ICMAT
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EDITORIAL

The ICMAT attends the great congress of mathematics

The International Congress of Mathematicians (ICM) has been held every four years for more than a century and is the most important scientific event for the mathematical community. For that reason the ICMAT decided to send an institutional representation there on several levels.

First an internal call was organized with the aim of funding the participation of young researchers (pre- and post-doctoral) who would give a talk or present a poster at the event, thereby enabling them to make their research work known on this unique occasion.

The ICM is a very special congress and any mathematician should be able to take part at least once in life. For a young mathematician, to share time and space with the most distinguished mathematicians, in particular with Fields Medal winners, is an exceptional opportunity. Furthermore, the Institute collaborated on a stand called "Research in Europe", together with Research Councils from the United Kingdom, Holland and Germany, on behalf of the Consejo Superior de Investigaciones Científicas (CSIC). This initiative grew out of the annual meetings of representatives of mathematics belonging to the funding agencies of European countries. We trust that this will be repeated on future occasions, since it fosters a greater mutual acquaintance and opens the door to new opportunities. In addition, with the help of the Spanish Secretary of State for Research, Development and Innovation, the ICMAT approached the Spanish Embassy in Seoul to organize a visit by the Spanish consul and the cultural attaché to the Spanish delegation, which for a few hours brought together all the Spanish researchers attending the congress in Seoul on an occasion to "rally around the flag", so to speak.

Finally, the ICMAT wanted to provide press coverage to ensure that the congress and mathematics itself received all due attention in the Spanish media. To that end, the person in charge of the ICMAT press office also travelled with our delegation, and a communication plan was carefully drawn up. In addition to interviews with the Fields Medal winners and other figures attending the ICM, press coverage also included articles and reports – the first of which appears in this newsletter – updates on the progress of the congress on social networks, a daily chronicle in the blog Mathematics and its Frontiers, and perhaps the newest development, a series of nine articles in the Spanish daily El Mundo, coordinated by our press officer and mainly written by young ICMAT researchers who attended the congress. The ICMAT training program in communication designed for its members was thus continued as part of its strategy. In summary, this was an enriching experience for everyone involved, and we hope to repeat it at the next ICM due to be held in Rio de Janeiro in 2018.

Manuel de León, director of the Instituto de Ciencias Matemáticas (ICMAT).

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Report: Internacional Congress of Mathematicians (ICM)

Breaking Barriers

For more than a century, the congress regarded as the most important mathematical event in the world has been held every four years. The International Congress of Mathematicians (ICM) was held from August 13th to August 21st in the city of Seoul (South Korea), with an attendance of more than 5,000 participants from 122 different countries, one of which was Spain. A delegation from the ICMAT was on the spot, the members of which witnessed how for the very first time a woman was awarded a Fields Medal, and how a mathematician from Latin America was also a first-time winner. After an intense program stretching over nine days and with 1,200 speakers, now it is the time to look back on what happened at the "great fiesta of mathematics".

Ágata A. Timón. The International Congress of Mathematicians (ICM) is the most important meeting of the International Mathematical Union (IMU) and is without doubt the "great fiesta" of mathematics. The 27th edition was held in Seoul (South Korea) between August 13th and 21st, after Zurich (Switzerland) held the first edition in 1897. At the second ICM, held in 1900 in Paris, David Hilbert stated the famous list of the 23 most important open problems in mathematics at the time. Since then, the congress has been held every four years without interruption, except for a hiatus during World War I and World War II.

On this occasion the ICMAT had a considerable scientific and institutional participation at the ICM. In the words of ICMAT director Manuel de León, "the presence of the ICMAT has been noteworthy, with a delegation consisting of nine members, which amounts to 20% of the Spanish total". Six young researchers belonging to the center presented the results of their latest research work, and the ICMAT was the representative of the excellence of Spanish mathematics on the Mathematics in Europe stand, together with those from Germany, Holland and the United Kingdom.

The congress was held at the COEX Center of Exhibitions and Conventions in Seoul, an immense enclosure in which the most relevant advances and developments in practically all the fields of mathematics were on show. The program consisted of seven keynote talks (given by the Fields medal winners and others by IMU award winners), 21 plenary talks, 178 invited speakers, 6 panel discussions, 662 short communications and 388 poster presentations covering everything from subjects in pure mathematics, such as algebra, topology and number theory, to others concerning different areas of knowledge such as mathematical physics, computation, education and dissemination, and the history of mathematics. Furthermore, in the rest of the region there were more than 50 satellite conferences dealing with different topics in a more specific manner.

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New Fields medalists, minutes before the ceremony.

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The winners in the opening ceremony of ICM posing with authorities who presented the awards.

"This year we tried to have a lot more interdisciplinary talks. We wanted the unity of mathematics to be much more visible in the composition of the congress", said Carlos Kenig, director of the ICM Program Committee. "My main aim (when drawing up the program) was to ensure that the most currently active mathematics was represented, as well as providing an overall view of the discipline. And then, to try to respect the balance of gender and geography".

Making History

During the opening of the congress on August 13th a landmark was established in the history of mathematics: for the very first time a woman obtained the highest award in the discipline. The Iranian Maryam Mirzakhani (Stanford University, USA) received the Fields Medal. At a press conference after the ceremony, Ingrid Daubechies, chair of the International Mathematical Union (IMU) until the celebration of this ICM, said: "This is great news. There are still not enough women involved in mathematical research, and Mirzakhani is a role model for inspiring more women to attain leading positions." ICMAT director Manuel de León added: "This is a landmark in the history of mathematics and puts an end to decades of taboos".Geographical

barriers have also been broken: Mirzakhani is the first person from Iran to be awarded this prize. Artur Ávila, who is doubly associated to the Centre National de la Recherche Cientifique (CNRS, France) and the National Institute of Pure and Applied Mathematics (IMPA, Brazil), was the first medal winner to come from the Latin American continent. Together with them, Manjul Bhargava (Princeton University, USA), who is the first Indian mathematician to receive the award, and Martin Hairer (University of Warwick Coventry, United Kingdom) are also the new Fields Medal winners.

The Fields Medals carry a modest cash award (15,000 Canadian dollars, 10,000 euros approx.). Its value is therefore mainly symbolic. "I think the awards are important for showing that mathematics is a live science that continues to progress", said Ávila after the presentation ceremony. The medals are struck in gold and bear the name of their promoter, the Canadian mathematician John Charles Fields (1863-1932). They have been awarded at the ICM since it was held in Oslo in 1936 and are subject to strict rules. Only a total of four medals can be awarded at each ICM, and the prospective winners must be mathematicians younger than 40 years of age. This is because they are awarded in recognition of completed work – for a career in research rather than a single achievement – and also as an incentive for future development. IMU secretary Martin Grötschel acknowledges that the age restriction is a subject of debate among members of the Union's Executive Committee, although no change in this criterion is foreseen for the time being.

