2011 Steele Prizes

The 2011 AMS Leroy P. Steele Prizes were presented at the 117th Annual Meeting of the AMS in New Orleans in January 2011. The Steele Prizes were awarded to HENRYK IWANIEC for Mathematical Exposition, to INGRID DAUBECHIES for a Seminal Contribution to Research, and to JOHN W. MILNOR for Lifetime Achievement.

Mathematical Exposition: Henryk Iwaniec

Citation

Henryk Iwaniec is awarded the Leroy P. Steele Prize for Mathematical Exposition for his long record of excellent exposition, both in books and in classroom notes. He is honored particularly for the books *Introduction to the Spectral Theory of Automorphic Forms* (Revista Matemática Iberoamericana, Madrid, 1995) and *Topics in Classical Automorphic Forms* (Graduate Studies in Mathematics, 17, American Mathematical Society, Providence, RI, 1997). These books give beautiful treatments of the theory of automorphic forms from the author's perspective of analytic number theory. They have become classics in the field and are now a fundamental resource for students. The two books are complementary, with the first presenting the non-holomorphic theory of Maass forms for GL(2) and the latter focusing on holomorphic modular forms.

Henryk Iwaniec

Introduction to the Spectral Theory of Automorphic Forms begins with the basics of hyperbolic geometry and takes readers to the frontiers of research in analytic number theory. Many topics, such as the Kuznetsov formula and the spectral theory of Kloosterman sums, are covered for the first time in this book. It closes with a discussion of current research on the size of eigenfunctions on hyperbolic manifolds. By making these tools from automorphic forms widely accessible, this book has had a tremendous influence on the practice of analytic number theory.

Topics in Classical Automorphic Forms develops many standard topics in the theory of modular forms in a nontraditional way. Iwaniec's aim was "to venture into areas where different ideas and methods mix and interact". One standout part is the treatment of the theory of representation of quadratic forms and estimating sizes of Fourier coefficients of cusp forms. The breakthrough in the late 1980s in understanding representations by ternary quadratic forms originated with the seminal work of Iwaniec, which is described beautifully here.

Biographical Sketch

Henryk Iwaniec graduated in 1971 from Warsaw University, got his Ph.D. the next year, and became professor at the Institute of Mathematics of the Polish Academy of Sciences before leaving for the United States in 1983. After taking several visiting positions in the United States (including a long-term appointment at the Institute for Advanced Study), in January 1987 he was offered a chair as New Jersey State Professor at Rutgers, the position he enjoys to this day.

Iwaniec's main interest is analytic number theory and automorphic forms. Prime numbers are his passion. His accomplishments were acknowledged by numerous invitations to give talks at conferences, including the International Congress of Mathematicians. Iwaniec is a member of the Polish Academy of Sciences, the American Academy

of Arts and Sciences, the National Academy of Sciences, and the Polska Akademia Umiejetnosci.

Among several prizes Iwaniec has received are the Jurzykowski Foundation Award, the Sierpinski Medal, the Ostrowski Prize, and the Cole Prize in Number Theory.

Iwaniec teaches graduate students and collaborates with researchers from various countries. In 2005 he was honored with the Doctorate Honoris Causa of Bordeaux University. In 2006 the town council of his native city made Iwaniec an Honorary Citizen of Elblag, a distinction he cherishes very proudly.

Response

I thank the American Mathematical Society and the Committee of the Steele Prize for this award. I am very honored and happy. This is a very meaningful recognition for me because the citation is telling not only about my fascination with the subjects but also about my attention to educating new generations of researchers. Modern analytic number theory takes ideas from the theory of automorphic forms and gives back new enhanced methods and results. While more arithmetical aspects of automorphic forms are covered relatively well in the literature, there is still not a sufficient exposition of analytic aspects. Hopefully more books will be written by other specialists that will address similar topics from many different directions. These two books selected by the Committee for the award came out of my teaching graduate courses and giving presentations in workshops, so inevitably they contain some of my favorite ways of handling the problems. I am glad that my choices and writing style are well received. If indeed these works do have "influence on the practice of analytic number theory", I will be most happy.

