1999 Steele Prizes

The 1999 Leroy P. Steele Prizes were awarded at the 105th Annual Meeting of the AMS in January 1999 in San Antonio. These 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 Steele Prizes are awarded in three categories: for expository writing, for a research paper of fundamental and lasting importance (for 1999 limited to papers in analysis), and for cumulative influence extending over a career, including the education of doctoral students. The current award is $4,000 in each category.

The recipients of the 1999 Steele Prizes are Serge Lang for Mathematical Exposition, John F. Nash and Michael Crandall for a Seminal Contribution to Research, and Richard V. Kadison 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: Richard A. Askey, Ciprian Foias, Bertram Kostant, H. Blaine Lawson Jr., Andrew J. Majda, Louis Nirenberg, Marc A. Rieffel, Jonathan M. Rosenberg, and John T. Tate.

The text that follows contains, for each prize recipient, the committee's citation, a brief biographical sketch, and a response upon receiving the award.

Steele Prize for Mathematical Exposition: Serge Lang

Citation

The Leroy P. Steele Prize for Mathematical Exposition is awarded to Serge Lang of Yale University for his many mathematics books. Perhaps no other author has done as much for mathematical exposition at the graduate and research levels, both through timely expositions of developing research topics (e.g. Arakelov Theory, Complex Hyperbolic Geometry, Diophantine Geometry) and through texts with an excellent selection of topics. Among Lang's most famous texts are *Algebra* [Addison-Wesley, Reading, MA, 1965; Second edition, 1984; Third edition, 1993, ISBN 0-201-55540-9] and *Algebraic Number Theory* [Addison-Wesley, Reading, MA, 1970; Second edition, Graduate Texts in Mathematics, 110, Springer-Verlag, New York, 1994, ISBN: 0-387-94225-4]. Lang's *Algebra* changed the way graduate algebra is taught, retaining classical topics but introducing language and ways of thinking from category theory and homological algebra. It has affected all subsequent graduate-level algebra books. Lang's *Algebraic Number Theory* similarly changed the teaching of that subject. We quote briefly from the review of the second edition in *Mathematical Reviews* by M. Ram Murty, MR 95f:11085:

> This book is the second edition of Lang's famous and indispensable book on algebraic number theory…Lang's

> books are always of great value for the graduate student and the research mathematician. This updated edition of *Algebraic Number Theory* is no exception.

We also quote from a review of one of Lang's more specialized books, *Introduction to Arakelov Theory*, Springer-Verlag, New York-Berlin, 1988, ISBN: 0-387-96793-1. Here are the comments of Joseph H. Silverman (last year's Exposition Prize winner) in *Math. Reviews*, MR 89m:11059:

> The author has written an excellent book in a new, exciting, and very active area of research. It will undoubtedly become a standard reference in the field of arithmetic geometry, since it brings together in a coherent fashion the basic material which had previously only been available in the original journal articles. However, a potential reader should be warned that this is not a textbook for beginners…But for those with the necessary background, *Introduction to Arakelov Theory* provides a welcome entree to recent advances in arithmetic geometry.

The great diversity of Lang's books is not limited to his graduate textbooks and research-level monographs; he has written quite a number of undergraduate textbooks as well, especially at the junior-senior level. While they concentrate on the basics, Lang's textbooks do not talk down to the student. All of Lang's books display the mathematical taste of a first-class research mathematician.

Biographical Sketch

Serge Lang was born on May 19, 1927. He received his bachelor's degree at the California Institute of Technology in 1946. He served in the U.S. Army during 1946–47, after which he became a graduate student at Princeton University. He received his doctorate there in 1951 and served as an instructor for one year. He then went to the Institute for Advanced Study (1952–53) and to the University of Chicago (1953–55), where he served as an instructor. He spent fifteen years at Columbia University and held visiting positions at Princeton and Harvard Universities before going to Yale University in 1972, where he is currently professor of mathematics.

During 1957–58, Lang was a Fulbright Fellow. He received the AMS Cole Prize in 1959 and the Prix Carrière of the Académie des Sciences, Paris, in 1967. Lang has written 34 mathematics books ranging from elementary books—such as *Math! Encounters with High School Students*, *Geometry—A High School Course* (with Gene Murrow), *Basic Mathematics, The Beauty of Doing Mathematics* (talks at the Palais de la Découverte in Paris)—to advanced research monographs. He has also written three political books: *The Scheer Campaign* (Benjamin, 1967), *THE FILE* (Springer-Verlag, 1981), and *Challenges* (Springer-Verlag, 1998).

