ICM prize citations with biographical sketches by Elaine Kehoe
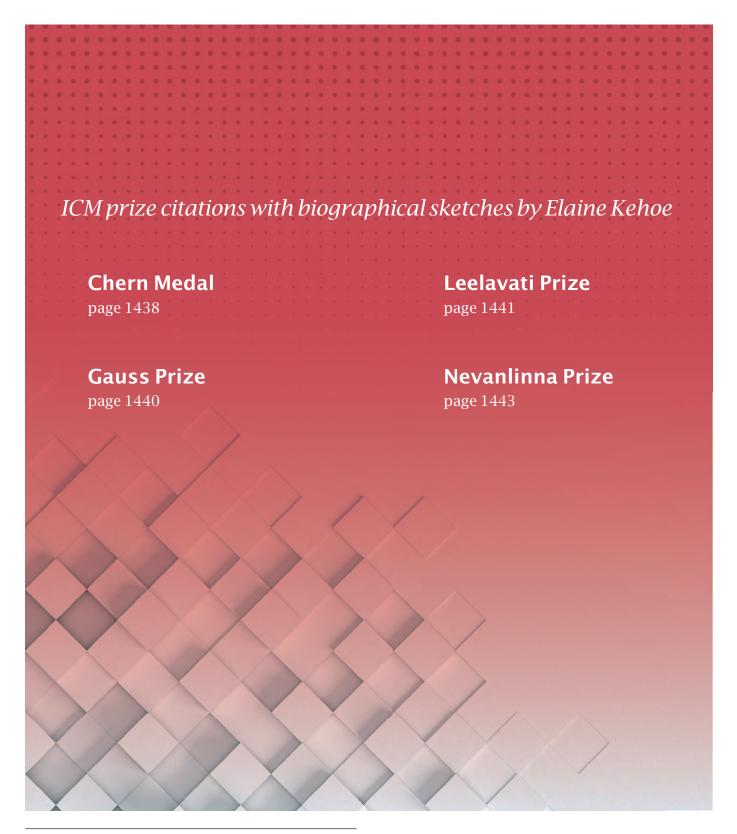
Kashiwara Awarded Chern Medal

MASAKI KASHIWARA of Kyoto University was awarded the 2018 Chern Medal at the 2018 International Congress of Mathematicians in Rio de Janeiro, Brazil, "for his outstanding and foundational contributions to algebraic analysis and representation theory sustained over a period of almost fifty years."

The work of Masaki Kashiwara

Masaki Kashiwara

Masaki Kashiwara's mark on current mathematics is exceptional. It extends from microlocal analysis, representation theory, and combinatorics to homological algebra, algebraic geometry, symplectic geometry, and integrable systems. Most notable are his decisive contributions to theory of D-modules and his creation of crystal bases, which have shaped modern representation theory.

Over a span of almost fifty years he has established the theory and applications of algebraic analysis. Introduced by Sato around 1960, algebraic analysis is a framework in which systems of linear differential equations are formulated as modules over a ring D of differential operators and are analyzed with algebraic means such as rings, modules, sheaves, and categories. Sato's idea of D-modules was greatly developed by Kashiwara in his 1971 thesis and has become a fundamental tool in many branches of mathematics. With Sato and Kawai, he developed microlocal analysis, the study of partial differential equations, locally combining space and Fourier variables, and working on the cotangent bundle of the base manifold. In the 1980s with Schapira he further introduced and developed microlocal sheaf theory.

One of his early major results was his 1980 construction of the Riemann-Hilbert correspondence, a far-reaching generalization of Hilbert's twenty-first problem about the existence of a linear differential equation on the projective line with prescribed monodromy. Greatly generalizing work of Deligne, Kashiwara (and later, independently, Mebkhout) established an equivalence between the derived category of regular holonomic D-modules on a complex algebraic variety ("systems of linear differential equations") and the derived category of constructible sheaves on the same variety ("solutions"), thereby creating a fundamental bridge between algebra and topology.

The Riemann–Hilbert correspondence found a remarkable application to a problem in representation theory: the Kazhdan–Lusztig conjecture, proved independently by Brylinski–Kashiwara and Beilinson–Bernstein. This beautiful synthesis of algebra, analysis, and geometry may be viewed as a precursor to geometric representation theory in its modern form. With Tanisaki, Kashiwara generalized the conjecture yet further to infinite dimensional Kac-Moody Lie algebras, a critical ingredient for the completion of Lusztig's program in positive characteristic.