Seminal Contribution to Research: Ingrid Daubechies

Citation

The Leroy P. Steele Prize for Seminal Contribution to Research is awarded to Ingrid Daubechies for her paper "Orthonormal bases of compactly supported wavelets" (*Comm. Pure Appl. Math.* **41** (1988), no. 7, 909–996). In this paper Daubechies constructs the very first examples of families of wavelets (rescalings of a single "mother wavelet") that are simultaneously smooth, orthonormal, and compactly supported; earlier examples of wavelets had two out of three of these properties, but not all three at once. The orthonormality makes them good as a basis to decompose arbitrary signals; the smoothness removes edge artifacts and makes wavelet series converge rapidly; and the compact support makes them viable for use in actual practical applications. The wavelets also came with a parameter that traded off their smoothness for the width of their support and amount of oscillation, making them flexible enough to be used in a variety of situations. As such, these wavelets (now known as Daubechies wavelets) became extremely popular in practical signal processing (for instance, they are used in the JPEG 2000 image compression scheme). Even nowadays they are still the default, general-purpose wavelet family of choice to implement in any signal processing algorithm (although for specialized applications, sometimes a more tailored wavelet can be slightly superior).

Ingrid Daubechies

At the time of this paper, wavelet theory was already a booming field, with hundreds of papers devoted to wavelet construction, efficient algorithms, and so forth. At present the field is more mature and settled, an effect to which Daubechies's paper significantly contributed by largely "solving" the problem of the best wavelets to use in general (and also by giving order to the chaotic explosion of literature).

In his MathSciNet review of the paper, Hans Feichtinger wrote, "Even before its publication, the paper had a remarkable impact within applied analysis, and great interest in wavelet theory has been shown from many sides. By the summer of 1989 there was already a software package available, running on PCs, which is based on the construction described in this note. This sheds some light on the speed with which new mathematical algorithms are brought to work these days and can serve to underline the importance of mathematical research to applied fields."

Biographical Sketch

Ingrid Daubechies received both her bachelor's and Ph.D. degrees (in 1975 and 1980, respectively) from the Free University in Brussels, Belgium. She held a research position at the Free University until 1987. From 1987 to 1994 she was a member of the technical staff at AT&T Bell Laboratories, during which time she took leaves to spend six months (in 1990) at the University of Michigan and two years (1991–93) at Rutgers University. She is now at the Mathematics Department and the Program in Applied and Computational Mathematics at Princeton University.

Her research interests focus on the mathematical aspects of time-frequency analysis, in particular wavelets as well as applications. In 1998 she was elected to the National Academy of Sciences and became a fellow of the Institute of Electrical and

Electronics Engineers. The American Mathematical Society awarded her a Leroy P. Steele Prize for Mathematical Exposition in 1994 for her book *Ten Lectures on Wavelets*, as well as the 1997 Ruth Lyttle Satter Prize. From 1992 to 1997 she was a fellow of the John D. and Catherine T. MacArthur Foundation.

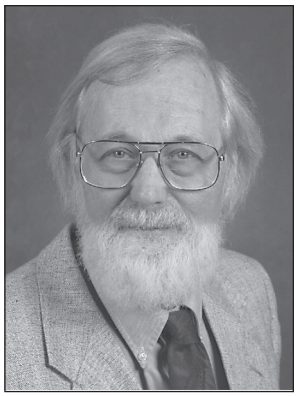
She is a member of the American Academy of Arts and Sciences, the American Mathematical Society, the Mathematical Association of America, the Society for Industrial and Applied Mathematics, and the Institute of Electrical and Electronics Engineers. In addition, Daubechies was elected in 2010 to serve as the next president of the International Mathematical Union.

Response

I am delighted and very grateful to receive this award, especially for this paper. In my work, I try to distill, from extensive contacts with scientists and engineers, challenging mathematical problems that nevertheless are still connected to the original question. When I am lucky, as was the case for this paper, the answer to the question or the results of the study are not only interesting mathematically but also translate into something new and useful for the application domain. I also would like to thank *Communications in Pure and Applied Mathematics,* where the paper appeared, for accepting those long tables of coefficients—its impact in engineering would not have been the same without the tables, at that time a standard feature of papers on filter constructions in signal analysis.

Lifetime Achievement: John W. Milnor

Citation



John Milnor

The 2011 Steele Prize for Lifetime Achievement is awarded to John Willard Milnor. Milnor stands out from the list of great mathematicians in terms of his overall achievements and his influence on mathematics in general, both through his work and through his excellent books. His discovery of twenty-eight nondiffeomorphic smooth structures on the 7-dimensional sphere and his further work developing the surgery techniques for manifolds shaped the development of differential topology beginning in the 1950s. Another of his famous results from this period is a counterexample to the Hauptvermutung: an example of homeomorphic but not combinatorially equivalent complexes. This counterexample is a part of a general big picture of the relation between the topological, combinatorial, and smooth worlds developed by Milnor. Jointly with M. Kervaire, Milnor proved the first results showing that the topology of 4-dimensional manifolds is exceptional by revealing obstructions to the realization of 2-dimensional spherical homology classes by smooth embedded 2-spheres. This is one of the founding results of 4-dimensional topology.

