

In High Gear: Spanish Mathematics Looks to the Future—and to ICM2006

Allyn Jackson

The International Congress of Mathematicians will be held in Madrid, Spain, August 22–30, 2006. The Second Announcement of the Congress appeared in the December 2005 issue of the *Notices*, pages 1407–1432, and contains information about the scientific program, the social program, registration, and accommodations. Updated information may be found on the ICM2006 website, <http://www.icm2006.org>.

Today, mathematics in Spain is in high gear. Many Spanish mathematicians are working at the top international echelons of research, speaking at important conferences, and publishing papers in the best journals. But this high level of mathematical activity is a relatively recent phenomenon in Spain. Even as Spanish mathematicians applaud the growth in their field, they see challenges ahead and know that sustaining the newfound momentum will take plenty of effort. Their successful bid to bring the International Congress of Mathematicians (ICM) to Madrid in August 2006 is emblematic of their efforts to highlight Spanish mathematics and keep it thriving.

Scientifically, A Developing Country

When it comes to scientific and mathematical research, Spain is in many ways a developing country. “We don’t have a tradition of research in Spain,” said Manuel de León, a permanent researcher at the Consejo Superior de Investigaciones Científicas (CSIC, High Council for Scientific Research) and president of the Executive Committee for ICM2006. During the Middle Ages there were very good Arabic and Jewish mathematicians in Spain, and in 1572 King Phillippe II founded the Academia de Matemáticas de Madrid. Nevertheless, Spain has traditionally been known more for its arts and literature than for science and mathematics. In the early part of the twentieth century, some mathematical activity began to develop. The Real Sociedad Matemática Española (Royal Spanish Mathematical Society, RSME) was founded in 1911 and

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a mathematics research laboratory was established in Madrid in 1915. But the laboratory disappeared during the Spanish Civil War, and the RSME began a slow decline that was reversed only with its re-founding in 1997.

During much of the twentieth century, when many other countries were building up the infrastructure and traditions that support research, Spain was under the dictatorship of Francisco Franco, which lasted from the 1930s until Franco’s death in 1975 and kept Spain rather isolated from research at the international level. The Franco regime did make some efforts to support research within Spain and in particular founded the CSIC, which remains today one of the country’s most important organizations for research. The CSIC consists mainly of a collection of institutes with permanent research staffs. In 1939, the Instituto Jorge Juan de Matemáticas was created in the CSIC. Although this institute was run more on the basis of influence and connections than on mathematical accomplishment, it nevertheless played an important role in keeping mathematics alive in Spain. So it was a setback for the Spanish mathematical community when the Jorge Juan Institute was shut down in 1984. Today mathematicians who work within CSIC are employed by institutes in other areas. For example, de León works in a Madrid-based CSIC institute focused on theoretical and fundamental physics, which is the only CSIC institute that has a mathematics department. This department has seven permanent members, eight postdoctoral researchers, and eight doctoral students.

The improvement over the last couple of decades of Spain's economic condition led to increased investment in research and education, which in turn improved the climate for mathematics. During this time, and particularly in the last ten years, mathematics in Spain has undergone a revival. There are many more Spanish mathematicians working at the top levels of mathematics research than before. According to data collected by the Institute of Scientific Information (ISI), the percentage of mathematics research papers written by Spanish authors has grown from 0.3 percent in 1980 to close to 5 percent today. "Now when you open international journals, it is common to see Spanish authors," commented Carlos Andradas of the Universidad Complutense de Madrid, who is the current president of the RSME and vice president general of the ICM2006 Executive Committee. "This was not the case several years ago." One also sees more Spanish mathematicians on editorial boards of journals, as winners of international prizes, and as participants in research programs such as the international networks funded by the European Union.

The ISI also publishes a list of the world's most highly cited scientists. Among the fifteen Spaniards on this list, mathematics has the largest showing, with four mathematicians. The four are: David Nualart of the Universitat de Barcelona and the University of Kansas, Jesús María Sanz Serna of the Universidad de Valladolid, and Juan Luis Vázquez and Enrique Zuazua, both of whom are at the Universidad Autónoma de Madrid. Vázquez will deliver a plenary lecture at ICM2006, while Nualart and Zuazua will present section lectures. Indeed, de León pointed to the strong showing of Spanish mathematicians among ICM2006 speakers—nine in all—as yet another indication of the burgeoning of mathematics in Spain.

