Lafforgue and Voevodsky Receive Fields Medals

Laurent Lafforgue

Vladimir Voevodsky

On August 20, 2002, two Fields Medals were awarded at the opening ceremonies of the International Congress of Mathematicians (ICM) in Beijing, China. The medalists are LAURENT LAFFORGUE and VLADIMIR VOEVODSKY.

The Fields Medals are presented in conjunction with the ICM, which is held every four years at different locations around the world. Although there is no formal age limit for recipients, the medals have traditionally been presented to mathematicians not older than 40 years of age, as an encouragement for future achievement. The medal is named after the Canadian mathematician John Charles Fields (1863–1932), who organized the 1924 ICM in Toronto. At a 1931 meeting of the Committee of the International Congress, chaired by Fields, it was decided that the $2,500 left over from the Toronto ICM "should be set apart for two medals to be awarded in connection with successive International Mathematical Congresses." In outlining the rules for awarding the medals, Fields specified that the medals "should be of a character as purely international and impersonal as possible." During the 1960s, in light of the great expansion of mathematics research, the possible number of medals to be awarded was increased from two to four. Today the Fields Medal is recognized as the world's highest honor in mathematics.

Previous recipients are: Lars V. Ahlfors and Jesse Douglas (1936); Laurent Schwartz and Atle Selberg (1950); Kunihiko Kodaira and Jean-Pierre Serre (1954); Klaus F. Roth and René Thom (1958); Lars Hörmander and John W. Milnor (1962); Michael F. Atiyah, Paul J. Cohen, Alexandre Grothendieck, and Stephen Smale (1966); Alan Baker, Heisuke Hironaka, Sergei P. Novikov, and John G. Thompson (1970); Enrico Bombieri and David B. Mumford (1974); Pierre R. Deligne, Charles L. Fefferman, Grigorii A. Margulis, and Daniel G. Quillen (1978); Alain Connes, William P. Thurston, and Shing-Tung Yau (1982); Simon K. Donaldson, Gerd Faltings, and Michael H. Freedman (1986); Vladimir Drinfeld, Vaughan F. R. Jones, Shigefumi Mori, and Edward Witten (1990); Jean Bourgain, Pierre-Louis Lions, Jean-Christoph Yoccoz, and Efim Zelmanov (1994); Richard Borcherds, William Timothy Gowers, Maxim Kontsevich, and Curtis T. McMullen (1998).

The medals are awarded by the International Mathematical Union, on the advice of a selection committee. The selection committee for the 2002 Fields Medalists consisted of: James Arthur, Spencer Bloch, Jean Bourgain, Helmut Hofer, Yasutaka Ihara,

H. Blaine Lawson, Sergei Novikov, George Papanicolaou, Yakov Sinai (chair), and Efim Zelmanov.

Laurent Lafforgue

Laurent Lafforgue was born on November 6, 1966, in Antony, France. He graduated from the École Normale Supérieure in Paris (1986). He became a *chargé de recherche* of the Centre National de la Recherche Scientifique (CNRS) (1990) and worked on the Arithmetic and Algebraic Geometry team at the Université Paris-Sud, where he received his doctorate (1994). In fall 2000 he was promoted to *directeur de recherche* of the CNRS in the mathematics department of the Université Paris-Sud. Shortly thereafter he became a permanent professor of mathematics at the Institut des Hautes Études Scientifiques in Bures-sur-Yvette, France.

Laurent Lafforgue has made an enormous advance in the Langlands Program by proving the global Langlands correspondence for function fields. The Langlands Program, formulated by Robert Langlands in the 1960s, proposes a web of relationships connecting Galois representations and automorphic forms. The influence of the Langlands Program has grown over the years, with each new advance hailed as an important achievement.

