1992 Steele Prizes

Three Leroy P. Steele Prizes were awarded at the Joint Mathematics Meetings in San Antonio, Texas.

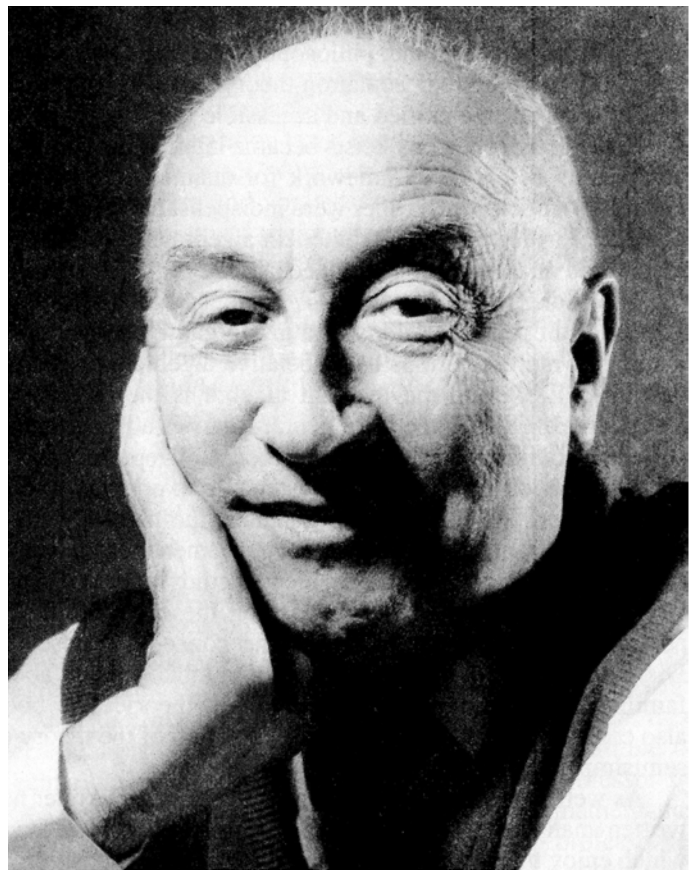
The Steele Prizes are made possible by a bequest to the Society by Mr. Steele, a graduate of Harvard College, Class of 1923, in memory of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein.

Three Steele Prizes are awarded each year: One for expository mathematical writing, one for a research paper of fundamental and lasting importance, and one in recognition of cumulative influence extending over a career, including the education of doctoral students. The current award is $4000 in each of these categories. Traditionally, the Steele Prizes have been awarded each year at the AMS Summer Meeting. Because there was no summer meeting in 1992, they were awarded at the following winter meeting.

The recipients of the Steele Prizes for 1992 are JACQUES DIXMIER for the expository award; JAMES GLIMM for research work of fundamental importance; and PETER D. LAX for the career award. The prizes were presented at the AMS-MAA Prize Session on January 15, 1993, at the Joint Mathematics Meetings in San Antonio.

The Steele Prizes are awarded by the Council of the Society, acting through a selection Committee whose members at the time of these selections were Sylvain E. Cappell, Alexandre J. Chorin, William J. Haboush, Arthur M. Jaffe, Vaughan F. R. Jones, Harry Kesten, Joseph J. Kohn, George Lusztig, Mark Mahowald (chair), Jane Cronin Scanlon, and Jean E. Taylor.

The text that follows contains the Committee's citations for each award, the recipients' responses, and a brief biographical sketch of each recipient. The biographical sketches were written by the recipients or were based on information provided by them.



Jacques Dixmier (Photo courtesy of Maurice Rougemont.)

Jacques Dixmier

Citation

The Steele Prize for expository writing in mathematics recognizes this year the extraordinary books, *von Neumann Algebras*, *C^*-Algebras*, and *Enveloping Algebras* by Jacques Dixmier. All three were first written in French and then translated into English because of the great demand.

"Rings of Operators" were introduced by F. Murray and J. von Neumann in a series of papers from 1936 to 1943. They are $*$-closed algebras of bounded operators in a Hilbert space closed in the topology of pointwise convergence. But until the appearance of Dixmier's *von Neumann Algebras*, in 1956, the Murray-von Neumann papers remained the only source work on the subject. Because of the rather forbidding nature of these papers the material remained difficult and mysterious. Everything was changed by Dixmier's book, which allowed for a smooth and systematic introduction to the subject and access to the most advanced material. It also cleared up almost all of the foundational questions and, incidentally, gave the name "von Neumann algebras" to what had previously been called "rings of operators". The book became the bible for workers in the subject and remained this way through many years and editions. It is still one of the best introductions for beginners.