Furthermore, it is essential for the identity of the winners to be kept secret until the day on which the medals are awarded. Each individual winner is informed of the decision several months before the ceremony is due to take place, although he or she is unaware of whom the others might be. This year, however, due to a mistake by the organizers of the congress, the list of prize winners was leaked the day before the ceremony and appeared on the IMU's own website at 18.00 GMT. Even so, the members of the committee who awarded the medals (with the exception of the chair) remained anonymous until the ceremony was held. This took place at 9:30am Korean time (2.30am in Spain) on 13th August in the midst of tight security measures, since the event was attended by the South Korean president Park Geun-hye. The South Korean Minister for Science, Information and Communication Technology and Future Planning, Choi Yanghee completed the presidential table, together with the then IMU chair, Ingrid Daubechies, the 2014 ICM director, Hyungju Park, and the IMU secretary, Martin Grötschel.

"This is a landmark in the history of mathematics and puts an end to decades of taboos"

In addition, the Nevanlinna Prize for contributions of mathematics to the information society was awarded to Subhash Khot (Courant Institute of Mathematical Sciences, New York University, USA); the Gauss Prize for the application of mathematics to other fields to Stanley Osher (University of California Los Angeles, USA), and the Chern Medal for lifelong achievement to Phillip Griffiths (Princeton University Institute for Advanced Study, USA). At the closing ceremony, the Leelavati Award for outstanding achievement for public outreach was conferred on the Argentinian Adrián Paenza.

Fields Medals for Asia, America and Europe

The Fields Medals are the most prestigious awards worldwide for achievements in mathematics. They are conferred every four years by the International Mathematical Union at the International Congress of Mathematicians (ICM). The list of prizewinners at the ICM2014 is as follows:

Maryam Mirzakhani (Iran, 1977) is a researcher at Stanford University (USA) where she works in the field of geometry and dynamic systems. After completing her thesis at Harvard she has held research positions with the Clay Mathematics Institute and Princeton University. The IMU Committee highlighted "her important contributions to the study of Riemann Surfaces and their moduli spaces".

Artur Ávila (Brazil, 1979) is a researcher at the CNRS Institut Mathématique de Jussieu-Paris Rive Gauche (France) and the Rio de Janeiro National Institute of Pure and Applied Mathematics (Brazil), where he also completed his doctoral thesis. His work centers mainly on the field of dynamic systems and analysis. The ICM jury made special mention of "his deep contributions to the theory of dynamical systems, which have changed the face of the field, based on the powerful idea of renormalization as a unifying principle".

Manjul Bhargava (Canada, 1974) is a specialist in number theory as Princeton University (USA), where he completed his doctorate under the supervision of Andrew Wiles, who famously proved Fermat's Last Theorem. He was awarded the prize for "the development of new and powerful methods in the theory of algebraic numbers and their applications to the study of elliptic curves".

Martin Hairer (Austria, 1975) is a professor at the University of Warwick (United Kingdom). He completed his thesis at the University of Geneva (Switzerland). Since then he has concentrated his work on the area of stochastic partial differential equations, that is, equations incorporating random elements. The citation for the prize emphasized "his outstanding contributions to the theory of stochastic partial differential equations and, in particular, the creation of a theory of regular structures for these equations".

Sharing without limits

One of the main new developments in this congress was the Nanum 2014 solidarity program, which provides aid to mathematicians belonging to developing countries, enabling them to attend the meeting. Travel grants between 1,200 and 2,500 American dollars were offered a few months ago to mathematicians from developing countries. While 1,000 were originally invited, the final number of those who attended as a result of this program was 657, because of visa difficulties according to Park, and at least two cases because of political reasons. Manuel de León said "South Korea has tried very hard to enable these mathematicians to attend".

South Korea's interest in this program rose from the fact that its own members of the mathematical community benefitted from schemes like this under the auspices of the IMU in the 1970s and 1980s. As the Korean organization explained: "having started late, and based on its own experience, the South Korean mathematical community understands the challenges facing mathematicians in many developing countries", and has therefore set this initiative in motion. In this sense, on August 12th, the day before the congress, the MENAO Symposium:

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The ICMAT delegation in the ICM during the conference dinner.

Mathematics in developing countries, was held. This meeting, held for the first time in Seoul, underlines the commitment shown at this year's congress to the development of mathematics in emerging countries.

The congress schedule also included activities devoted to bringing mathematical knowledge closer to society at large. Many events were aimed at the general public: James Simons (Stony Brook University and member of the US National Academy of Sciences) gave a talk open to the public on the first day. Simons has made fundamental contributions to geometry, but he has also worked on the application of mathematics to different areas. In 1982 he founded Renaissance Technologies, which became one of the most well-known hedge fund management companies in the world. In 2006, Simons was quoted in the Financial Times as being "the most intelligent multi-millionaire in the world".

In addition, on the last night of the congress, the winner of the Leelavati, Prize for mathematical outreach gave a talk on education and how to provide students with a good gateway into mathematics. A competition of Go, the famous Korean table game, was also held, as well as the Bridges 2014 satellite conference, which turned out to be the biggest interdisciplinary meeting between art and mathematics. Furthermore, the film "How I Came to Hate Maths" (2013) was shown, and one of the films' protagonists, former Fields Medal winner Cèdric Villani, gave the presentation. This is a documentary filmed in different countries (USA, India, Germany, France) over a period of more than three years in which the director, Olivier Peyon, reflects on the way mathematics is taught in schools, as well as how research is done in international centers and how it is applied to the stock exchange and financial markets. Students, teachers, philosophers and researchers are also interviewed about their relations with mathematics.

Among other social events, the gala dinner was also held at the COEX convention center and included a special show consisting of percussionists, dancers, acrobats and an exhibition of Taekwondo. More

A new president, a new executive

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Shigefumi Mori is the first Asian who chairs the IMU.

At the weekend prior to the congress, August 10th and 11th, the General Assembly of International Mathematical Union was held; the IMUE was the organizer of this event, at which a new president, Shigefumi Mori (University of Kyoto), was named, and where it was also announced that the next venue for the 2018 congress would be Rio de Janeiro (Brazil).

It will therefore be the first time that the ICM will take place in Latin America, and also the first in the southern hemisphere. Manuel de León, director of the ICMAT and member of the ICM Executive Committee was also present. "It's the first time in a century of the ICMs existence that [this meeting] will be held in Latin America, which is a reflection of the substantial improvements that have taken place in mathematical research in the zone over the last few years", he said. Currently a full professor at the University of Kyoto Institute of Research in Mathematical Sciences (Japan), Mori was a member of the Executive Committee of the Institution between 1995 and 1998, and thus comes to the post with plenty of experience in the matter.

"This was undoubtedly one of the most persuasive arguments when it came to making the choice", said León. But it was not the only one; Mori's scientific credentials are underpinned, among other things, by the Fields Medal, which he was awarded in 1990 for his work on algebraic geometry, a field where he has worked throughout his professional career. Indeed, his research into the classification of algebraic surfaces – the leading subject in this discipline since the early 20th century – was regarded as "the most profound and exciting of the last decade" by his colleague Heisuke Hironaka, himself a Fields Medal winner. Together with Mori, the names of the members of the new IMU Executive Committee were also announced, and include Helge Holden (Norway) as secretary; Alicia Dickenstein (Argentina) and Vaughan Jones (New Zealand/USA) as vice-presidents; and Vasudevan Srinivas (India), John Tolland (United Kingdom), Wendelin Werner (Switzerland), Huyngjun Park (South Korea), Christiane Rousseau (Canada) and Benedict Gross (USA), as ordinary members.

