International Congress of Mathematicians

The lecture hall at the Technical University of Berlin, site of the Plenary Lectures for ICM98 .

About 3,500 people attended the 1998 International Congress of Mathematicians (ICM98) in Berlin last August. The tremendous variety on the program ensured that there was always something interesting to do, leaving participants exhausted but satisfied. The meeting was in many ways a marvel, combining Germany's legendary efficiency with its deep cultural heritage.

Berlin's Culture on Display

It has been ninety-four years since the ICM was last held in Germany. The reason, of course, is that German mathematics nearly died out during World War II, when many of the country's best mathematicians fled the Nazi regime. ICM98 clearly meant a great deal to German mathematicians, as it provided an opportunity to heal the wounds of the past and to show the world that their country has regained some, if not all, of its mathematical strength. At the Congress, the chilling facts of Germany's past were not glossed over, but confronted directly. At the Opening Ceremonies, ICM Honorary President Friedrich Hirzebruch, who has been a central figure in the rebuilding of mathematics in postwar Germany, devoted nearly his entire speech to the subject. In particular, he called attention to a special ICM event organized by the Deutsche Mathematiker Vereinigung (German Mathematical Society) called "Terror and Exile: Berlin Mathematicians under the Nazi Regime 1933–1945".

Of all German cities, Berlin perhaps most potently symbolizes how much the country has changed in the past several decades. At times Berlin feels like one gigantic construction site, with new buildings going up everywhere. The western and eastern parts of the city have long since reintegrated, but there are many reminders of the Berlin Wall, from streets that dead-end in peculiar ways to memorials to those who perished trying to cross to the other side. Still, the city retains a great deal of old world elegance and grandeur, as well as a high degree of cultural sophistication, which was amply showcased during the Congress. It happened by chance that on the Saturday night during the ICM, Berlin held an event called "The Long Night of Museums", for which museums all over the city stayed open until 2 a.m. and offered special programs of music and dance. One of the main events on the ICM social program was a performance of *The Magic Flute* by the Deutsche Oper Berlin, for which ICM participants could purchase specially priced tickets.

In celebration of the ICM, the Berlin-Brandenburg Academy of Science sponsored a public lecture by the noted German writer Hans-Magnus Enzensberger. The title of his lecture was "Zugbrücke außer Betrieb, oder die Mathematik im Jenseits der Kultur: Eine Außenansicht" ("Drawbridge Out of Order, or Mathematics Outside of Culture: A View from the Outside"). Enzensberger pondered

Photographs used in this article are courtesy of Gerd Fischer.

ICM Honorary President Friedrich Hirzebruch (left) and Andrew Wiles.

the strange position of mathematics in today's society, in which people proudly proclaim their ignorance of mathematics but would never take the same attitude toward other parts of human culture, such as music. The lecture, which presented a view of mathematicians that was at once sympathetic and unsparing, drew rave reviews. "It was marvelous," said Hermann Karcher of the University of Bonn. "It is amazing that someone outside of mathematics could have so much insight into the field itself and its communication problems."

Mathematics *für Alles*

The Enzensberger lecture was part of an extensive program for the general public that took place in the Urania, a public lecture institute in Berlin. The stereotype of Germans as a dour, serious lot might lead one to suspect that this part of the ICM program would be filled with stuffy, instructive lectures. Quite the opposite was true. Fun and whimsy prevailed in the lobby of the Urania, where groups of young and not-so-young people gathered around the many mathematical games and puzzles on display. There was one contraption that makes enormous soap bubbles: Pull a cord, and a hula hoop-sized ring rises from a circular vat of soap solution, leaving a shimmering, tubular trail of a soap bubble. There was a festival of mathematical videos, as well as public lectures on such topics as mathematics and sculpture, and financial mathematics.

The ICM organizers worked hard in advance of the Congress to ensure that there was plenty of media coverage. Their work paid off in daily articles in the local German newspapers, as well as in a half-hour television broadcast about the Congress. To give reporters time to get a handle on the work of the Fields Medalists, the organizers gave newspapers information several months in advance. To keep the names secret, each medalist was initially given a code name, like "Quantum" and "Moonshine", but these were changed to numbers when it was realized they were too obvious. Generally the press was favorable toward mathematics, but there was at least one exception. *Der Spiegel*, one of the main nationwide news magazines in Germany, ran an unsigned article entitled "Nobelpreis für Quatsch" ("Nobel Prize for Nonsense"). The title referred to the work of Fields Medalist Richard Borcherds on the "moonshine" conjectures in the theory of finite simple groups. The story ridiculed the work of Borcherds and of Andrew Wiles (who received a special one-time award at the Congress) as lacking practical applications. Even when the story grudgingly acknowledged that the work of Fields Medalist Maxim Kontsevich was interesting, the jeering tone remained, as the story referred to Kontsevich as a "Milchgesicht" ("babyface"). Fields Medalists William Timothy Gowers and Curtis McMullen fared better, as they were not mentioned in the piece.[1]