The subject of C^*-algebras (closure in norm topology rather than pointwise convergence) developed alongside von Neumann algebras, and Dixmier's book was once again fundamental. Results of Glimm showed that there is a beautiful class of C^*-algebras whose representation theory is smoothly parametrizable. An axiomatic development of C^*-algebras (independent of any particular Hilbert space representation) had also been perfected by Gelfand, Naimark, and others. Applications of both the philosophy and the results were appearing in group representation theory. Dixmier's book put all this together in a unified and accessible form.

In the early 1960s physicists became interested in operator algebras as an abstract framework for quantum field theory, and the two books of Dixmier were indispensable for the work of Haag, Kastler, Araki, and others in algebraic quantum field theory and quantum statistical mechanics.

The book *Enveloping Algebras* is about a different subject. The study of representations of a group can be converted to a study of representations of associative algebras, and in the case of a Lie group the relevant algebra is the enveloping associative algebra of the Lie algebra. It carries a Hopf algebra structure coming from the tensor product of representations. Dixmier's book gives the first systematic exposition of this point of view which gives, for instance, the natural context for the important Casimir operators as elements of the center of the enveloping algebra. The idea of studying a group via Hopf algebras is very much in fashion these days with the advent of quantum groups where the concepts exposed in Dixmier's book are now the only way to talk correctly about familiar ideas from group representation theory. The book also contains an extremely elegant exposition of the theory of semisimple Lie algebras.

As well as these research-oriented textbooks, Dixmier has written many texts at the graduate and undergraduate level which enjoy the same clarity and conciseness of exposition as the three works mentioned above.

Response

I felt extraordinarily honored when I heard that I was awarded the Steele Prize. Thanks to the AMS!

To make things shorter, I'll restrict my answer to comments concerning my book on von Neumann algebras. First, I must say that I slightly disagree when the citation talks about "the rather forbidding nature" of the Murray-von Neumann papers. On the contrary, I think that I was really lucky at the beginning of my career; the Murray-von Neumann papers are in fact written very carefully and very clearly. I cannot imagine what would have happened to me had I chosen some other subjects, very important for sure, but for which the introduction was not made easy for beginners by the haughty or secretive manners of the relevant authorities (in order not to be sued, I prefer to give no examples). Well, my book was the first book on the subject, and that has advantages and disadvantages: a first book has to create some traditions; a second, a third book, etc., have to circumvent them. When writing my book, I had, as far as I remember, the following main objectives. 1) The key idea of the Murray-von Neumann classification was the dimension function, and then a very difficult proof constructed the traces from the dimensions. Now, in the main examples, the traces could be obtained directly. So I decided to make the traces the main characters of the play and to push back the "difficult proof" to the very end (with some simplifications, obtained simultaneously and independently by R. V. Kadison and me: in fact, the whole thing had been made very simple by F. J. Yeadon in 1971). 2) The construction, by von Neumann, of type III factors seemed at the time quite formidable. But, without any new idea, a careful presentation made the thing relatively easy. 3) It was already clear that the notion of Hilbert algebra was useful in the theory; I tried to use it as often as possible. 4) Although I realize that, by now, I take serious risks in saying so, I tried to make a Bourbaki exposé of the subject.

In the introduction of my book about C^*-algebras in 1964, I said that the theory of von Neumann algebras had reached a stable state; and I repeated this statement in 1969 for the second edition. Now, rather ironically, I saw the theory exploding under my eyes at the beginning of the 1970s, because I was the (again very lucky) thesis advisor of a young student named Alain Connes. When my book was translated into English in 1981, Professor E. C. Lance was kind enough to write a preface giving, without proof, some of the revolutionary recent developments.

I still often receive letters from colleagues asking for information concerning operator algebras. But, in fact, I have not worked on the subject for twenty years, and I don't understand the theory any more. Well, I suppose that such a situation frequently occurs when one grows old.

