicists in such areas are a rich source of important research problems. I found it somewhat disconcerting to be almost always far behind the physicists. What a mathematician can prove rarely surprises a physicist anymore. Nevertheless, I greatly enjoyed working on such models and only hope that I can continue to work on them for a while longer.