Efficiency Pays Off

Many at the Congress remarked on its efficient organization. This showed in many small ways—such as the fact that water, fruit juice, coffee, and tea were always available for free outside the lecture rooms—and in many large ones too—such as the extensive use of e-mail and the Web to communicate information about the Congress and to register participants. Another organizational feat was getting two of the three proceedings volumes published in time for participants to pick them up with their registration packets. The efficiency attracted some jokes: The ICM "circular letters" sent out in e-mail during the preceding year or so by Martin Grötschel, president of the organizing committee, were said to number in the thousands, but really totaled only thirty-four. In one of these letters Grötschel felt compelled to address complaints that the ICM was being "overorganized". But witnessing how smoothly the Congress ran, one might conclude that too much organization was just enough.

Consider the Opening Ceremonies, an especially complex event that was held in Berlin's International Congress Center. The musical interludes were accompanied by a light show projected onto a screen on the stage. There was a succession of speakers, some of whose presentations were accompanied by slides or short video programs, and all were flawlessly timed. (On the other hand, efficiency did not dictate every aspect: Two attractive young women with long blonde hair and very short skirts ferried the Fields Medals around the stage, calling to mind the presentation of trophies at an automobile race.) The most impressive display of efficiency came with the serving of a buf-

[1] *An article about the mathematical work of the Fields Medalists appears in this issue of the* Notices. *There was also a shorter report in the November 1998 issue, pages 1358-1361.*

fet lunch to the 3,000 people who attended the Opening Ceremonies. The curtain on the stage went up, and a collective gasp rose from the crowd. There in the enormous backstage area stood a dozen or so waiters and waitresses, carrying trays of drinks, and behind them was the buffet lunch, laid out on several tables. No one had to leave the lecture hall to have lunch; they simply poured onto the stage. Although those who had sat in the far reaches of the auditorium had to wait in line quite a long time, everyone got fed.

The Scientific Program

The main part of the ICM scientific program consisted of twenty-one 1-hour Plenary Lectures, and more than one hundred fifty 45-minute Invited Lectures; there were also poster sessions and short communications of fifteen minutes' duration. Some participants commented that the Plenary Lectures were presented at just the right level for a general mathematical audience. Among the highlights was the lecture by Nevanlinna Prize winner Peter Shor of AT&T Labs. In the last few years, Shor has gained worldwide attention for his work on quantum computing, which he described in his lecture. His most famous result was to exhibit an algorithm that, if implemented on a quantum computer, could factor integers in polynomial time. Currently no such algorithm is known to exist for conventional computers. The simple and fundamental quality of the ideas in Shor's lecture appealed to many ICM participants. Some were so impressed that they said his work seemed more exciting than that of the Fields Medalists.

Quantum computing also arose in a highly speculative Invited Lecture by Michael Freedman of Microsoft Research, who spoke in the topology section. In recent years, Freedman, a 1986 Fields Medalist, has become interested in trying to use topology to address some of the central questions in theoretical computer science. He began his lecture by asking whether there is a "speed limit" on knowledge, akin to the limit on the speed of light: Is there inherent in the laws of nature an obstacle to solving certain very hard problems within a reasonable amount of time? Here "reasonable" means an amount of time that grows only polynomially with the size of the problem. After discussing the idea of quantum computing, Freedman proposed a new model called "quantum conformal field computing", which attempts to exploit connections between the Jones polynomial for knots and conformal field theory to attack hard computing problems that have not yielded to conventional algorithms.

The ICM organizing committee made room on the program for the Fields Medalists to present 45-minute ad hoc lectures (Curtis McMullen was already on the schedule to present an Invited Lecture in the dynamical systems section before the medals were announced). These lectures provided an opportunity for Congress participants to get a better understanding of the medalists' work. All of the medalists put in a lot of effort to make their talks comprehensible to a general mathematical audience. McMullen, known for being an excellent expositor, discussed the role that topological rigidity plays in dynamical systems. Borcherds provided an accessible lecture about his work on the "moonshine" conjectures in finite group theory and the development of the notion of vertex algebras. Rather than talk about his work in Banach spaces, which seems to be the reason for his getting a Fields Medal, Gowers spoke on his work on a problem of Szeméredi in arithmetic number theory. Kontsevich described some of his newest work concerning quantization of Poisson manifolds using ideas involving motives from arithmetic geometry.

Nevanlinna Prize winner Peter Shor, right, with Ronald Graham of the University of California, who spoke on Shor's work.

Fields Medalist Tim Gowers, right, with Béla Bollobás of the University of Memphis, who spoke on Gowers' work.