ICMAT director Manuel de León this year comes to the end of his second and last period as a Committee member. "Personally, it's been a great experience to form part of the most important international organization in mathematics, as well as having the opportunity to get to know great colleagues", he said. His membership of the committee also constitutes a significant recognition of Spanish mathematics and, in particular, the organization of the ICM 2006, held in Madrid, of which De León was president. He will now go on to form part of the "IMU Circles", a new structure that was unveiled at the Assembly and which will be composed of a group selected from among former post-holders at the Union. As de León remarked: "This circle will be responsible for advising the new IMU Executive Committee on different matters".

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The South Korean president delivers Maryam Mirzhakani Fields Medal .

than one thousand guests attended the dinner, which was presided by the Mayor of Seoul, Park Won-soon, who also gave a speech in which he stressed the importance of mathematics, and in particular the honor of providing the venue for a congress on this discipline in the city of Seoul. Afterwards, those with chief responsibility for the Congress, Ingrid Daubechies, as chair of the International Mathematical Union (IMU), and Hyungju Park, director of the Organizing Committee, both dressed in traditional Korean costume, proposed a toast for the new prize-winners and for all the mathematicians attending the congress. In conclusion, a speech was given by Philip Griffiths, researcher at the Institute of Advanced Studies and recent recipient of the Chern Medal.

"Ingrid Daubechies was entrusted with thanking all those who had collaborated in the organization of this ICM"

In well-rehearsed formation, the waiters began serving the guests with the meal, based on an international style cuisine. The conversations during the banquet ranged from mathematics and anecdotes about recent experiences in Seoul to the peculiarities between all the different countries, altogether constituting a scientific and cultural exchange of opinions. Before the dessert was served, the drumbeats of the buks once again drew attention towards the stage. Various musicians energetically beat this traditional Korean instrument, while a dance troupe performed to the sound of the tribal rhythm. At the end, a group of young people gave an impressive exhibition of Taekwondo, including somersaults, double and triple head-high kicks and a large number of broken tiles.

See you in Rio!

After other more informal dinners, and above all an enormous number of conferences – plenary, invited, parallel, short and long – at 3.15pm Korean time on August 21st, the last event of the 2014 International Congress of Mathematicians was held: the closing ceremony. In the midst of many expressions of acknowledgement to the organizers, speakers, volunteers, committee members, and of course all the participants, the Leelavati Prize for public outreach of mathematics was awarded to the Argentinian mathematician and TV presenter, Adrián Paenza.

The prize was presented by Ingrid Daubechies to this professor belonging to the University of Buenos Aires and star of Argentine television with programs such as "Científicos industria argentina" and "Alterados por Pi". Paenza dedicated the award to his students and colleagues at the university and, in Spanish, to all Argentineans. He stressed the recent achievements of Latin American mathematics, among which was the Fields Medal awarded to Artur Ávila, and said that they were not just isolated incidents but part of "something greater".

"The congress schedule also included activities devoted to bringing mathematical knowledge closer to society at large"

Among these remarkable successes of Latin American mathematics is the celebration of the next ICM in 2018 in Rio de Janeiro (Brazil). The director of this congress is Marcelo Viana (IMPA), who advanced some details about it during the closing ceremony. "I promise that we will provide the best of Brazilian creativity at this event", he said. The ICM 2018 already has its website up and running (http://icm2018.sbm.org.br/#) and is open to the reception of satellite conferences for the congress.

Ingrid Daubechies was entrusted with thanking all those who had collaborated in the organization of this ICM: the Scientific Committee; Selection Committees for the Awards; plenary and guest speakers; session directors; panellists; all who had given scientific communications during the congress; the organizers of receptions and parties; the Mayor of Seoul, who attended the gala dinner; the President of South Korea, who presided over the closing ceremony, and especially the local organizers and the volunteers.

University of Kyoto professor and Fields Medal winner in 1990, Shigefumi Mori, introduced the new IMU Executive Committee, his first official act since his election as chair of the Union. Finally, diplomas were presented to representatives of the volunteers, who occupied the stage as true protagonists of this "fiesta of mathematics".

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The opening ceremony of ICM incorporated traditional performances.

Scientific Review: ICMAT Researchers at the ICM 2014

The International Congress of Mathematicians (ICM), the biggest event in the world of mathematics, was held in August this year in Seoul (South Korea). A group of seven young pre- and post-doctoral researchers from the ICMAT were able to travel there, thanks to help from the Institute, to present their most recent scientific results. What follows is a report on those results.

Ágata A. Timón and Lorena Cabeza.

"The feeling of happiness and relief you get when you solve a problem you've been pondering for months makes up for everything"

Jezabel Curbelo was born in 1987 in los Realejos, Tenerife. She began her degree in Mathematics in the 2005-2006 academic course at the Universidad de la Laguna, and in 2008 had her first contact with research when she received a JAE-Intro introductory grant from the CSIC. In 2008-2009 she was awarded an excellence grant and a further collaboration grant with the Department of Mathematical Analysis, and at the end of that year she gained her degree in Mathematics. She pursued her career in research with a JAE pre-doctoral grant to do a PhD at the UAM, where during 2009-2010 she obtained a Master in Mathematics and Applications. Her master thesis constituted the first step towards the subjects in which she would eventually specialize: "Numerical studies in convection problems with temperature-dependent viscosity", supervised by Ana María Mancho (ICMAT). Mancho also supervised her PhD thesis entitled "Instabilities in geophysical fluid dynamics: the influence of symmetry and temperature dependent viscosity in convection", which she presented this year 2014. Since 2012 she has been a lecturer at the Department of Mathematics of the Autonomous University of Madrid, and has done accredited stays at the Faculty of Mathematical and Statistical Sciences of Arizona State University (USA). She is also a member of the ICMAT where she joined the Stephen Wiggins (Bristol University) Laboratory as well as collaborating with the ICMAT Scientific Culture Unit.

For her doctorate she studied convection problems with viscosity strongly dependent on temperature, from the point of view of both the analysis of stationary and time-dependent solutions and the numerical methods used to calculate them. Her areas of interest are applied mathematics, in particular the dynamics of geophysical flows (mantle and ocean), partial differential equations in fluid mechanics, the numerical methods applied to these equations, instability, bifurcations and dynamical systems.

She says that she decided to study mathematics on the basis of what she most enjoyed doing at that time: "I'd follow the path that the future marked out for me. What I enjoyed (and still enjoy) doing most was undoubtedly mathematics. It's incredible how mathematics has provided answers to questions years before society even posed them". Although research is certainly not always a bed of roses: "In research, as in everything, there are good times and bad, and sometimes very bad", she says. "But the feeling of happiness and relief you get when you solve a problem you've been pondering for months makes up for everything".

The influence of symmetry and temperature-dependent viscosity on the instability generated in fluid convection. Jezabel Curbelo (ICMAT-UAM). A work in collaboration with Ana M. Mancho (ICMAT).