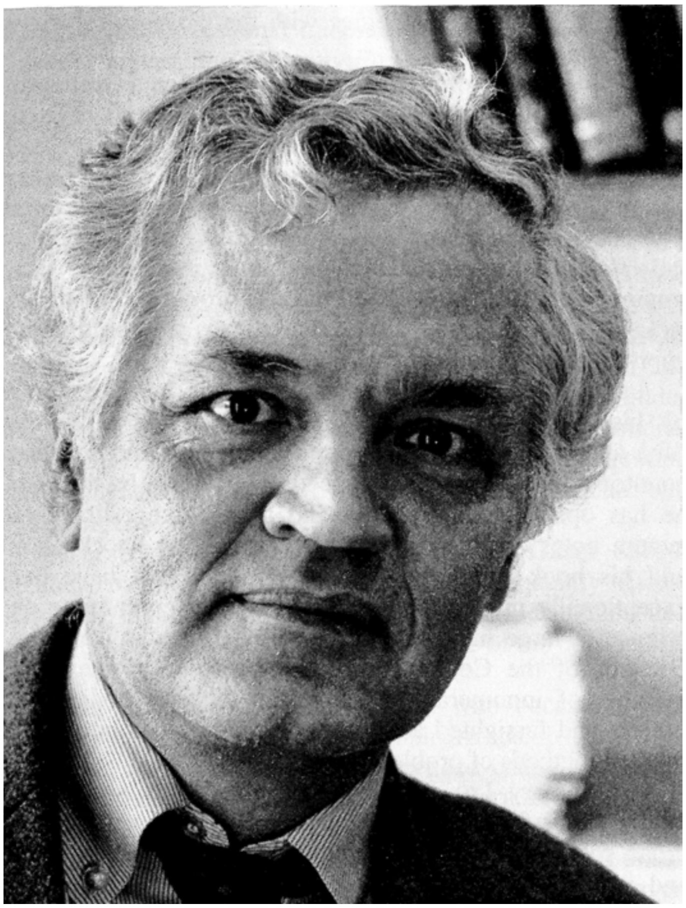
Biographical Sketch

Born in 1924, Dixmier was a student at Ecole Normale Supérieure from 1942 to 1946; *Maître de Conférences* at the Universities of Toulouse (1947–1949) and Dijon (1949–1955); *Maître de Conférences* and later *Professeur* at the University of Paris (Paris VI since 1969) (1955–1984); and invited guest at the Institut des Hautes Etudes Scientifiques (1984–1988). He spent a sabbatical leave in 1966–1967 as a professor at Tulane University.

James Glimm

Citation

To James Glimm for his ground-breaking paper, "Solution in the large for nonlinear hyperbolic systems of conservation laws," *Communications on Pure and Applied Mathematics*, XVIII, (1965) 697–715. This paper contains the first proof of global existence of solutions for this extremely important class of equations, where classical tools of functional analysis fail because the solutions are typically discontinuous. Even today, Glimm's method of proof is the only one that yields existence in the general case of systems without Riemann invariants.



James Glimm (Photo courtesy of Ed Bridges.)

Glimm's proof is of broad interest and has been very influential. The major problem in trying to prove existence for nonlinear hyperbolic equations lies in finding strong enough estimates to ensure compactness for a class of trial solutions. Glimm discovered that delicate estimates of wave interactions provide compactness for a class of small trial solutions. Glimm's trial solutions were random. Later analysis, building on Glimm's ideas, largely removed the randomness from the proof, but the imaginative idea of using random trial solutions has been very fruitful. Glimm's proof is a source of inspiration for many of the recent applications of probabilistic tools in the theory of partial differential equations.

The results of this paper have led directly to the Lax-Glimm theory of the decay of solutions of conservation laws. In addition, the ideas in the proof have been extremely useful in applications. The random choice method of computational fluid mechanics is a computer implementation of Glimm's construction, and various recent implementations of front tracking can be viewed as generalizations of his wave analysis. The concise and elegant paper for which the prize is being awarded is a landmark in the theory of partial differential equations, as well as in their applications, and a true masterpiece of hard analysis.

Response

It was Peter Lax who taught me the beautiful and fascinating subject of conservation laws, and I thank him for the encouragement he so generously gave to me and other workers in this field.

Jumping a decade of history, I will add to the information in the citation by recounting a comment of van Leer's, that his development of the higher-order Godunov Methods was influenced by Chorin's proposals to use random choice methods for serious computations.

Coming to the present, we find a dramatic flowering of novel phenomena and new unifying ideas for the understanding of Riemann solutions, i.e., scale symmetry invariant solutions of conservation laws. In addition to the mathematical depth of this body of work, an additional point should be noted. Here, pure and applied mathematics have shown the power to interpret and rewrite basic equations of engineering and physics. For example, the basic equations of three-phase flow (Stone's model) of petroleum reservoir engineering have lost favor to another set of equations (Pope's model) due in large part to studies of Riemann problems.