Response

I thank the Council of the AMS and the Selection Committee for the Steele Prize, which I accept. It is of course rewarding to find one's works appreciated by people such as those on the Selection Committee.

At the same time, I am very uncomfortable with the situation, because I resigned from the AMS in early 1996, after nearly half a century's membership. On the one hand, I am now uncomfortable with spoiling what could have been an unmitigated happy moment, and on the other hand, I do not want this moment to obscure important events which have occurred in the last two to three years, affecting my relationship with the AMS.

Indeed, the *Notices*, February 1996, published a 12-page article "Using Mathematics to Understand HIV Immune Dynamics" by Denise Kirschner, pp. 191–202. Having had occasion to be well informed on the issue of HIV pathogenesis and of strong objections (not only by me) against certain abuses of mathematical modeling in connection with HIV, I communicated an extensive file of documentation to AMS higher-ups at the time concerning the hypothesis that HIV is not pathogenic. This hypothesis of course is incompatible with the official orthodoxy. Readers can evaluate some of my documentation, published in a 114-page chapter of my recent book, *Challenges*.

I resigned from the AMS because of the way my documentation was handled in 1996, principally by the *Notices* editor, Hugo Rossi, in connection with the Kirschner article, and the way official responsibilities were met by those involved. Subsequently, about two years later on 5 January 1998, I submitted a 7-page piece for publication in the "Forum" of the *Notices*. The piece explained:

- encouraging events (see for example p. 714 of *Challenges*) which led me to submit a piece for publication in the *Notices*, rather than disengaging as I had done up to that point;
- my detailed objections to the responses which I got from AMS officials at the time in 1996;
- direct criticisms of the Kirschner piece per se.

I regard all three as important. Although the "Forum" editor, Susan Friedlander, told me she would have accepted the piece, it was rejected for publication by the 1998 editor-in-chief, Tony Knapp. Thus members of the AMS at large have not been informed through official channels of my resignation, nor of the very serious context of continued problems after the resignation, including the rejection of my "Forum" piece. I tried to inform some members by a direct mailing to 160 chairs of departments in January 1998, but such a mailing can reach only few among the total membership (nearly 30,000).

Torn in various directions, sadly but firmly, I do not want my accepting the Steele Prize to further obscure the history of my recent dealings with the AMS.

Steele Prize for a Seminal Contribution to Research: John F. Nash

Citation

The award to John Nash is for his remarkable paper: "The embedding problem for Riemannian manifolds", *Ann. of Math.* (2) **63** (1956), 20–63.

This paper solved an old problem in Riemannian geometry, but the heart of it is Analysis. In it Nash cleverly reduces the question to a local perturbation problem for a system of nonlinear partial differential equations. If one tries to use the Implicit Function Theorem one fails because, though the linearized operator is invertible, the inverse loses some degree of differentiability; so the situation seems hopeless. But Nash devised a memorable iteration scheme coupled with a smoothing process to overcome the difficulty. It is a most original idea. Later Moser modified and generalized the idea, and we now have the "Nash-Moser" technique which is applicable to many problems. This is one of the great achievements in mathematical analysis in this century.

Biographical Sketch

John F. Nash Jr. was born June 13, 1928, in Bluefield, West Virginia. He went to the public schools in Bluefield from kindergarten through high school, and did supplementary study at Bluefield College. He entered Carnegie Tech (now Carnegie-Mellon University) as a George Westinghouse Scholar. Originally he was a chemical engineering major and later changed to chemistry and finally to mathematics. He obtained an "advanced standing" and received both B.S. and M.S. degrees at the time of graduation in 1948. He did his graduate study at Princeton University, 1948–50, where he stayed on for one year as an instructor after receiving his Ph.D. in mathematics in 1950. He arrived in the Boston area in summer 1951 and began teaching at the Massachusetts Institute of Technology. He was a C.L.E. Moore Instructor in the mathematics department of MIT and continued on the faculty until 1959. He was an occasional "member" of the Institute for Advanced Study. His honors include scholarships and foundation awards. He has received the Von Neumann Medal of the Operations Research Society, a share of the Nobel Prize in Economics (1994), and the *Business Week* award at Erasmus University in the Netherlands (1998). He was elected a Fellow of the Econometric Society and the American Academy of Arts and Sciences, and in 1996 was elected a Member of the National Academy of Sciences.