Fields Medalist Curtis McMullen.

The talks at the ICM demonstrated that classical questions in dynamical systems, such as questions about closed orbits, are alive and well. Examples include the Invited Lecture by Krystyna Kuperberg of Auburn University, who spoke on the real analytic counterexample she produced to the so-called Seifert Conjecture, a long-standing problem in this area, and the Plenary Lecture by Helmut Hofer of the Courant Institute, which approached these questions from the viewpoint of symplectic geometry. Christopher Deninger of the University of Münster presented an intriguing talk about an idea for a new kind of cohomology theory in number theory that has parallels to the cohomology theory that already exists for dynamical systems associated with foliations. If the theory works out as Deninger hopes, it would produce a vast generalization of the Weil conjec-

Fields Medalist Maxim Kontsevich, left, with Clifford Taubes of Harvard University, who spoke on Kontsevich's work.

Fields Medalist Richard Borcherds, left, with Peter Goddard of the University of Cambridge, who spoke on Borcherds's work.

tures in number theory. Pierre Deligne proved the last of these conjectures, known as the Riemann Hypothesis for Finite Fields, and as a result received a Fields Medal in 1978.

Ideas from physics arose in many of the talks. In his Invited Lecture, Clifford Taubes of Harvard University described his celebrated result showing that the Seiberg-Witten invariants in gauge theory and the Gromov invariants in symplectic geometry are one and the same. This talk showed a sense in which Taubes was correct when, in his Plenary Lecture at the ICM in Zürich four years ago, he predicted that symplectic geometry would one day be incorporated into anti-self-dual geometry. The influence of physics was also notable in the Plenary Lecture of Peter Sarnak of Princeton University. He discussed the close parallels between the statistics of the spacing of the zeroes of the Riemann zeta function and the statistics of the distribution of eigenvalues of certain matrices, which physicists refer to as the Gaussian Unitary Ensemble. The picture of a phase transition familiar from physics—which shows a graph that is horizontal, suddenly dips sharply, and then becomes horizontal again—arose in surprising places, such as in the lectures of Freedman and McMullen. It also showed up in the Plenary Lecture by Persi Diaconis, in which he described a model for understanding the probabilities of distribution of cards after shuffling. It turns out that 6 shuffles tend to leave the cards in almost the same order, but there is a "phase transition" between 6 shuffles and 7, after which the cards tend suddenly to become randomly mixed. Diaconis described how the card-shuffling model can be generalized to more complicated problems, such as random walks on buildings.

The Plenary Lectures were held in a large auditorium in one of the buildings of the Technical University of Berlin, and the Invited Lectures were in smaller rooms in this building as well as in the mathematics building across the street. Some of these smaller rooms were packed to the rafters, with people sitting or standing in the aisles. In such cases it was clear that the talks were attracting specialists and nonspecialists alike, making it hard for speakers to know which group to address. As a result, there were some complaints that the Invited Lectures were not as understandable to nonspecialists as were the Plenary Lectures.

There were also complaints about scheduling conflicts among the Invited Lectures, which were presented in parallel sessions. There were a number of cases in which speakers in related areas were scheduled for the same time slot. Such conflicts are unavoidable, but they seemed especially abundant at this Congress and afflicted several areas, from geometry to fluid dynamics. One especially odd case concerned the talks of three geometers who work in very closely aligned areas: Yakov Eliashberg and Simon Donaldson, both of Stanford University, and Clifford Taubes. Before the Congress, Eliashberg complained to the organizing committee that Taubes and Donaldson had been scheduled to speak at the same time. Eliashberg hoped to attend both his colleagues' talks, but it was not to be. The organizing committee eliminated one conflict but created another: It moved Eliashberg to Donaldson's time slot, thereby putting Eliashberg at the same time as Taubes. After it became clear that there were many problems with conflicts between the talks in the geometry and topology sections, the organizers attempted to reschedule them in separate weeks of the Congress. However, the attempt came too late, as many of the speakers had already purchased nonrefundable plane tickets.

Although it was supposed to be a secret until the Closing Ceremonies, the fact that the next Congress will take place in Beijing in 2002 was widely known. (It had even been mentioned in the *Notices* [August 1998, p. 864].) Glossy posters announcing the event, which will take place in the Great Hall of the People in Tianenman Square, were available well before the end of the Berlin Congress. Some expressed discomfort about holding the ICM in a country where human rights abuses have been a continuing problem. It is also not clear whether mathematicians from countries such as Taiwan would be allowed to attend. But perhaps Berlin will prove an exemplar for Beijing. ICM98 provided an opportunity for Germany to examine how the country's past abuses afflicted its mathematicians and to make a commitment to renewal. There could be no better precedent for the Beijing Congress.

—Allyn Jackson