The roots of the Langlands program are found in one of the deepest results in number theory, the Law of Quadratic Reciprocity, which was first proved by Carl Friedrich Gauss in 1801. This law allows one to describe, for any positive integer d, the primes p for which the congruence $x^2 \equiv d \bmod p$ has a solution. Despite many proofs of this law (Gauss himself produced six different proofs), it remains one of the most mysterious facts in number theory. The search for generalizations of the Law of Quadratic Reciprocity stimulated a great deal of research in number theory in the nineteenth century. Landmark work by Emil Artin in the 1920s produced the most general reciprocity law known up to that time. One of the original motivations behind the Langlands Program was to provide a complete understanding of reciprocity laws.

The global Langlands correspondence for GL_n proved by Lafforgue provides a complete understanding of reciprocity laws for function fields. Lafforgue established, for any given function field, a precise link between the representations of its Galois groups and the automorphic forms associated with the field. He built on work of 1990 Fields Medalist Vladimir Drinfeld, who in the 1970s proved the global Langlands correspondence for GL_2.

Vladimir Voevodsky

Vladmir Voevodsky was born on June 4, 1966, in Russia. He received his B.S. in mathematics from Moscow State University (1989) and his Ph.D. in mathematics from Harvard University (1992). He held visiting positions at the Institute for Advanced Study, Harvard University, and the Max-Planck-Institut für Mathematik before joining the faculty of Northwestern University in 1996. In 2002 he was named a permanent professor in the School of Mathematics at the Institute for Advanced Study in Princeton, New Jersey.

Vladimir Voevodsky made one of the most outstanding advances in algebraic geometry in the past few decades by developing new cohomology theories for algebraic varieties. This achievement has its roots in the work of 1966 Fields Medalist Alexandre Grothendieck. Grothendieck suggested that there should be objects, which he called "motives", that are at the root of the unity between number theory and geometry.

One of the most important of the generalized cohomology theories is topological K-theory, developed chiefly by another 1966 Fields Medalist, Michael Atiyah. An important result in topological K-theory is the Atiyah-Hirzebruch spectral sequence, developed by Atiyah and Friedrich Hirzebruch, which relates singular cohomology and topological K-theory.

For about forty years mathematicians worked hard to develop good cohomology theories for algebraic varieties; the best understood of these was the algebraic version of K-theory. A major advance came when Voevodsky, building on a little-understood idea proposed by Andrei Suslin, created a theory of "motivic cohomology". In analogy with the topological setting, there is a relationship between motivic cohomology and algebraic K-theory. In addition, Voevodsky provided a framework for describing many new cohomology theories for algebraic varieties. One consequence of Voevodsky's work, and one of his most celebrated achievements, is the solution of the Milnor Conjecture, which for three decades was the main outstanding problem in algebraic K-theory. This result has striking consequences in several areas, including Galois cohomology, quadratic forms, and the cohomology of complex algebraic varieties.

—Allyn Jackson

Madhu Sudan Receives Nevanlinna Prize

Madhu Sudan

On August 20, 2002, the Rolf Nevanlinna Prize was awarded at the opening ceremonies of the International Congress of Mathematicians (ICM) in Beijing, China. The prizewinner is MADHU SUDAN.

In 1982 the University of Helsinki granted funds to award the Nevanlinna Prize, which honors the work of a young mathematician (less than 40 years of age) in the mathematical aspects of information science. The prize is presented every four years in conjunction with the ICM. Previous recipients of the Nevanlinna Prize are: Robert Tarjan (1982), Leslie Valiant (1986), Alexander Razborov (1990), Avi Wigderson (1994), and Peter Shor (1998).

The Nevanlinna Prize is awarded by the International Mathematical Union on the advice of a selection committee. The selection committee for the 2002 prize consisted of: Andrei Agrachev, Ingrid Daubechies, Wolfgang Hackbusch, Michael O. Rabin (chair), and Alexander Schrijver.

Madhu Sudan was born on September 12, 1966, in Madras (now Chennai), India. He received his B. Tech. degree in computer science from the Indian Institute of Technology in New Delhi (1987) and his Ph.D. in computer science at the University of California at Berkeley (1992). He was a research staff member at the IBM Thomas J. Watson Research Center in Yorktown Heights, New York (1992–7). He is currently an associate professor in the Department of Electrical Engineering and Computer Science at the Massachusetts Institute of Technology.