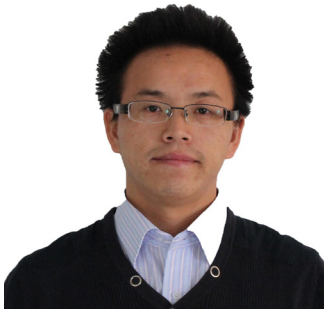
The poster presented at the ICM2014 by Jezabel Curbelo describes the instabilities that appear in a fluid in convection under the influence of symmetry. One example of this type of fluid is the material found inside planets, and thus the results can be applied to the movement of terrestrial tectonic plates. The model presents an alternative to subduction as a cause of plate dynamics, since it shows examples of fluids in convection indicating that the movement may occur spontaneously as an exclusive result of the internal dynamics of the fluid and in the presence of symmetry. The results suggest that the symmetry of the Earth's sphere may be significant for the formation of plates in movement.

Curbelo's study focuses mainly on the laws of viscosity that model an abrupt transition of the viscosity in terms of changes in temperature. In particular, both a smooth transition and an abrupt transition are explored. As regards abrupt transitions, attention is mainly given to time-dependent solutions in which an upper stationary layer is alternated with a layer or plate that moves rigidly either to the left or the right.

These results provide an innovatory approach to the understanding of styles of convection in the interior of planets. The existence of subduction is not ruled out, but the processes they describe may be particularly illustrative for the understanding of convective styles prior to subduction.

"Doing mathematics has benefited me a lot; it has helped me to correct my intuition and clarify confussion"

A Severo Ochoa appointee at the ICMAT since 2012, Guixiang Hong obtained his degree in Mathematics in 2007 in China, where he also did a Master at the Normal University of Beijing (China). It was there where his interest in harmonic analysis and Fourier analysis began. Guixiang Hong then went on to obtain a doctorate at the Université de Franche-Comté (France) in 2012 with a thesis entitled "Problems in Non-commutative Harmonic Analysis". His current fields of research are functional analysis, harmonic analysis, quantum probability and ergodic theory. The methods he employs include operator algebra and operator spaces. Furthermore, semi-commutative harmonic analysis is closely related to the vector-valued one, which has motivated him to address problems in vector-valued harmonic analysis. The essence of much of his research work resides in the fruitful interaction between harmonic analysis and martingales.



He says that he feels proud of how his thesis worked out: "Before arriving in France I didn't know anything about Van Neumann algebras, operator spaces or quantum probability. I spent the first year learning about these things. Then in the second year three problems arose, which I eventually solved in the third year with the help of my supervisor and my collaborators".

About his relation with mathematics, he points out "precision" as one of the main characteristics of this discipline, and goes on to say: "If you want to make a mathematical statement you have to show that it's based on facts. In my daily life I've benefited a lot from doing mathematics in this way, because it has helped me to correct my intuition and clarify confusion".

Non-commutative ergodic theorems. Guixiang Hong (ICMAT).

Ergodic theory is a branch of mathematics that studies dynamical systems with an invariant measure such as volume. Its initial development was motivated by problems of statistical physics such as the analysis of the behavior of molecules of a gas in a receptacle.

One of the main problems of this theory is to understand the movement of the dynamical system over a long period of time. One of the first results in this regard is the Poincaré recurrence theorem, which states that any system with a finite amount of energy and confined within a finite spatial volume will after a sufficiently long period of time return to a state arbitrarily close to the initial state.

Several later ergodic theorems give more detailed information about this phenomenon, stating that under certain conditions the time average of a function along the trajectories exists almost everywhere and it is related to the space average. The trajectory of a point is the set of all the positions or states of the point over time. Thus, a function along the trajectories may be the position, the linear or angular momentum, the temperature, etc, of those points. Consequently, in a time average, the characteristics of the dynamical system are homogeneously distributed in the space (for example, the temperature will end up being similar along all the trajectories).

One of the most important theorems on this subject is Birkhoff's theorem (1931), which states that for some special class of ergodic systems, the time average along each trajectory is the same for almost all initial states (space average). Statistically speaking, one could say that the system that evolves over a long period of time "forgets" its initial state in the sense that, if we have a function defined in the system, after a sufficient amount of time the value of the function tends to become constant (equal to the space average), thereby losing precise information about the function.

In 2007, Marius Junge and Quanhua Xu established a non-commutative analogy of Birkhoff's result, the Dunford-Schwartz maximal theorem. In particular, they proved the maximal ergodic theorem for the group R, acting in non-commutative Lp spaces. This was followed by the resolution of the theorem for free group actions by Anantharaman and Hu. These researchers arrived at the same result independently of each other and using different approaches.

The work that Guixian Hong presented at the ICM continued in this line and constitutes the first step towards establishing non-commutative ergodic theorems for actions that preserve the trace of locally compact and countable groups. This result is the analogue of maximal ergodic theorems associated to the series of spherical averages on the Heisenberg group. The tools employed in its proof come from the operator space theory, non-commutative geometry, classical spectral methods, the Littlewood-Paley-Stein theory and analytical interpolation.

"I'd willingly do my doctorate over again because enjoying my work is one of my goals in life"

David Fernández was born in Valladolid in 1987. Despite his interest in literature and philosophy, he decided to study mathematics because he liked to pose himself mathematical questions and think about how the different concepts in this discipline were related, and approach that still guides him today. He obtained his degree at the Autonomous University of Madrid, where he acquired a solid background in partial differential equations. He also gained a Master in Mathematics and Applications at the same university.

Since 2010 he has enjoyed a FPI-UAM grant to study for his PhD under the supervison of ICMAT member Luis Álvarez Cónsul. His thesis falls within the emerging field of Non-commutative Algebraic Geometry, which is situated at the interface between Geometry, Algebra and Mathematical Physics. The aim of his thesis is to define new and interesting geometrical structures that are non-commutative analogues - following the Kontsevich-Rosenberg Principle – of known geometric notions. For example, a question he posed (and resolved) is how to define the non-commutative analogue of a Lie algebroid. Furthermore, thanks to articles by M. Kontsevich, N. Seiberg and E. Witten, non-commutative geometry in general, and these new geometrical concepts in particular, seem to constitute a vital tool for addressing problems in string theory as well as shedding light on the so-called Homological Mirror Symmetry, which in the eyes of many is the most important problem in mathematical physics. Fernández hopes to have the opportunity of exploring these relations in the future. The path followed by this young researcher has so far been "very nice, but not entirely free of difficulty". Indeed, as he says: "If I had to start again, I'd willingly do a doctorate because enjoying my work is one of my goals in life".

Bisymplectic NQ-algebra. David Fernández (ICMAT).

Manifolds are geometric objects that generalize the intuitive idea of a curve (1-manifold) and of a surface (2-manifold) to any dimension and on diverse bodies (not necessarily that of real bodies). Symplectic manifolds are spaces equipped with a geometric structure known as a symplectic form, which appears in the Hamiltonian formulation in classical mechanics. The study of symplectic manifolds is a very active branch of topology in current research. NQ manifolds are a particular class of manifolds used for solving quantization problems.