In this way Milnor opened several fields: singularity theory, algebraic K-theory, and the theory of quadratic forms. Although he did not invent these subjects, his work gave them completely new points of view. For instance, his work on isolated singularities of complex hypersurfaces presented a great new topological framework for studying singularities and, at the same time, provided a rich new source of examples of manifolds with different extra structures. The concepts of Milnor fibers and Milnor number are today among the most important notions in the study of complex singularities.

The significance of Milnor's work goes much beyond his own spectacular results. He wrote several books—*Morse Theory* (Princeton University Press, Princeton, NJ, 1963), *Lectures on the h-Cobordism Theorem* (Princeton University Press, Princeton, NJ, 1965), and *Characteristic Classes* (Princeton University Press, Princeton, NJ, 1974), among others—that became classical, and several generations of mathematicians have grown up learning beautiful mathematical ideas from these excellent books. Milnor's survey "Whitehead torsion" (*Bull. Amer. Math. Soc.* **72** (1966), no. 3, 358–426) provided an entry point for topologists to algebraic K-theory. This was followed by a number of Milnor's own important discoveries in algebraic K-theory and related areas: the congruence subgroup theorem, the computation of Whitehead groups, the introduction and study of the functor K_2 and higher K-functors, numerous contributions to the classical subject of quadratic forms, and in particular his complete resolution of the theory of symmetric inner product spaces over a field of characteristic 2, just to name a few. Milnor's introduction of the growth function for a finitely presented group and his theorem that the fundamental group of a negatively curved Riemannian manifold has exponential growth was the beginning of a spectacular development of the modern geometric group theory and eventually led to Gromov's hyperbolic group theory.

During the past thirty years, Milnor has been playing a prominent role in development of low-dimensional dynamics, real and complex. His pioneering work with Thurston on the kneading theory for interval maps laid down the combinatorial foundation for the interval dynamics, putting it into the focus of intense research for decades. Milnor and Thurston's conjecture on the entropy

monotonicity brought together real and complex dynamics in a deep way, prompting a firework of further advances. And, of course, his book *Dynamics in One Complex Variable* (Friedr. Vieweg & Sohn, Braunschweig, 1999) immediately became the most popular gateway to this field.

The Steele Prize honors John Willard Milnor for all of these achievements.

Biographical Sketch

John Milnor was born in Orange, New Jersey, in 1931. He spent his undergraduate and graduate student years at Princeton, studying knot theory (then a very unfashionable field that has since become amazingly fashionable) under the supervision of Ralph Fox. After many years at Princeton University and the Institute for Advanced Study, with shorter stays at UCLA and MIT, he has settled at Stony Brook University, where he is now codirector of the Institute for Mathematical Sciences. Over the years, he has wandered randomly from subject to subject, studying game theory, differential geometry, algebraic topology, differential topology, quadratic forms, and algebraic K-theory. For the past twenty-five years, his main focus has been on dynamical systems, and particularly on low-dimensional holomorphic dynamical systems. Among his current projects is the preparation of a book to be called *Dynamics: Introductory Lectures*.

Response

It is a particular pleasure to receive an award for what one enjoys doing anyway. I have been very lucky to have had so many years to explore and enjoy some of the many highways and byways of mathematics, and I want to thank the three institutions that have supported and inspired me for most of the past sixty years: Princeton University, where I learned to love mathematics; the Institute for Advanced Study for many years of uninterrupted research; and Stony Brook University, where I was able to reconnect with students and (to some extent) with teaching. I am very grateful to my many teachers, from Ralph Fox and Norman Steenrod long ago to Adrien Douady in more recent years; and I want to thank the family, friends, students, colleagues, and collaborators who have helped me over the years. Finally, my grateful thanks to the selection committee for this honor.

About the Prize

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 1905–1906, and Birkhoff served in that capacity during 1925–1926. 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) 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; (2) Mathematical Exposition: for a book or substantial survey or expository research paper; (3) 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. Each Steele Prize carries a cash award of US$5,000.

Beginning with the 1994 prize, there has been a five-year cycle of fields for the Seminal Contribution to Research Award. For the 2011 prize, the field was applied mathematics. The Steele Prizes are awarded by the AMS Council acting on the recommendation of a selection committee. For the 2011 prizes, the members of the selection committee were: Peter S. Constantin, Yakov Eliashberg, John E. Fornaess, Barbara L. Keyfitz, Gregory F. Lawler, Richard M. Schoen, Joel A. Smoller, Terence C. Tao, and Akshay Venkatesh. The list of previous recipients of the Steele Prize may be found on the AMS website at `http://www.ams.org/prizes-awards`.