Kashiwara's 1990 discovery of crystal bases is another landmark in representation theory. Quantum groups are deformations of the enveloping algebras of Kac–Moody Lie algebras originating from certain lattice models in statistical mechanics. Here the deformation parameter q is temperature, with $q = 0$ corresponding to absolute zero. Crystal bases are bases of representations of quantum groups at $q = 0$ which encode essential information about the representations. Kashiwara proved that for all q, crystal bases lift uniquely to global bases which turned out to coincide with the canonical bases discovered earlier by Lusztig. Being a powerful combinatorial tool, crystal bases have had great impact with many applications, including solving the classical problem of decomposing tensor products of irreducible representations.

Kashiwara's work, with many different coauthors, continues to be groundbreaking. He has been at the forefront of recent developments on crystal bases, including the categorification of representations of quantized enveloping algebras. Other highlights include the solution of two well-known open problems about D-modules: the "codimension 3 conjecture" (2014) and the extension of the Riemann-Hilbert correspondence to the irregular case (2016). His work on sheaf quantization of Hamiltonian isotopies (2012) opened the way to applications of microlocal sheaf theory to symplectic geometry.

Kashiwara has many other results too numerous to mention. For example, he obtained major results on representations of real Lie groups, and on infinite-dimensional Lie algebras, in particular in connection with integrable systems and the KP hierarchy.

Kashiwara's influence extends far beyond his published work. Many of his informal talks have initiated important subjects, and his ideas have been a source of inspiration for many people. Several of his books have become essential references, his book on sheaves with Schapira being regarded as the bible of the subject. He has served as di-

rector of the Research Institute for Mathematical Sciences (RIMS, Kyoto) and was vice president of the International Mathematical Union from 2003 to 2006.

Kashiwara's work stands out in depth, breadth, technical brilliance, and extraordinary originality. It is impossible to imagine either algebraic analysis or representation theory without his contributions.

Biographical Sketch

Masaki Kashiwara was born in Yuki, Ibaraki, Japan in 1947 and received his PhD from Kyoto University in 1974 under the direction of Mikio Sato. He was associate professor at Nagoya University (1974–1977). He became associate professor at RIMS, Kyoto University, in 1978 and full professor in 1984. Since 2010 he has been emeritus professor at Kyoto and project professor at RIMS, Kyoto. His awards and honors include the Iyanaga Prize (1981), the Asahi Prize (1988), the Japan Academy Prize (1988), the Fujihara Award (2008), and the Kyoto Prize in Basic Sciences for Outstanding Contributions to a Broad Spectrum of Modern Mathematics (2018). He is a member of the French Academy of Sciences and of the Japan Academy.

Photo credit

Photo of Masaki Kashiwara courtesy of Inamori Foundation.

Donoho Awarded Gauss Prize

DAVID L. DONOHO of Stanford University was awarded the Gauss Prize at the 2018 International Congress of Mathematicians in Rio de Janeiro, Brazil, for "his fundamental contributions to the mathematical, statistical, and computational analysis of important problems in signal processing."

Citation

David Donoho

Large amounts of data are today generated at an increasingly accelerated pace. Processing it by sampling, compression and denoising has become an essential undertaking.

David Donoho has throughout his remarkable research career helped us make sense of data, which often is in the form of signals and images. His research transcends boundaries between mathematics, statistics, and data science. The contributions range from deep mathematical and statistical theories to efficient computational algorithms and their applications.

Already in his early research Donoho was reaching outside of the mainstream of classical applied mathematics and statistics. He understood the importance of sparse representation and optimization in signal processing. He also recognized the power of wavelet type representations for a variety of tasks in signal and image analysis. One example is his work with Johnstone, where they exploit sparsity in wavelet representations together with soft thresholding for enhanced signal estimation and denoising.

The development, analysis and application of curvelets by Donoho and collaborators introduced another powerful tool in sparse image representation. While wavelets can be seen as a generalization of delta functions and Fourier expansions by using a basis that represents both location and frequency, curvelets go further by adding localization in orientation. Much of what wavelets do for one-dimensional signals, curvelets can do for multidimensional data. Efficient representation and processing of images with edges are natural and successful applications.