The poster presented at the ICM by David Fernández – a joint work with Luis Álvarez Cónsul (ICMAT) – belongs to this area, in particular, the cases in which the commutative property is not fulfilled. In this work, the concept of bisymplectic NQ-algebra is defined, which is the non-commutative analogue of NQ-symplectic manifolds. They are fundamental for finding solutions to the classical master equation within an approach to research – known as the AKSZ Formalism –developed for quantization in Lagrangian formulations of classical field theory in a mathematically rigorous way.

Furthermore, the work by Fernández and Álvarez Cónsul is also associated with one of the main problems in non-commutative geometry: the development of a notion of non-commutative Poisson algebra, another fundamental algebraic object. Based on the work by M. Van den Bergh on double Poisson structures and on bisymplectic geometry carried out by W. Crawley-Boevey, P. Etingof and V. Ginzburg, the authors prove the existence of a correspondence between bisymplectic NQ-algebras of weight 1 and double Poisson algebras in Van den Bergh's sense. In fact, this work constitutes the first step towards the definition of non-commutative sigma models.

"Certain theorems change your perspective on what you want to study"

Alberto Navarro studied for his degree and a master at the Complutense University of Madrid before going on to do his doctorate at the University of Extremadura. He is currently completing his thesis under the supervision of José Ignacio Burgos (ICMAT) and Frédéric Déglise (École Normale Supérieure de Lyon). "Throughout the Mathematics degree there are certain theorems that change your perspective on what you want to study (for example, the Galois theorem or Gauss's Theorema Egregium). On finishing my degree, while I was studying Riemannian geometry, I heard some students at the school in Salamanca talking about the Gauss-Bonet theorem, about how these types of theorem can be stated in algebraic geometry and even in arithmetic geometry, and also how they have a suitable framework in Grothendieck's work on motives. So animated by this view, which I couldn't address in degree or master courses, I decided to write a thesis on it".

On cohomology theories in algebraic geometry. Alberto Navarro (ICMAT).

In differential geometry, there are two basic ways of describing the topology of a manifold; its homotopy and its cohomology. Although the first is more refined it is complicated to calculate and to study, while the second is simple and relatively easy to calculate as well as being sufficient for many questions, and is therefore a very important tool for the understanding of the different characteristics of manifolds.

In the mid-20th century, while revolutionizing algebraic geometry the stateless mathematician Alexander Grothendieck found that in the algebraic context there was a group of cohomology theories more or less analogous to the classical theory: étale, algebraic de Rham, Chow's ring and the K-theory. The Riemann-Roch theorem (1957), probably the most brilliant result of all the work by Grothendieck that earned him his Fields Medal in 1966, compares several of these cohomology theories.

In order to compare two cohomologies, H and H', it is first necessary to construct a relation - a morphism ch_X: H(X)-->H'(X) - for all the manifolds X. Finally, in cohomology theories the construction of the direct image is always skilful and relatively complicated. The direct image of a morphism f:X-->Y of algebraic manifolds is the linear application f_*: H(X)-->H(Y), which reflects the information about this morphism in cohomology. Thus, the comparison essentially consists of describing the following diagram:

$$\begin{array}{ccc} H(X) & \xrightarrow{f_*} & H(Y) \\ {\scriptstyle ch_X}\downarrow & & \downarrow{\scriptstyle ch_Y} \\ H'(X) & \xrightarrow{f'_*} & H'(Y) \end{array}$$

The definition of a direct image among any pair of manifolds X and Y always requires a hypothesis on manifolds; for example, that both are smooth. In the past decade, Gabber proved the so-called Grothendieck purity conjecture for étale chomology by using a generalized direct image for regular inmersions on non necessarily smooth manifolds.

At this ICM, Alberto Navarro presented a construction based on the Theory of Motives of Gabber's generalized direct image valid for all types of cohomology theories. Moreover, he also presented a demonstration of a Riemann-Roch theorem in a non-smooth context.

Partial differential equations and the Strichartz linear theory

Giuseppe Negro was born in Bari, Italy, in 1980. He studied Mathematics at the Aldo Moro University in Bari between 2006 and 2012 under Enrico Jannelli, Sandra Lucente (UniBA) and Luca Fanelli (Universitá di Roma 1). His research fields at that time were differential equations in quantum mechanics, both relativistic and non-relativistic.

Since the autumn semester, 2012, he has lived in Madrid, where he studied for a master in Mathematics at the Autonomous University of Madrid. His final master assignment, written under the supervision of Ana Vargas (UAM), dealt with the problem of points of convergence for solutions to the Schrödinger equation.

Negro joined the ICMAT in October, 2013, as a PhD student. His supervisors are Keith Rogers (CSIC) and Thomas Duyckaerts (Université de Paris 13). He is currently interested in problems concerning partial differential equations; in particular, he is working on Schrödinger and wave equations and is trying to discover to what extent the Strichartz linear estimates can be extended to this scenario.

The existence of maximizers in the Strichartz norm for solutions to the energy-critical nonlinear wave equation. Giuseppe Negro (ICMAT).

The wave equation mathematically models the oscillations of a vibrating string; for example, a guitar string. It was one of the very first models in mathematical physics and since then has proved extremely useful for understanding different phenomena. Indeed, it is not only used for describing elastic vibrations, but also for electromagnetic radiation and the nature of light itself. Nevertheless, the original model is too simple for some applications.

Nonlinear wave phenomena exist, such as the so-called solitary waves, which in different circumstances may be observed in the real world: a pulse of light transmitted by optic fiber or an isolated ocean wave, which require more sophisticated modeling.

The work presented by Giuseppe Negro at the ICM focuses on the nonlinear modifications of the original wave equation known as critical energy. It is the perturbation of the most simple equation that serves to describe solitary waves satisfactorily. The aim of this research work is to provide a better understanding of the model in a low-energy regime.

"The possibility of understanding the relations between the applied sciences and theoretical problems fascinates me"

Giancarlo Breschi studied for his degree in Mathematics at the Universitá di Roma-La Sapienza (Italy). During that time he also carried out two stays abroad; a semester in Paris (Université de Paris VII-Pierre et Marie Curie) and in Barcelona (UPC). He then moved to Madrid to study for a PhD under the supervision of Marco Antonio Fontelos at the ICMAT and the UAM. While studying for his doctorate he had the opportunity of doing some research work for six months in Paris, as well as participating in congresses and scientific meetings in the United Kingdom, Germany and Spain. These trips have enabled him to meet top-rank scientists and broaden his view of the importance of mathematics and its applications. He says that what "fascinates me about mathematics is the possibility it provides of understanding more deeply the relations between the applied sciences and theoretical problems". For that reason he has focused his research work on mathematical physics.

Long-term behavior of solutions to the fragmentation equation. Giancarlo Breschi (ICMAT).

The so-called fragmentation equation is a physical model for the divisions of clusters or composite particles. It describes a continuous, linear and spontaneous dynamic which may be observed, for example, when drops of water split. Giancarlo Breschi presented a study on the long-term behavior of solutions to this equation.

It is interesting to find out what happens to these solutions in the long-term; that is, after the elapse of a long period of time. In mathematics, this means studying their behavior when the time variable approaches the infinite, in other words, their asymptotic behavior. The self-similar profiles for these and other equations provide information about asymptotic regimes, their stability and conserved quantities.