Response

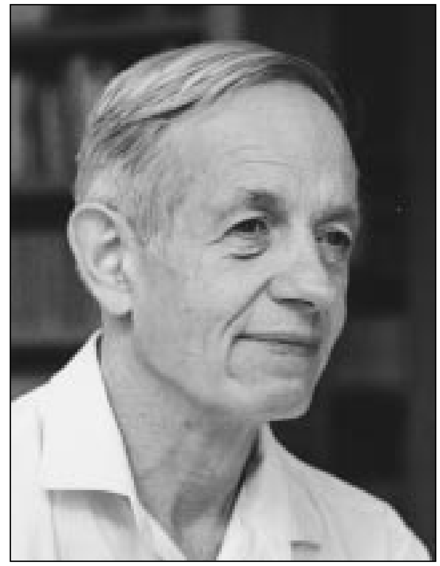


Photo by Robert P. Matthews, courtesy of Communications Dept., Princeton University.

John F. Nash Jr.

It is indeed an honor to be awarded a share of the Leroy P. Steele Prize for 1999 for influential research.

Perhaps a few remarks about the context of my work, back in the 1950s, on the isometric representation of Riemannian manifolds are appropriate. Psychologically, I was influenced by the significant function of a metric tensor on the 4-continuum in the theory of general relativity and by the fact that I was a student in Princeton at a time when Einstein was still alive and resident in the town. This must have had an influence on my studies that related to manifolds, differentiable or Riemannian.

When I first studied the problem of obtaining an isometric embedding for an arbitrary given manifold with a Riemannian metric, I did not find a way to realize a smooth (highly differentiable when described by functions) realization of it as a subvariety of a Euclidean space, but instead I found the possibility of a C^1 embedding, so that the description of the embedding would be given by functions that would have continuous first derivatives but would not have any more smoothness than that.

But this result, although not really what one should hope for if the given Riemannian manifold were of high smoothness, had the nice property that it did not require a large number of dimensions for the Euclidean space of the representation. And moreover, the metric originally given did not need anything more than C^0 smoothness, merely to be describable by a metric tensor described by continuous functions.

In the context of the so-called Nash-Moser theory, the methods that were found to be effective for these C^1 embeddings were not of any direct relation to that. But for me the solution of the "embedding problem" in this first fashion provided a gateway to an approach to the problem in terms of desiderata of higher smoothness. It turned out to be possible to use the ideas involved in the study of low smoothness results to set up an initial approximation to a solution of the embedding problem with higher smoothness; then that problem became the problem of suitably perturbing an existing embedding so as to obtain a smooth embedding of isometric type. And this became a problem describable as one of finding an appropriate perturbation of small, but finite rather than infinitesimal, type which would realize the desired correction of a metric that was approximately already correct for isometry.

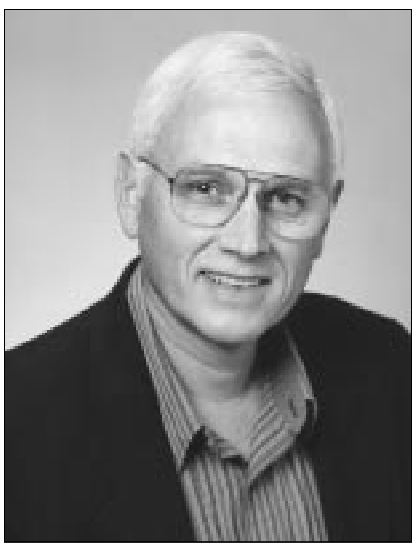
My work on the low smoothness embeddings was soon improved upon by N. H. Kuiper, who improved the technique and achieved consequentially that the maximum possibly needed dimensionality of the Euclidean space would be less than according to my results.

I feel that it is of interest to observe that at the present time there are still some simple questions that remain unanswered in the context of isometric representations. In particular, if a manifold is given with a Riemannian metric of C^2 differentiability, then the most that is known is that it can be embedded isometrically with the embedding functions (from the abstract manifold) being of C^1 type. But actually it would seem that the embedding should be at least of C^2 type and to achieve the C^3 level here would not be inconsistent and indeed simply parallel to achieving a C^1 imbedding when a C^0 Riemannian metric was given on the abstract manifold.