Compressed sensing is a technique for efficiently sampling and reconstructing a signal by exploiting sparsity in an incoherent representation and thus beating the classical limit on the required sampling rate imposed by the Nyquist-Shannon sampling theorem. This technique has, for example, been applied to shorten magnetic resonance imaging scanning sessions. Donoho and collaborators have contributed to develop and refine this powerful theory. He showed that one could solve some types of underdetermined linear systems via L_1-minimization provided that the solution is sufficiently sparse. He derived the existence of sharp transitions for the recovery of sparse signals from special kinds of random measurements.

David Donoho stands out in his ability to bring together pure and applied aspects of mathematics and statistics. He has had a fundamental influence by his original research, and also by his writing and mentoring of students and postdocs.

Biographical Sketch

David Donoho received his PhD from Princeton University in 1983 under the direction of Peter J. Huber. From 1984 to 1990 he served on the faculty at the University of California Berkeley. He has been at Stanford since 1990. He is a Fellow of the AMS. His honors include a MacArthur Fellowship (1991), the John von Neumann Prize of the Society for Industrial and Applied Mathematics (SIAM; 2001), the SIAM-AMS Norbert Wiener Prize in Applied Mathematics (2010), and the Shaw Prize (2013). He is a Fellow of SIAM and of the American Academy of Arts and Sciences, a foreign associate of the French Académie des Sciences, and a member of the US National Academy of Sciences.

Photo Credit

Photo of David L. Donoho by Jamie Lozano.

Nesin Awarded Leelavati Prize

ALI NESIN was awarded the 2018 Leelavati Prize at the 2018 International Congress of Mathematicians in Rio de Janeiro, Brazil, "for his outstanding contributions towards increasing public awareness of mathematics in Turkey, in particular for his tireless work in creating the 'Mathematical Village' as an exceptional, peaceful place for education, research and the exploration of mathematics for anyone." The Leelavati Prize, sponsored by Infosys, recognizes outstanding contributions for increasing public awareness of mathematics as an intellectual discipline and the crucial role it plays in diverse human endeavors.

The work of Ali Nesin

Ali Nesin

Ali Nesin was born in Istanbul in 1957, and he began his early academic career as a distinguished research mathematician. He graduated in France at Université Paris VII, earned his PhD at Yale University in 1985, and took several temporary positions at prestigious universities in the United States.

On the death of his father, the renowned writer Aziz Nesin, in 1995, he made a conscious decision and returned to his native Turkey. In place of pursuing his academic career in the United States, he decided that it was desirable and worthwhile to contribute to the development of mathematics in Turkey. He pursued his father's work as the director of the Nesin Foundation, a nonprofit institution devoted to providing educational opportunities for children who did not have them, and he created the Nesin Mathematics Village, which is now the main activity of the foundation.

Since his return to Turkey, he has devoted himself to developing the appreciation of mathematics as an element of modern Turkish culture. His activities towards the awareness of mathematics in Turkish society are numerous:

- He was the founder and editor-in-chief of *Matematik Dünyası* (*The World of Mathematics*), a magazine for the popularization of mathematics in Turkish, mainly addressed to high school students.
- He is a member of the editorial committee of *NTV-Bilim*, a Turkish popular science journal.
- He authored nine popular mathematics books (e.g., *Mathematics and Games, Mathematics and Nature, Mathematics and Infinity, Mathematics and Truth*)

and many popular mathematical articles in several periodicals.
- Several lecture notes and monographs by Ali Nesin received awards and became recommended material by the Turkish Academy of Sciences.

His books, popular journals, editorial work, articles, public lectures, and Internet activities had an enormous influence on enabling a new generation of Turkish mathematicians to flourish.

However, what makes the work of Nesin unique and goes beyond all envisaged activities for the Leelavati Prize is his creation, organization, and development of the Mathematics Village, despite difficult economic and political conditions. The Nesin Mathematics Village is a physical site south of Izmir, near the ancient Greek town of Ephesus, entirely devoted to the mathematical enrichment of gifted students at all levels, from elementary school through graduate level, as well as constituting a major venue for international conferences. It is perhaps most appropriately characterized by Gizem Karaali in *The Mathematical Intelligencer* as constituting "a possibly unique experiment in building a mathematical community in one of the most unexpected places on earth."

Ali Nesin's work in mathematics education and popularization of mathematics has and continues to have a truly transformative effect on Turkish culture with respect to the profile and appreciation of mathematics.