Previously, an abstract understanding existed about solutions to the fragmentation equation: existence, uniqueness, and convergence to some self-similar profile, but details about them were unknown. This present work also provides explicit formulas and regularity results.

Fragmentation equation models have been used in several applications ranging from the splitting of rocks and combustion (pure fragmentation) to polymer degradation and cell division (fragmentation associated with growth and coalescence phenomena).

Mathematicians take Madrid

The 10th American Institute of Mathematics (AIMS) Conference on Differential Equations, Dynamical Systems and Applications took place in Madrid in July of this year. This event, which attracted more than 2,800 researchers from all over the world, was held on the UAM Cantoblanco Campus and was co-organized by the ICMAT, together with other institutions.

Ágata A. Timón (ICMAT). On July 7th, the first researchers arrived bright and early at the Palacio Municipal de Congresos in Madrid. One hour later the place was packed, and the conversations in English – and also in Italian and Chinese – were echoing around the marble of the main hall. Approximately 2,800 mathematicians from all over the world descended on Madrid to attend the 10th American Institute of Mathematics (AIMS) Conference on Differential Equations, Dynamical Systems and Applications. In the words of Shouchuan Hu, the director of the conference, on seeing the queues forming at the registration desks: "This tenth meeting is a landmark; the previous most highly attended conference has on this occasion been doubled".

"The main aim is to bring top rank mathematicians to Madrid"

This is the second largest mathematical meeting to be held in Spain and the biggest in applications. "It provides the opportunity to underline the fundamental importance of mathematics in science as well as its applications to other sciences and to industry", said the Consejo Superior de Investigaciones Científicas (CSIC) President, Emilio Lora Tamayo, during the opening ceremony. The CSIC is one of the main organizers of the event, together with the ICMAT, the AIMS, the UAM and the University de North Carolina Wilmington. "The main aim is to bring top rank mathematicians to Madrid and contribute to the internationalization of mathematics in Spain as well as the international relations of the ICMAT", said Manuel de León, the director of the ICMAT and of the Organizing Committee of the congress, as he travelled on the bus taking the participants from the Palacio de Congresos to the ICMAT, where a welcoming cocktail had been arranged at lunchtime on the first day of the conference.

Miguel Ángel Garrido, who is studying for a Mathematics Degree at the UAM and was one of the volunteers at the conference, decided to devote the first week in July to helping in the organization of the event, because as he said: "You have to respond to the confidence placed in Spain for the organization of a conference of this magnitude. We've got to develop and improve Spanish science, and this is a great opportunity to do so". To say nothing, of course, of the motivation provided by the scientific interest of the event itself, which in Garrido's case concerns on differential equations and probability.

Waves, Van Gogh Canvases and Solids

There are several indicators that highlight the scientific standing of the event, one of which is the quality of the plenary speakers, who according to Manuel de León, "have surpassed all previous conferences in the series". The program speaks for itself: the line-up on the first day included a Fields Medal winner, the Chair of the International Mathematical Union and a mathematics professor from Princeton University. The first to speak was Charles Fefferman (Princeton University), who devoted his inaugural address to his work on the formation of singularities in incompressible fluids. Fefferman stated that he was "especially happy to be speaking in Madrid, where the work I am about to present is being undertaken in collaboration with ICMAT researchers".

He was followed by Ingrid Daubechies (Duke University), who described some of her recent contributions to the analysis of works of art, in collaboration with the Van Gogh Museum and also the Prado

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Shouchuan Hu, director of AIMS, José María Sanz , rector of the Autonomous University of Madrid, Emilio Lora-Tamayo, president of CSIC, and Manuel de León, the director of the ICMAT.

Museum. Her mathematical approaches have been applied to image processing, in particular the authentication of paintings, and their restoration from cracking and the damage caused by the frames used to support them during years of storage. Weinen E. (Princeton University) spoke about the mathematical theory of solids, especially the relation between the fundamental principles of quantum mechanics and practical macroscopic models.

Mathematics as the driving force of economic development

Among the glasses of wine and canapés, and protected from the sun by the large sunshades set out for the event, the guests listened to the words of welcome from Carmen Vela, the Minister for Research, Development and Innovation, and from José Mª Sanz Martínez, Rector of the UAM. Carmen Vela underlined the role played by the ICMAT as a leading research center, the success of which is endorsed by the many grants and competitive funding it has obtained. "Even at a time of great difficulty," she said, in reference to the Institute, "Spain has managed to conduct science of excellence".

The AIMS for the first time awarded prizes for the best scientific articles by students

She also pointed out the importance of mathematics to the contribution of welfare and economic development. This has been the central theme of the conference, which provided an extensive program of sessions devoted to the relations of mathematics with other sciences and with industry. While it is just beginning to take off elsewhere, this is a subject that remains to be addressed in Spain. "There are groups devoted to knowledge transfer, and efforts have been made through the Consolider i-Math program", says De León. "However, much remains to be done, because there are only a few groups that are making a real impact in applications to industry. This is a task we have to tackle in the future, because it's very important for the economy of the country and for opening up new opportunities for young mathematicians".

Even more, mathematics can provide a vital tool for making progress in the great challenges faced in other sciences, such as biology and health, with important implications for society. For example, research into cancer treatment and HIV, where mathematical techniques have been applied for years, areas on which special sessions have been held during the conference.

A meeting of colleagues

"This conference is enormous," said a smiling Mats Gyllenberg, expert in biomathematics at the University of Helsinki. "There are about three thousand people here and so many talks and sessions and it's impossible to attend all of them. I'd say that the social side is the most important part; meeting up with old friends again and speaking about mathematics". Gyllenberg led a session on population dynamics with applications to ecology and evolution by natural selection. In the bright cafeteria in the main quadrangle of the UAM, after the highly attended talk by Fields Medal winner, Cèdric Villani, Gyllenberg went on to say that, "I've also been working on physiological models such as those on respiration and snoring, as well as on microbiological applications to the growth of bacteria and their classification".

In this more social aspect, one of the great events at the conference was the gala dinner held on Wednesday, July 9th. At 8 o´clock in the evening, the buses left the Plaza de España in the center of Madrid and the different hotels where the 2,800 people who came to the conference were staying. Some 700 of them attended the dinner, which was held at the Casa de Mónico in Madrid. After an apéritif in the patio of the enclosure, the meal was served in the dining rooms inside. On conclusion of the second course, AIMS director Shouchuan Hu gave a speech to the assembled guests, in which he took the opportunity to thank all who had helped to make the conference a success, among them the local organizers led by Manuel de León.

In parallel with this busy conference program, a meeting of the editors of the AIMS journals was held at the ICMAT

Furthermore, the AIMS for the first time awarded prizes for the best scientific articles by students. First Prize was awarded to Anton Savostianov, a doctoral student at the University of Surrey (UK), where he belongs to a group working on the analysis of partial differential equations under the supervision of Sergey Zelik. Second Prize and the two Honorable Mentions went to Andrei Tarfulea (Princeton University) and to Bao Tang and Piotr Kamienski, respectively.

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AIMS students volunteers during the gala dinner.