I will conclude with the observation that the subject of conservation laws has provided an early demonstration of two trends which are currently energizing a number of areas of mathematics: the synergism to be found in joining theory with applications and theory with computations.

Biographical Sketch

James Glimm was born March 24, 1934, in Peoria, Illinois. He received his A.B. (1956), A.M. (1957), and Ph.D. (1959) degrees from Columbia University. He spent the years 1959–1960 at the Institute for Advanced Study in Princeton, then became assistant professor at the Massachusetts Institute of Technology in 1960, advancing to the rank of professor by 1968. From 1974 to 1982 he was professor of mathematics at Rockefeller University. He was a visiting professor at the Courant Institute of Mathematical Sciences (1980–1982) and became professor of mathematics there in 1982. He is currently a professor at the State University of New York at Stony Brook.

Glimm has served on several of the Society's committees, including the Science Policy Committee, and has delivered a number of invited addresses. He was a fellow of the National Science Foundation (1959–1960) and a fellow of the Guggenheim Foundation (1964–1966). He was awarded the Physical and Mathematical Sciences Award of the New York Academy of Sciences in 1979 and the Heineman Prize in 1980. He is a member of the National Academy of Sciences and the American Academy of Arts and Sciences. His major research interests are nonlinear differential equations, functional analysis, operators on Hilbert space, mathematical physics, quantum field theory, and computational fluid dynamics.

Peter D. Lax

Citation

To Peter D. Lax for his numerous and fundamental contributions to the theory and applications of linear and nonlinear partial differential equations and functional analysis, for his leadership in the development of computational and applied mathematics, and for his extraordinary impact as a teacher.

Peter D. Lax (Photo courtesy of NYU/ L. Pellettieri photo.)

Lax's contribution to partial differential equations is of exceptional breadth and significance. His pioneering work on singular integral operators and problems with oscillatory initial data has marked indelibly the development of pseudodifferential and Fourier integral operators; his work with Phillips on scattering theory gave new perspectives to that field and led, in particular, to beautiful new results in harmonic analysis.

In the nonlinear realm, Lax has been a leader in the theory of nonlinear hyperbolic equations and shock waves; his work includes incisive contributions to the Riemann problem for systems of hyperbolic conservation laws, the formulation of the Lax shock conditions, and a study of the role of entropy in shock theory. His work on Riemann problems influenced Glimm's work on global solutions to nonlinear hyperbolic systems, which was continued in the Glimm-Lax work on formation and decay of shock waves. Lax's analysis of complete integrability produced the celebrated method of Lax pairs, a wonderfully flexible tool for producing completely integrable systems. In addition, Lax and Levermore have given rigorous results on the small dispersion limit and, in his study of dispersive approximations to hyperbolic equations, brought forward illuminating analogies with the closure problem of turbulence.

Lax's work encompasses the approximation as well as the theory of partial differential equations and has thereby had a major impact on developments in many fields of science. The Lax-Wendroff scheme is the starting point of the modern computational methodology for solving hyperbolic systems. The Lax equivalence theorem is the key observation on the relation between boundedness and convergence. Many important results on the stability of approximations are due to Lax, as is the basic theorem that affirms the possibility of approximating ergodic mappings.

Lax's contribution to mathematics has been magnified by his Ph.D. students, of whom he has had more than fifty, and by the numerous young mathematicians, in many countries, whom he has influenced by example, by the vistas he has opened, and by kind and timely suggestions. His lecture notes on hyperbolic equations and on shock waves and his book (with R. Phillips) on scattering have been exceptionally influential. The mathematical community and science at large have greatly benefited from his service as Director of the Courant Institute, President of the AMS, member of innumerable panels and advisory bodies, and tireless and farsighted advocate of scientific computing and modern methods of problem solving.

In summary, Lax is, and has been for four decades, one of the major forces in mathematics. His achievements in a broad spectrum of topics are characterized by rare elegance and insight. His influence on mathematics and science is enormous.

Response

Many thanks for the kind words and for this honor that eases my passage into becoming what Americans kindly call an old-timer, and whom the French describe more frankly as "un viellard".