Biographical Sketch

Ali Nesin was educated all over the world: high school in Switzerland, the Université Paris VII Jussieu, and Yale University. After receiving his PhD in mathematics from Yale, he taught at the University of California Berkeley (1985–1986), University of Notre Dame (1987–1988), and the University of California Irvine (1988–1996). He also spent time as a visitor at the Mathematical Sciences Research Institute (MSRI) at Berkeley (1989), as a visiting professor at Bilkent University (1993–1994), and as a visitor at the University of Lyon I (2001–2002). He has been professor at Istanbul Bilgi University since 1996. From 1996 to 2013 he served as chair of the mathematics department, and he reassumed that role in 2018. Since 1995 he has been director of the Nesin Foundation. In 2005 he founded the Nesin Publishing House to publish the books of his father, the writer Aziz Nesin. He has been director of the Corporation of the Turkish Mathematical Society (2007–2009) and was a member of the administrative committee of

the Turkish Mathematical Society (2007–2009). Among his nonmathematical works are a four-volume publication of correspondence of Aziz and Ali Nesin, a biography of Aziz Nesin, and a number of children's books translated from French. He is also a painter who has held a number of exhibitions.

Photo Credit

Photo of Ali Nesin courtesy of Ali Nesin.

Daskalakis Awarded Nevanlinna Prize

Constantinos Daskalakis of the Massachusetts Institute of Technology was awarded the Nevanlinna Prize at the 2018 International Congress of Mathematicians in Rio de Janeiro, Brazil, "for transforming our understanding of the computational complexity of fundamental problems in markets, auctions, equilibria, and other economic structures. His work provides both efficient algorithms and limits on what can be performed efficiently in these domains."

Citation

Constantinos Daskalakis

Constantinos Daskalakis has developed a powerful body of results that resolve the computational complexity of some of the central problems in economic theory. These results have also been key to an important emerging theme in computer science, in which algorithms are designed for agents who behave according to their own self-interest.

Daskalakis's early work (with Goldberg and Papadimitriou) showed that finding Nash equilibria is complete for the complexity class PPAD; this implies that it is computationally equivalent in a precise sense to finding Brouwer fixed points, thus establishing a natural converse to Nash's famous construction of equilibria using fixed-point theorems. This computational difficulty in finding the Nash equilibrium in general raises important questions about the role of Nash equilibria as predicted outcomes when players interact in a fashion modeled by a game.

Daskalakis has also made important contributions to the theory of mechanism design, creating algorithms for use by selfish agents. The prior state of the art in this area (including Myerson's Nobel-Prize-winning work on optimal auctions) had been restricted largely to problems where participants' objectives are one-dimensional, described by a single parameter for each participant. Daskalakis (with Cai and Weinberg) provided a general method for transforming multidimensional mechanism design problems to pure problems in algorithm design, in the process developing mathematical tools that he used (with Deckelbaum and Tzamos) to make significant progress on characterizing optimal multidimensional mechanisms, an area that has been open for several decades. The underlying technique relies on a new and powerful geometric interpretation of a collection of large implicitly defined optimization problems at the heart of the transformation.

In addition to his work on issues at the interface of computational and economic theory, Daskalakis has produced work contributing to an impressive diversity of further areas in the theory of computation. This includes his resolution (with Mossel and Roch) of a fundamental conjecture in the reconstruction of evolutionary trees and his recent approaches to challenges in the theory of machine learning, including (with Tzamos and Zampetakis) new global guarantees for the well-known expectation-maximization heuristic from statistics for mixtures of two Gaussians with known covariances.

Biographical Sketch

Constantinos Daskalakis was born in Athens, Greece, in 1981. He received his PhD in electrical engineering and computer science from the University of California Berkeley in 2008. His awards and honors include the 2007 Microsoft Graduate Research Fellowship, the 2008 ACM Doctoral Dissertation Award, the 2008 Kalai Game Theory and Computer Science Prize from the Game Theory Society, the 2010 Sloan Fellowship in Computer Science, the 2011 SIAM Outstanding Paper Prize, the 2011 Ruth and Joel Spira Award for Distinguished Teaching, the 2012 Microsoft Research Faculty Fellowship, the 2015 Research and Development Award of the Vatican Giuseppe Sciacca Foundation, the 2017 Google Faculty Research Award, and the 2018 Simons Investigator Award.

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