Impact journals

In parallel with this busy conference program, a meeting of the editors of the AIMS journals was held at the ICMAT. 65 editors debated different aspects of their publications, and all were of the opinion of the need to carry out a quantitative and qualitative study of the quality of the journals, to improve contacts with authors and the mathematical community in general, and to adapt to the new recommendations regarding Open Access. The AIMS currently publishes 16 titles devoted to mathematical research, with significant impact factors on the Web of Science JCR. ICMAT director Manuel de Léon is a founder of the Journal of Geometry and Mechanics (which occupies second place in impact among the 16 journals) and has been an editorial director since it first appeared in 2008.

In parallel with this busy conference program, a meeting of the editors of the AIMS journals was held at the ICMAT

Open Access was one of the main subjects of interest, as well as the positioning of the AIMS and its journals, and the need to follow the recommendations of both the International mathematical Union (IMU) and the International Council for Science (ICSU) on best editorial practice and universal access to scientific literature. This debate will continue over the next two years, culminating in the next AIMS conference to be held in the United States in 2016.

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Charles Fefferman next to Antonio Córdoba during AIMS gala dinner.

José María Sanz, Rector of the Autonomous University of Madrid

"Mathematics has a lot to say, in both biology and physics"

José María Sanz (Madrid, 1952) is a professor of Applied Physics and has been rector of the Autonomous University of Madrid (UAM) since 2009. During his first term as rector, the UAM-CSIC Campus of International Excellence was established, a project which also gave rise to the emergence of the ICMAT. Sanz is still extremely proud of the endeavor, not only as a means of optimizing resources and providing students with the opportunity to come into contact with cutting-edge research, but also as a way of making a mark on the European scene. He replied to the following questions after the opening ceremony of the 10th AIMS conference in Madrid.

Question: What's the relation between the ICMAT and the UAM?

Answer: The ICMAT is a mixed institute, that is, one built between the University and the CSIC. This is a special case because it is composed of three Madrid universities and the CSIC. It's a commitment to bringing together high-quality researchers who share infrastructures and resources so that research activity can be more efficient and achieve a greater quality.

Q: So the research activity can also involve students.

A: Of course; it provides access to certain professors who are able to transmit that knowledge. Many of the professors belonging to these joint institutes give classes at a post-graduate level above all, but also in some cases at a graduate level too.

Q: Is the Campus of International Excellence related to the ICMAT?

A: Yes, the idea for the Campus of International Excellence is the result of the reality we living in, and on this campus there are five joint institutes plus four belonging to the CSIC. We all share the campus and have very close relations; the CSIC professors and researchers are involved in joint projects. The idea for the UAM+CSIC Campus of Excellence came about quite naturally, and the ICMAT was the outcome of these development plans.

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José María Sanz, professor of Applied Physics and Rector of the Autonomous University of Madrid.

Q: You're a physicist, so you know the role of mathematics in applications very well. What would you say about it?

A: Mathematics is fundamental. It's said that this is going to be the century of biology, but mathematics has a lot to say in both biology and physics. I think that a mixture of biology, physics and mathematics will be the instrument required to explain and develop systems as complex as those in biology. Mathematics is necessary for all of us.

Interview: Cédric Villani, the director of the Institut Henri Poincaré y 2010 Fields medallist

"I proceed from one direction to another through the opportunities that arise"

Ágata A. Timón. Cédric Villani (Brive-la-Gaillarde, France, 1973) is one of the best known living mathematicians both inside and outside the scientific community. Currently the director of the Institut Henri Poincaré, in 2010 he was awarded the highest recognition in the discipline – the Fields Medal – for his work on the Landau damping and the Boltzmann equation, the latter being closely related to physics, and in particular for the motion of gases. Lately he has to a large extent devoted his efforts to the popularization of mathematics. In recent years he has given hundreds of public lectures, written a biographical book on mathematical creation, which has yielded him more royalties than his strictly scientific work, has worked side by side with a graphic artist on a comic book that is about to be published, has strongly supported a federal Europe, and has been head of the committee in support of the current Mayoress of Paris, Anne Hidalgo. On the day before giving his plenary talk at the 10th American Institute of Mathematics (AIMS) Congress on Differential Equations, Dynamic Systems and Applications, held in Madrid in July of this year, we spoke with him about his many-sided career.

"The Fields Medal came a lot of fuss and commotion, but I thought that it wouldn't last very long"

Question: After winning the Fields Medal you became a kind of popular hero of mathematics. How did that come about?

Answer: The truth is I didn't plan it that way. With the Fields Medal came a lot of fuss and commotion, but I thought that outside of the mathematical community it wouldn't last very long. Then for some reason this new situation crystallized and I continued to get a lot of attention. I became a public figure for a large section of society, which began to ask me for all kinds of things. The only thing I did from that moment on was respond to requests to give public talks in schools, for political parties, associations, round-table discussions and think tanks. I've given hundreds of such talks in the last four years and I've had to turn down to just as many or more.

Q: What makes you devote so much time to popularizing mathematics?

A: One important reason is to stimulate interest in young people in taking up a career in science. In Europe, the number

"The presence of scientists should be kept at the forefront of the community"

of people wanting to dedicate themselves to that is declining; they think it's something long and complicated that is poorly adapted to the speed of present society. But the speed of development we are living through is in fact driven by science and technology, and it's necessary to have a long-term background and training in order to keep up with it. A scientific career is a good investment in the future. What's more, the presence of scientists should be kept at the forefront of the community. When I take part in debates with politicians, with people from industry, with the media and so on, it's a way of showing that what scientists have to say is important.

Q: What reactions have you had from the scientific community?

A: Some people don't like it because they think we should concentrate on science, which is the "noble" part of our profession, and not get mixed up in the "dirty" side of things like politics. I respect this point of view, but I don't think it's the right way to approach reality. Sometimes, in public debate, knowledge about the subject being discussed is lacking, and we as scientists can provide it.

Q: You've given your support to Anne Hidalgo's campaign, who belongs to the French Socialist Party and is currently Mayoress of Paris. What was that experience like?

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Cédric Villani, the director of the Institut Henri Poincaré.

A: I received some very explicit criticism from the scientific community, but the truth is that it was a very interesting experience. I was able to see from the inside how these types of political events are organized. For example, the team of her main rival published an article in which they implied that my participation in the campaign was given in exchange for certain favors extended to my institute (the Institut Poincaré), and so I had to make a public reply. I could feel the latent violence that exists in these circles.

Q: Why did you decide to get involved in politics?

A: It wasn't really like that; I don't belong to any political party. It was a one-off decision that arose from my participation in the support committee. The fact is that it came out of a quite innocent approach. I was asked to support the candidacy. I was given the political program, a meeting was arranged with Hidalgo, I thought her proposals were good ones and so I accepted.

Q: How did you contribute to the campaign?

"We as scientists are working in the real world, and we have the right to give an opinion on matters that affect the public"

A: By giving my support; in our present society the level of trust we place in politicians is very low, and if you read the newspapers it isn't very difficult to see why. What's more, scientists are much more highly thought of. I don't believe that politics is the exclusive preserve of professional politicians. We can't just leave things in their hands; some are corrupt, others are innocent, but many of them have pursued a professional career that is totally out of touch with the real world. We as scientists are working in the real world, which is important for the whole of society, so I think we have the right to give an opinion on matters that affect the public, and give it freely and openly if we are asked. In the past there have been many examples of how politics and mathematics can work well together. Fourier and Laplace, for instance, are good examples of people who were both excellent politicians and mathematicians. At the end of the day, mathematicians devote their time to solving very complicated problems, and that's what politics is about too.