Rising Investment in Mathematics

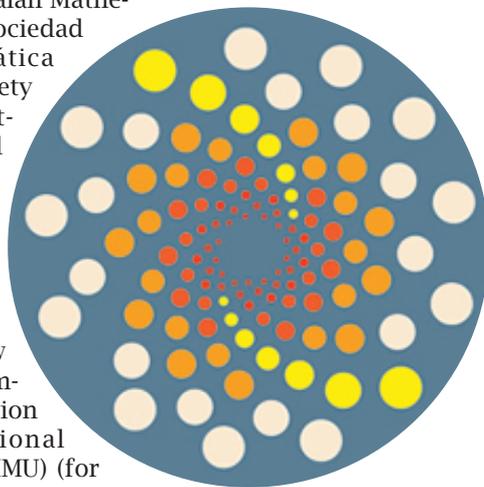
Mathematics research in Spain is concentrated mainly in the country's universities. Judging by percentage of mathematics papers written, the primary centers are in Andalusia (19 percent), Barcelona (21 percent), and Madrid (24 percent). There are also strong groups in Granada, Santiago, Sevilla, and other places. There is one mathematics research institute that operates at the international level, the Centre de Recerca Matemàtica (CRM), based at the Universitat Autònoma de Barcelona. The CRM is supported by the Institut d'Estudis Catalans, a scholarly academy devoted to the promotion of Catalan culture. de León estimates that there are about 3,000 permanent positions for Spain's approximately 6,000 mathematicians and that about one-quarter of these individuals are actively doing research. Among the main areas of strength are algebraic topology,

algebraic and differential geometry, partial differential equations, probability theory, and Fourier, complex, and functional analysis. Some branches of mathematics, such as number theory and logic, have little representation in Spain. Most of the research, even in such areas as PDEs and numerical analysis, tends toward the theoretical end of the spectrum.

Aside from the RSME, Spain has three other major mathematical societies: the Societat Catalana de Matemàtiques (Catalan Mathematical Society), the Sociedad Española de Matemática Aplicada (Spanish Society of Applied Mathematics), and the Sociedad de Estadística e Investigación Operativa (Society for Statistics and Operations Research). In 1998 these four organizations banded together to create a new Spanish National Committee for representation within the International Mathematical Union (IMU) (for many years, Spain's IMU representation was handled directly by the Ministry of Education and Science, which is the official adhering organization to the IMU).

These four organizations also collaborated to prepare the bid to the IMU to hold the 2006 ICM in Madrid. Carles Casacuberta of the Universitat de Barcelona, who is the current president of the Catalan Mathematical Society and a vice president of the ICM2006 Executive Committee, stated in an email message: "The bid's success testifies to the progress and unity of the Spanish mathematical community, in spite of its rich thematic and geographical diversity. Now Spain is willing and prepared to host this ICM. I doubt it would have been possible twenty years ago, or perhaps even ten years ago. Nowadays we have strong teams in almost every mathematical subject, linked by growing research structures, and the whole community is ready to support the ICM." The four mathematical societies—

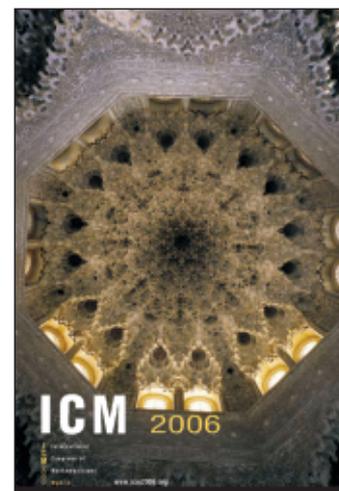
together with two other societies in education and history, plus a federation of teachers' associations—have formed the Comité Español de Matemáticas (Spanish Committee for Mathematics, CeMAT), which aims to coordinate Spanish activities connected with the IMU.



Logo of ICM2006. The logo is an idealized image of a sunflower. The number of spirals to the right and left in a sunflower are consecutive numbers of the Fibonacci sequence. The logo also symbolizes the idea of Spain as a Mediterranean country. The colors of the logo are used to identify different fields of ICM2006 activity. For example, orange represents scientific activity.

The ICM2006 Alhambra Poster.

The Hall of the Two Sisters (Sala de las dos Hermanas) derives its name from the twin marble flagstones forming part of the floor. This hall was in the center of a series of chambers where the Sultana and her family lived. The hall was built by order of Mohammed V. It is square, has interlacing ceilings and bedchambers connected with the Emperor's Chambers (Habitaciones de Carlos V) and, through a balcony, with the Gardens of the Partal (Jardines del Partal). Visitors may access the hall through a semicircular festooned arch, where the original wooden doors are still preserved. A passageway leads to the high chambers, with ceilings carved in the 16th century. Three little arches, with Mozarabs on the lateral arches and arch scallops on the central arch, lead to the chamber of the mirador. You can see the Patio of the Lions (Patio de los Leones) from there. The hall's paving is made of marble and has a small fountain with a jet and a little channel that carries the water to the Patio of the Lions. The most impressive feature of the hall is the beautiful and perfect Mozarabic dome. Its