From the very beginning, my way into mathematics was guided by helping hands. My parents, both prominent physicians, didn't press me to become a doctor, but wholeheartedly supported the choice of a mathematical career. My first teacher was my uncle, a distinguished electrical engineer, who in 1916 had won the Eotvös competition in mathematics. The Hungarian community, always on the lookout for talented youngsters, took over. I was tutored by the outstanding logician and pedagogue Rósza Péter and given problems to solve by Paul Turán and later by Paul Erdős. When the time came for my family to flee to America at the end of 1941, Denes König, the creator of graph theory, wrote to von Neumann asking him to look out for me, which he did. Added to the good fortune of getting to America, I got into Stuyvesant High School, and I basked in the stimulation and companionship of members of the math club and math team of 1942–1943. Two of their members, Rolf Landauer and Marshall Rosenbluth, became leading scientists.

I was taken into the Army in 1944; after basic training, I was sent to study engineering at Texas A&M (I have had a warm spot in my heart for Texas ever since) and then to the Los Alamos National Laboratory. I took a staff position there for a year after I got my Ph.D. in 1949 and have been associated with them ever since. The stimulation of applied problems and the early introduction to computing shaped my mathematical outlook.

I was fortunate to be taken under the wings of Courant and Friedrichs at the Courant Institute, where I spent most of my scientific career. There I learned to look at mathematics in a large context, although I am keenly aware of how much there is that I don't know, or rather know just a little about, so that I wish I knew more. In the early days of the Courant Institute we were spared the external pressures of competition and the internal pressures were softened by the fatherly attitudes of Courant and Friedrichs. That my wife is a mathematician and part of the Courant family has created common ground and enough common interests to provide agreements and disagreements for a lifetime.

I learned a great deal of analysis from Gabor Szegő, an uncle by marriage. Because of him I frequently visited Stanford University, and there I had the good luck to meet and start collaborating with Ralph Phillips, one of the outstanding analysts of our time.

I had many outstanding students who became distinguished mathematicians; I bask in their friendship.

I have always preached and practiced changing the undergraduate curriculum in light of our modern understanding. In 1976, Anneli, Sam Burstein, and I wrote a *Calculus with Computing* that contained many new ideas; therefore, I didn't expect it to become popular. Its lack of popularity, however, exceeded my wildest expectations. Since these days the winds of change are blowing, Anneli and I plan to revise it.

My mathematical tastes have changed from my Hungarian start, although I retain a residual love for analytic function theory, number theory, and combinatorics. In PDE my taste has turned from the general to the more special. I love theory, but even more when it has a practical surprise hidden in it. I find computing a royal road to applications and an indispensable tool in theory as well. Above all, I enjoy finding and studying new mathematical phenomena.

Biographical Sketch

Lax was born on May 1, 1926, in Hungary. He received his Ph.D. in 1949 from New York University, where he became assistant professor in 1951 and full professor in 1958. In 1963, he became the Director of the AEC Computing and Applied Mathematics Center of the Courant Institute of Mathematical Sciences. He was Director of the Courant Institute from 1972 to 1980, and at present is the Director of the Courant Mathematics and Computing Laboratory. He served in the United States Army and was a staff member of the Los Alamos Science Laboratory in 1945 and 1950 and has been a frequent visitor there.

Lax has assisted the Society in many professional, scientific, and educational tasks; he served on invitation and organizing committees for summer symposia, on the committee to select Gibbs lecturers, the committee to select the Birkhoff prize winner, plus many other committees concerned with Society affairs. He served on the Council (1962–1964) and the Executive Committee (1963–1964), was Vice President of the Society (1970–1971), and President (1979–1980).

Peter Lax gave as well as received: invited addresses and lectures, and talks at symposia of the AMS and Summer Research Institutes. He delivered the Colloquium Lectures in San Antonio in January 1987 and an invited address, "The Flowering of Applied Mathematics," at the AMS Centennial. He presented the Weyl Lectures at the Institute for Advanced Study in 1972 and the Hedrick Lectures of the Mathematical Association of America (MAA) in 1973.

Lax was a Fulbright Lecturer at Göttingen in 1958 and a Sloan Fellow from 1959 to 1963. He was awarded the MAA's Chauvenet Prize in 1974, the AMS Norbert Wiener Prize in Applied Mathematics in 1975, the National Academy of Sciences Prize in Applied Mathematics in 1983, the National Medal of Science in 1986, and the Wolf Prize in 1987.

He served on the National Science Board from 1980–1986 where he chaired an influential panel on large-scale computing. He is a member of the National Academy of Sciences, and Foreign Associate of the Académie des Sciences and of the Russian Academy of Sciences.

His major areas of research interest include partial differential equations, numerical analysis and computing, scattering theory, functional analysis, and fluid dynamics.