Madhu Sudan has made important contributions to several areas of theoretical computer science, including probabilistically checkable proofs, nonapproximability of optimization problems, and error-correcting codes.

Sudan has been a main contributor to the development of the theory of probabilistically checkable proofs. Given a proof of a mathematical statement, the theory provides a way to recast the proof in a form where its fundamental logic is encoded as a sequence of computer bits. A "verifier" can, by checking only some of the bits, determine with high probability whether the proof is correct. What is extremely surprising, and quite counterintuitive, is that the number of bits the verifier needs to examine can be made extremely small. The theory was developed in papers by Sudan, S. Arora, U. Feige, S. Goldwasser, C. Lund, L. Lovász, R. Motwani, S. Safra, and M. Szegedy. For this work, these authors jointly received the 2001 Gödel Prize of the Association for Computing Machinery.

Also together with other researchers, Sudan has made fundamental contributions to understanding the nonapproximability of solutions to combinatorial optimization problems. This work connects to the fundamental outstanding question in theoretical computer science: Does P equal NP? A problem is in P if there is a polynomial-time algorithm that solves it. A problem is in NP if it has the property that a proposed solution can be checked in polynomial-time but that no polynomial-time algorithm is known to solve it. What Sudan and others showed is that, for certain combinatorial optimization problems, approximating an optimal solution is just as hard as finding an optimal solution. This result is closely related to the work on probabilistically checkable proofs.

The third area in which Sudan made important contributions is error-correcting codes. A class of widely used codes is the Reed-Solomon codes (and their variants), which were invented in the 1960s. For forty years it was assumed that the codes could correct only a certain number of errors. By creating a new decoding algorithm, Sudan demonstrated that the Reed-Solomon codes could correct many more errors than previously thought possible.

—Allyn Jackson

2002 JPBM Communications Award

The Joint Policy Board for Mathematics (JPBM) Communications Award was established in 1988 to reward and encourage journalists and other communicators who, on a sustained basis, bring accurate mathematical information to nonmathematical audiences. The 2002 award was presented to HELAMAN FERGUSON and CLAIRE FERGUSON at the 50th anniversary meeting of the Society for Industrial and Applied Mathematics (SIAM) in Philadelphia in July 2002.

The JPBM provides a forum for joint projects of the AMS, SIAM, and the Mathematical Association of America. Previous recipients of the JPBM Communications Award are Keith J. Devlin (2001), Sylvia Nasar (2000), Ian Stewart (1999), Constance Reid (1998), Philip J. Davis (1997), Gina Kolata (1996), Martin Gardner (1994), Joel E. Schneider (1993), Ivars Peterson (1991), Hugh Whitemore (1990), and James Gleick (1988).

The citation for the 2002 award states: "The JPBM Communications Award is presented to the Fergusons, who together have dazzled the mathematical community and a far wider public with exquisite sculptures embodying mathematical ideas, along with artful and accessible essays and lectures elucidating the mathematical concepts.

"Helaman Ferguson began his studies as an apprentice to a stone mason, then studied painting at Hamilton College and sculpture in graduate school. He received his Ph.D. in mathematics from the University of Washington in Seattle and taught the subject for seventeen years at Brigham Young University. He now lives and works in Laurel, Maryland, where he has set up an extensive studio in his home. In addition to selling his works, he designs algorithms for operating machinery and for scientific visualization. He has exhibited and sold his sculptures worldwide.

Photograph by Lois Sellers, SIAM.

2002 JPBM Communications Award winners Helaman and Claire Ferguson (left), accepting the award from SIAM president Tom Manteuffel (right).

"Claire Ferguson has worked closely with Helaman as curator, expositor, and publicist on his mathematical sculptures. She is author of the book *Helaman Ferguson, Mathematics in Stone and Bronze*. She is also an artist in her own right and has won scholarships and prizes for her work."

—*Allyn Jackson*