Applications at the International Congress

By Marty Golubitsky

Grigori Perelman's decision to decline the Fields Medal, coupled with the speculations surrounding this decision, propelled the 2006 Fields Medals to international prominence. Stories about the medals and the award ceremony at the International Congress of Mathematicians in Madrid this summer appeared in many influential news outlets (*The New York Times*, BBC, ABC, . . .) and even in popular magazines (*The New Yorker*).

In Madrid, the topologist John Morgan gave an excellent account of the history of the Poincaré conjecture and the ideas of Richard Hamilton and Perelman that led to the proof that the three-dimensional conjecture is correct. As Morgan pointed out, proofs of the Poincaré conjecture and its direct generalizations have led to four Fields Medals: to Stephen Smale (1966), William Thurston (1982), Michael Freedman (1986), and now Grigori Perelman.

The 2006 ICM was held in the Palacio Municipal de Congressos, a modern convention center on the outskirts of Madrid, which easily accommodated the 3600 or so participants. The interior of the convention center has a number of intriguing views—my favorite, shown below, is from the top of the three-floor-long descending escalator.

The opening ceremony included a welcome from Juan Carlos, King of Spain, as well as the

Alfio Quarteroni's plenary lecture on cardiovascular mathematics was among the many sessions of interest to applied mathematicians.
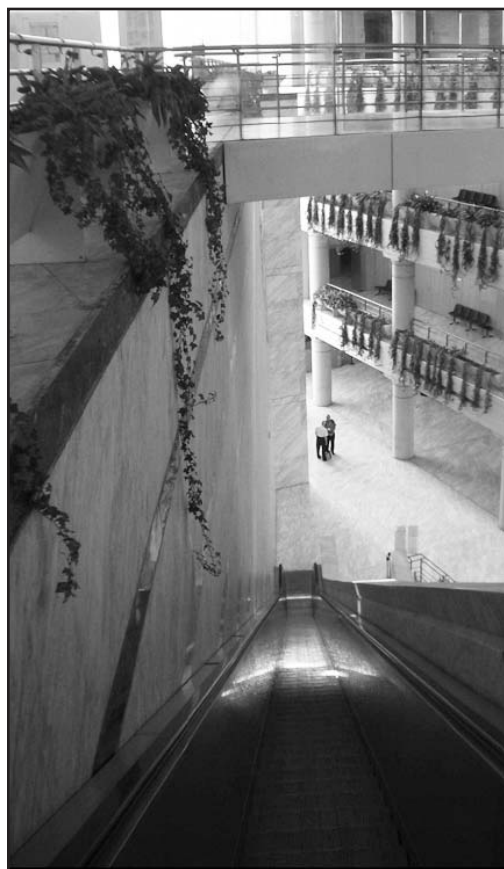
official announcement of the prize recipients—not only the four Fields Medals but also the Nevanlinna Prize and the (newly established) Gauss Prize. This was the only event for which the size of the main auditorium was not quite adequate, reflecting the excitement generated by the announcement of this year's Fields medalists.

A notable feature of this ICM was the prominent role played by applied mathematics, computational science, and theoretical computer science. The work of three of the Fields medalists touched significantly on applications, as did that of the recipients of the Nevanlinna and Gauss prizes.

As to the three Fields medalists who were present in Madrid, Wendelin Werner (Université de Paris Sud and Ecole Normale Supérieure) was cited for "his contributions to the development of stochastic Loewner evolution, the geometry of two-dimensional Brownian motion, and conformal field theory." He had done much of the work with Greg Lawler and Oded Schramm; a month earlier, at the SIAM Annual Meeting in Boston, the three had received SIAM's 2006 Pólya Prize. Peter Lax, over lunch in Boston, commented: "Here is another instance of a mathematical concept, Loewner deformation, invented for a purely mathematical purpose—to solve the Bieberbach conjecture—being used to tackle a problem in physics."

The Russian-born Andrei Okounkov (Princeton) received a Fields Medal "for his contributions bridging probability, representation theory and algebraic geometry." Okounkov proved that, for large n, the sequence of largest eigenvalues of random $n \times n$ matrices behave, from a probabilistic point of view, like the lengths of the longest increasing subsequences in permutations of the numbers 1 to n. His approach is through random surfaces, an area that has surprising connections to both algebraic geometry and melting crystals.

The Fields Medal to the Australian Terence Tao (UCLA) recognized his work in four different areas—most prominently the demonstration, with Ben Green, that prime numbers contain arithmetic progressions of any length. In addition to work on the Kakeya problem (higher-dimensional generalizations of the question "What is the minimum area in which a needle can be rotated by 180 degrees?"), Tao has contributed to the under-

standing of wave maps in general relativity and the existence of solutions in certain nonlinear Schrödinger equations.

Jon Kleinberg, a theoretical computer scientist at Cornell University, received the Nevanlinna Prize for a variety of network-related results (see article "The Way We Think About What It Means to Know Things"). He developed algorithms that enable analyses of the link structure of the Web, in addition to algorithms that, based only on local information, find shortest paths in small-world networks, which has implications for designing peer-to-peer file-sharing systems. Kleinberg has also given a rigorous definition of "bursts" in data streams; this research has a rather individual application—it can help in devising algorithms that organize e-mail archives automatically.

The Gauss Prize for Applications of Mathematics was awarded for the first time in Madrid, to the 90-year-old Japanese mathematician Kiyoshi Itō. The Itō calculus, as most readers will know, provides the mathematical basis for much of mathematical finance, in particular for the Black–Scholes formula for option pricing (see James Case's article "First Gauss Prize Is Awarded to Kiyoshi Itō in Madrid").

To understand the extraordinary presence of applied mathematics at this year's ICM, one need only look at the list of plenary speakers, about a third of whom are well known to the SIAM community. Among the group were Percy Deift, Ron DeVore, Bob Kohn, Arkadi Nemirovski, Alfio Quarteroni, Oded Schramm, and Avi Wigderson. Indeed, by next summer Kohn and Nemirovski will have had the distinction of giving plenary lectures at both ICM 2006 and ICIAM 2007 (Zürich).

Along with all this featured activity, several main topic areas of the Congress were devoted to applied mathematics and areas of interest to applied mathematicians, such as Numerical Analysis and Scientific Computing, Applications of Mathematics in the Sciences, and Mathematical Aspects of Computer Science. As a result, many whose presence could be expected at SIAM meetings (Max Gunzburger, Randy LeVeque, Yvon Maday, Michael Griebel, and Emmanuel Candès, to name just a few) were invited speakers in Madrid. It was a delight to see mathematics so broadly interpreted at center stage at this ICM.

For those who like to plan ahead, the next International Congress of Mathematicians will be held in Bangalore, India, in August 2010. In the meantime, though, the next International Congress on Industrial and Applied Mathematics will be held in Zürich, July 16–20, 2007 (see Rolf Jeltsch's preview "Program Choices Abound with Multiple Meetings Set to Converge in Zürich").

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