Steele Prize for a Seminal Contribution to Research: Michael G. Crandall

Citation

The award to Michael Crandall is for two seminal papers: "Viscosity solutions of Hamilton-Jacobi equations" (joint with P.-L. Lions), *Trans. Amer. Math. Soc.* **277** (1983), 1–42, and "Generation of semi-groups of nonlinear transformations on general Banach spaces" (joint with T. M. Liggett), *Amer. J. Math.* **93** (1971), 265–298.



Michael G. Crandall

Mike Crandall is one of the leaders in the world in applying abstract ideas to concrete applications. He is one of the inventors, in joint work with Pierre-Louis Lions, of the concept of "viscosity solution" for equations with rough solutions and of a formal comparison principle. This work has had wide ramifications in diverse applications, including control theory, image processing, phase field models, front propagation, and the Perron Procedure for degenerate fully nonlinear elliptic or parabolic equations. This joint work with Crandall is one of the main contributions in the citation for the Fields Medal which Lions was awarded in 1994 in Zürich.

Crandall is also world renowned for earlier work, beginning with the Crandall-Liggett Theorem, on characterizing contraction semigroups on nonreflexive Banach spaces. Crandall has played an important role in applying these results to concrete problems, such as scalar nonlinear conservation laws and their finite difference approximations, and degenerate equations for porous media.

Biographical Sketch

Michael Crandall was born November 29, 1940, in Baton Rouge, Louisiana. By the fifth grade he had attended five different elementary schools in Florida, Mississippi, Louisiana, and California as the family moved about following his father's work in construction. After graduating from Chula Vista High School in 1958 he supported himself via summer employment as a member of Hod Carriers and Laborers Local 89 in San Diego and part-time jobs during the academic year while attending the University of California, Berkeley, as an undergraduate, except for one fateful semester at the University of California, Los Angeles, where he met Sharon, his wife of thirty-six years.

After taking a bachelor's degree in engineering physics from UC Berkeley in 1962, Crandall reenrolled at Berkeley as a mathematics graduate student. He obtained his Ph.D. in 1965 under the direction of H. O. Cordes upon solving a problem in celestial mechanics posed by C. L. Siegel. Subsequently, he held an instructorship at Berkeley for a year followed by three years on a postdoctoral appointment at Stanford University. He then moved to UCLA, where he attained the rank of professor before accepting a professorship at the Department of Mathematics and Mathematics Research Center at the University of Wisconsin. Currently, Crandall is a professor at the University of California, Santa Barbara, where he has served a term as department chair. Crandall has also served the Society as a member at large of the Council, and he is currently on the Board of Trustees. He was also a managing editor of *Communications in Partial Differential Equations* for several years and a member of various editorial boards. He was an invited speaker at the 1974 Congress in Vancouver and has given an AMS invited hour address and an AMS Progress in Mathematics lecture.

Response

First, I would like to say that I am thrilled to be a recipient of the Steele Prize for publications of lasting impact. It was a bit subtle for the committee to award me the prize for two papers with three authors between them, but with me as the unique author on both. I thank the committee and salute my most excellent coauthors.

In this response I will follow my feelings, and what I feel is gratitude, not only for being awarded the prize, but for the circumstances and people who provided some of the backdrop for the cited works. I mention in particular Ralph Phillips, who put me and Amnon Pazy in contact with the lovely work of Y. Komura on generation of nonlinear semigroups in Hilbert spaces, and Tosio Kato, whose penetratingly clean mathematics is central to the theory of nonlinear evolution equations. Ralph passed away November 23; it was a privilege to know him.

Working with Amnon on the Hilbert space setting was exciting and satisfying. This start led to the work with Tom Liggett on generation in general Banach spaces. The application to scalar conservation laws brought the uniqueness proof of Kruzhkov into view, and this proof and Philippe Bénilan's abstract uniqueness theorem were both in the background when Pierre-Louis and I proved our first uniqueness results for viscosity solutions. Craig Evans's use of "Minty's trick in L^∞" to pass to limits in fully nonlinear equations was also part of the environment at the time. However, there is no doubt that the cited paper initiated a vigorous development by the many outstanding contributors to which the area owes its vitality. The outcome to date is a lot of beautiful mathematics, provided by a large community, for which the rest of the world has much use. I got to know Kato at Berkeley as a student, Ralph Phillips and Amnon Pazy at Stanford (and Paul Rabinowitz, but that is another story), Tom Liggett and Craig Evans at UCLA, and Pierre-Louis Lions at the former Mathematics Research Center (MRC) at Wisconsin; I wonder if people realize the enormous impact of MRC. In sum, I am a lucky man.