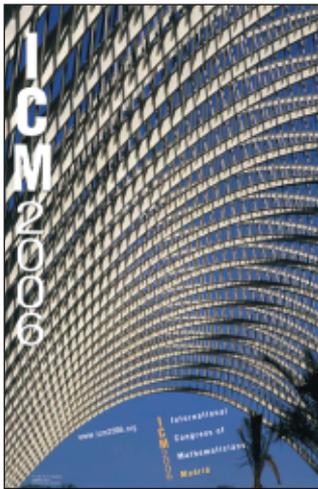
lighting was carefully considered and it receives the light from small lateral windows. The dome is therefore a beautiful and exquisitely rich flower. Ibn Zamrak wrote a poem about this dome, and some of his verses are reproduced on a tile skirting board that has metallic iridescence. The hall's walls are covered with extremely fine plasterwork with different themes, among which we find the classical Nasrid motto "Only God is victorious" and also, for example, a pair of clasped hands.

average for countries in the European Union is about 2 percent; the benchmark set by the EU is 3 percent. The current Spanish government has set a target to reach 2 percent by 2010, so it seems likely that funding for research in Spain will continue to grow. The government supports research primarily through the Ministry of Education and Science, which in particular provides funding for the CSIC. Employing about 2,500 scientists in 120 institutes across Spain, the CSIC is the country's main research organization. Very few mathematicians have positions in the CSIC, and there is no single CSIC institute devoted to mathematics. But in another sign of the progress of mathematics in Spain, plans are now being laid to launch a CSIC mathematics institute, possibly in 2006, in cooperation with the three major universities in Madrid (the Autónoma, the Complutense, and the Carlos III).

For the past twenty years or so, the Ministry of Education and Science has also supported research through grant programs. Mathematics did not have its own funding program but was funded through a general program for basic research overseen by a committee that also dealt with physics grants. This changed in 2001, when the government stepped up its support for research and decided to launch a separate mathematics program. Enrique Zuazua was appointed to get the new program off the ground, and after a transition period, the National Program in Mathematics was formally established in 2004. (In spring 2005 a new manager of the program was appointed, Enrique Fernández-Cara of Sevilla University.) The last five years have seen large growth in government funding for mathematics, from just under 2 million Euros (approximately US\$2.5 million) in 2000 to 5.5 million

Euros in 2004. The grants are usually given to teams of researchers and function much like grants from the U.S. National Science Foundation, although the Spanish government does not provide any salary for principal investigators. The increase in funding has had a large impact, improving the research conditions for mathematicians and making it easier to support students. "Every single active mathematician felt the effect" of the National Program in Mathematics, commented Casacuberta.

Zuazua and others said that the National Program in Mathematics has reached a plateau and now provides sufficient support for small teams of researchers. They argue that what is needed now is a more ambitious endeavor, such as establishing a major national center for mathematics in Spain. And indeed the Spanish government that was in power before the elections in spring 2004 agreed in principle to establish a National Research Center for Mathematics. But exactly what form this center will take and exactly when it will come into being are open questions. At least at first, it will most likely be a "distributed institute" consisting of a network of university-based groups, CSIC institutes, and the CRM. Deciding whether and where to erect a building that would serve as a permanent home for the center is, according to Zuazua, fraught with political difficulties that the government is not yet prepared to face. There are vague hopes that an announcement about the center's establishment will be made at the ICM in August 2006, but nothing is certain yet. Zuazua believes the government will eventually fund the center, but he sees some urgency in getting the project going soon. "We are losing important years," he noted. "There is a great generation of mathematicians in Spain right now.



The ICM2006 Calatrava poster.

This is a photograph of the City of Arts and Sciences in Valencia, Spain, designed by the Spanish architect Santiago Calatrava. The photograph depicts an example of the new Spain, a dynamic country open to science and technology.

"As the site is close to the sea, and Valencia is so dry, I decided to make water a major element for the whole site using it as a mirror for the architecture."
—Santiago Calatrava

Thanks to Manuel de León for providing text describing the subjects of the two ICM posters.

These people are getting older, and they cannot wait forever to have the right tools for their research."

Challenges Ahead

The many positive developments in mathematics in Spain seem to presage a bright future, but the mathematical community there nevertheless faces some substantial challenges. One is the declining number of students pursuing mathematics—a phenomenon that is not particular to Spain but in fact seems to be worldwide in scope. When he first came to Madrid in 1990, Zuazua would have perhaps fifteen students in his graduate classes. "Today, if I have three students, I am very happy," he said. In Spain, ties between mathematics and industry have traditionally been weak, so Spanish companies generally do not seek mathematically trained employees. As a result, the career path for those with advanced mathematical training points inevitably to academia—where in recent years jobs have been few and far between. But this situation is poised to change. Recently Andradas helped to prepare a study that concluded that about half of all professorial positions in Spain will open up in the coming decade. "For young people starting now, the perspectives are much better than for people who started ten years ago," he noted. Nevertheless, it remains difficult right now to convince students to pursue and remain in mathematics. de León noted that Spanish mathematicians have begun several initiatives to spark the interest of young people in mathematics, such as the "Divulgamat" website of the RSME that contains virtual exhibitions, popularizations, mathematical poetry, biographies of mathematicians, and other resources.