Steele Prize for Lifetime Achievement: Richard V. Kadison

Citation

The Leroy P. Steele Prize for Lifetime Achievement is awarded to Richard V. Kadison, Kuemmerle Professor of Mathematics at the University of Pennsylvania. For almost half a century, Dick Kadison has been one of the world leaders in the subject of operator algebras, and the tremendous flourishing of this subject in the last thirty years is largely due to his efforts. He was a key organizer of two major conferences on operator algebras—in Baton Rouge, Louisiana, in 1967, and in Kingston, Ontario, in 1980—which helped shaped the modern history of the subject. His students have included many world-class mathematicians not only in operator algebras but in other fields as well. And in mathematical exposition, Kadison's papers and his two-volume monograph with John Ringrose, *Fundamentals of the Theory of Operator Algebras* (originally published by Academic Press, now reprinted by the AMS), have been models of clarity and precision.

We quote from just a few of the many letters written in support of the nomination of Kadison for the Lifetime Achievement prize. Edward Effros of UCLA wrote that, "Quite simply, operator algebra theory would not exist as a subject today if it had not been for Dick." Fields Medalist Alain Connes wrote that Kadison's "global vision of the field was certainly essential for my own development." Isadore Singer of MIT wrote that "Dick is a most deserving candidate of a Steele Prize for Lifetime Achievement. I support the nomination with great enthusiasm because:

1) His many research papers are pathbreaking. They are a pleasure to read, combining clarity, power, and scholarship in a unique way.

2) His treatise with John Ringrose defines the field of operator algebras and is a source book for students and scholars alike.

3) Almost half a century of teaching the subject, encouraging graduate students and postdoctoral visitors at the University of Pennsylvania, and doing research at the cutting edge of the field have made Dick the leading light of operator algebras."

Richard V. Kadison

Biographical Sketch

Richard V. Kadison received his Ph.D. from the University of Chicago in 1950 and was a National Research Fellow that same year at the Institute for Advanced Study. He went to Columbia University as an assistant professor in 1952 and became an associate professor in 1956 and a full professor in 1960. In 1964 he took his present position as Kuemmerle Professor of Mathematics at the University of Pennsylvania. He was a Fulbright Research Fellow in Copenhagen (1954–55), a Sloan Fellow (1958–62), and a Guggenheim Fellow (1969–70). He received honorary doctoral degrees from the Université d'Aix-Marseille in 1986 and the University of Copenhagen in 1987. He is a member of the National Academy of Sciences, a foreign member of the Royal Danish Academy of Science and Letters, and a foreign member of the Norwegian Academy of Science and Letters.

Response

It is a great honor to receive the Steele Prize for Lifetime Achievement. I am very happy to accept it. This award is given occasionally, I'm sure, to people who can say that they did it all alone. That is certainly not the present case. I collaborated during much of my career with people who are splendid mathematicians as well as dear friends. My students, both graduate and postdoctoral, taught me much of what I know. My teachers during my graduate student days were a constant source of inspiration and support. To all of these people I owe a great debt of gratitude for whatever success I may have had.

The field in which I have worked for a large part of my life is the theory of operator algebras. I have had the good fortune to watch it flourish and make contact with most of mathematics and physics and a good many other subjects as well. Heisenberg and Schrödinger taught us that the analysis that goes with quantum physics is of a very special sort. Dirac and von Neumann formulated that *noncommutative* analysis in terms of operators on a Hilbert space and the algebraic interrelations among those operators. The physical observables of a quantum system are modeled by self-adjoint operators on such a space. With that as one of the principal grounds for Dirac and von Neumann's study, it was clear that the algebras of such operators are important mathematical constructs. It rapidly became clear as well that their structure was complicated and rich enough to keep an army of research mathematicians occupied for quite some time. The few of us at work on the subject fifty years ago knew that we would not be short of fascinating mysteries to occupy our thoughts.

It wasn't certain, however, that we would have much company on that journey of discovery. As it turned out, a formidable force of remarkably talented and dedicated researchers gathered and joined us. As with all the great fields of mathematics, this group included a small number of brilliant practitioners. They give the field much of its luster and direction. We are lucky to have our supply of such people. There are an encouraging number of very talented young mathematicians able and willing to join the ranks of serious researchers in all the great fields. They aren't expecting (nor will they find!) an easy life. A wise society would care for and make the best use of this precious resource.

It has been my privilege and joy to be among the workers in my field throughout most of my career. I'm hoping to continue working with them for some years to come.