A second challenge, according to Zuazua, is related to the lack of connection to industry. Such connections are not easy to cultivate, so, as Zuazua put it, "you continue to work on your inequality." As a result, Spanish mathematicians have developed

a propensity for deep but somewhat narrow research, and the infusion of new ideas that can come from interactions with other disciplines is missing. At the same time, there is little recognition for interdisciplinary work. But this too seems to be changing. "Ten years ago there was a big explosion of mathematics on Wall Street," Zuazua observed. "Now it is happening here in Spain." Spanish companies are slowly waking up to the value of mathematics, and industrial laboratories have gradually begun hiring mathematicians. However, the effect has not yet been large enough to lure more students into the field.

A third challenge for Spanish mathematics is the inbred nature of the academic hiring system. It is not only rare to find a foreigner in a Spanish mathematics department, it is even unusual to find someone from outside the local area. Zuazua recalled that, when he took a position at the Universidad Complutense in Madrid, there was grumbling that his job should have gone to a local; Zuazua is originally from Bilbao in the Basque country. Many mathematics departments are filled with people who received their Ph.D.'s there or at nearby universities. While a case can be made that such a strategy helps to build cohesive research groups, over the long term the result can be mediocrity. Andradas noted that Spain has made some efforts to try to improve the hiring system, but change has been exceedingly difficult. "Spain is a country where mobility is still not very common," especially when one is over thirty-five and has one's own family, he noted. "People try to work in the neighborhood where they grew up and where their family is living. Family still has a strong influence here."

Intense local loyalties have developed hand in hand with this hiring system, and big centers like Madrid are sometimes eyed with suspicion by mathematicians in other places. de León and the ICM2006 co-organizers seem determined to use

the occasion of the Congress to bring the Spanish mathematical community together. “We are trying to get every university, every mathematician, to feel that he or she is a part of the ICM organization,” he said. “It is not a separate thing—it’s an ICM by the full Spanish mathematical community.” To this end, the ICM executive committee has held its meetings in various cities around Spain, so that they could discuss the plans with local mathematicians. It would have been easier to have had all of the meetings in Madrid, de León noted. But the ICM organizers wanted to make the point that “this is the ICM for Spain, not just for Madrid.”

Reaching Out

In fact, the organizers are reaching out far beyond the borders of Spain. Because this is the first ICM to be held in a Spanish-speaking country, special efforts are being made to bring in participants from Latin America, through a program of travel grants. Because of Spain’s geographical and cultural proximity to north Africa, the ICM organizers are working to foster participation by mathematicians from that area. Also in the works is a special conference called “Mathematics for Peace and Development”, to be held in Córdoba in conjunction with the ICM. Spain has a unique cultural identity formed through an unusual combination of Jewish, Islamic, and Christian influences. The idea, said de León, is to capitalize on this heritage and “use mathematics as an instrument for peace.” The conference would bring together mathematics students from Latin America, north Africa, Israel, and the Middle East.

The Congress itself will be held at the Palacio Municipal de Congresos, a convention center in the northeast of Madrid. The format is the traditional one of plenary and parallel “section” lectures. While the breakdown of areas into sections is largely the same as for previous ICMs, some tweaking has been done. Also, rather than nineteen sections, as there were at ICM2002, there are now twenty: A section devoted to “Control Theory and Optimization” has been added. The cultural attractions of Madrid will be on full display, and there will be special events aimed at communicating mathematics to the wider Spanish public. At the previous ICM in 2002 in Beijing, the president of China, Jiang Zemin, presented the Fields Medals. That’s a tough act to follow, but the ICM organizers have received assurances from the King of Spain that he will attend the opening ceremonies.

Mathematics in Spain seems poised to grow and prosper, and many mathematicians there speak with great ambition about their aspirations for the future. At the same time, they are not resting on their laurels. They see challenges ahead, and they are working to meet them. Zuazua likened the development of mathematics in Spain to an orange

tree—it is not enough for the tree to flower, it must also bear fruit. “ICM06 is the flower, but we have to be extremely hard workers, clever and coordinated, and able to convince politicians if we want that to persist and to give the fruit of putting Spain in the first division of mathematics,” he said. “ICM06 is a proof of our success, but also the right time to be extremely, but positively, critical of ourselves.”