Q: Even so, you don't see many mathematicians in the public sphere.

A: No, many mathematicians have no interest in politics; they prefer to devote themselves exclusively to their own research work. They want to be left in peace to concentrate without distractions from the outside world. I think that's a decision completely worthy of respect, but so is the decision to participate in politics. It's good that some of us decide to do so.

Q: You've also collaborated in the European Federalist Party, haven't you?

A: Yes, that's really my only political activity, in support of a federal Europe. I'm a strong believer in federalism for Europe. I belong to a federalist association and take part in activities to support that.

Q: On the other hand, one of your latest projects is a comic book. What can you tell us about that?
A: I'm very excited about this project. I started working on it about a year ago with a graphic artist and we've just finished the first draft. He's working on the final version, which should be ready at the end of the summer. It's about the story of four people – scientists and military men – who played a crucial role in the Second World War.

Q: Are they mathematicians?

A: It's more general than that. The first character is Werner Heisenberg, and the second is Alan Turing, who strictly speaking is the only mathematician. The story in the comic deals with his doubts and thoughts, a mixture of anger, pride and fear… We get inside the heads of these people, into the awareness of the power involved in what they do, and also into the notion of national identity, when countries were committing terrible atrocities. We see each of the four characters at four different moments, in different worlds, represented in different styles of drawing.

Q: What was your involvement in the creative process?

A: I wrote the script and the dialogues. I also worked in tandem with the graphic artist; it's a collective project. I had to read a lot of biographical material on these characters, and I gathered a large amount of interesting information.

Q: You already had previous experience in the literary world with your book Théorème vivant (2012). What was that like?

A: Very different from writing a scientific article; I think it's been the biggest success of my career, second only to winning the Fields Medal. It was an enormous risk; the format of the book is rather peculiar. On the eve of publication I was in a real panic. I didn't know if people would like it or if they'd laugh at it.

A: Nevertheless, it was a great success.

Q: Yes, I've received emails from people who said they loved it, who said they recognized their own experiences in what I wrote, and even some who said it changed their lives. It's been a pretty intense experience. What's more, I've earned more money in royalties from the book than from my salary at the academy. Anyway, the success of the book depends on the context and needs special publicity. It was a big success in France and Germany, but in Italy the reception was very disappointing. It hasn't been published in Spain yet. I understand that Spanish publishers don't want to take the risk. The English version comes out next year at the end of spring.

Q: How would you describe the book?

A: It's a diary about the preparation of a scientific article. I think it's a unique document about the sociology of science. It contains poems, songs, excerpts from emails, portraits of people, fragments of mathematical theorems, everything in an unadulterated state, without explanations. Some readers have told me that they've spent time as much time studying the formulas as reading the text.

Q: Why did you decide to write it?

A: It was due to the suggestion of a publisher. He wanted a book describing the life of a scientist, especially a mathematician.

"Théorème vivant is a unique document about the sociology of science"

Q: Do you think there are any particular differences between mathematicians and other scientists?

A: Yes, we're quite extreme. We're very concerned with rules, and we take ideals into account a lot.

Q: Do you think there are also differences between the way in which mathematics is communicated compared with other sciences?

"Writing 'Théorème vivant' has been the biggest success of my career, second only to winning the Fields Medal"

A: Yes, although there should be fewer, but that also happens in specialized communication. People include too much information in their talks; they don't simplify enough.

Q: Let's try and simplify: What scientific results of yours would you highlight?

A: My work on Landau damping [for which he was awarded the Fields Medal]; I think these results are important and required a lot of effort. A great degree of interaction was required with physicists, and this shed new light on the phenomenon. In general, our work on problems of relaxation (the physical phenomenon produced, for example, when we release a stretched rubber band) without increase in entropy has been very important, because very little was known about the subject.

Q: Are you particularly fond of any other result which may not have received so much public recognition?

A: Yes, my work on Cercignani's conjecture. I wrote a couple of articles on the question, the second of which, in 2003, more or less solves the problem. I think the impact of this result has been less, but I also think that it's a rather beautiful paper with a lovely structure.

Q: Your results on optimal transport, bringing together physics, economics and mathematics, are too.

A: Thanks. The problem is about finding an optimal strategy for uniting a series of objects, such as a series of initial positions, with other objects, the final positions. They have to be joined one by one, so that the cost of taking the initial positions to the final ones is as low as possible. It's an economic problem, of course. The physical part comes from the entropy of the system, which is the measure of the disorder and provides a statistical distribution of how the particles spread. The mathematical part comes from the curvature.

Q: Your work in this field has been very influential.

A: It wasn't only me who made these advances: I was working in a team with other people. We wrote some articles on the subject, which seemed no more than that, but they have led to a considerable amount of activity. A lot of people are working on the subject now. I suppose the books I wrote about it have also had an influence: i brought one out with the American Mathematical Society and another with Springer. The second one was very important; it put a lot of ideas in the right place and attracted a lot of people to the field. It took a great deal of effort. I think it's one of the achievements I'm most proud of. I look at it now and wonder how on earth I could have done it.

Q: Are you still interested in the topic?

A: I've been working for years on a revised version of that book, but I don't have a lot of time so progress is slow. Meanwhile, progress in the field itself is extremely fast, so I don't think I can completely include all the current knowledge on the subject in the book, which is what I did in the first one. I'll probably write a chapter summarizing the most important developments since the first book, and that's a challenge in itself.

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Cédric Vllani next to Manuel de León, the director of the ICMAT.

Q: How do you manage to keep so many different irons in the fire?

A: There's a constant element in everything I do, and that has to do with proceeding from one direction to another through the encounters and opportunities that arise. I met a publisher and he led me to writing a book, which put me squarely in the public eye and which later I used for something else. I came into contact with the people involved in European Federalism through the Fields Medal. In mathematics, it was thanks to the Boltzmann equation that I worked with people involved in optimal transport and who were using similar ideas, and so on. I follow a series of connected events. Maybe it doesn't look like that from the outside, but I just put one foot in front of the other and advance little by little, and on the way I find new opportunities for doing things.

Q: You've also been director of the Institut Poincaré for the last five years. What do you have to say about this job?

A: I've learned a lot of things about how to make the administration work. It's tough getting things to move ahead; you have to devote an enormous amount of time to human resources.

Q: You're now starting your second term in this post. What would you like to achieve in the next five years?

A: If everything goes well, at the end of this period we will have expanded the Institute tremendously, doubling the number of offices and opening a new museum of mathematics. That would be great.

Interview: Helene Esnault, expert in Arithmetic Geometry

"German mathematics led the field and it took sixty years to rebuild it"

Freie Universität Berlin

Helene Esnault, full professor at the Free University of Berlin.

Hélène Esnault (Paris, 1953) is a full professor at the Free University of Berlin. Although her vocation for mathematics arrived late – she felt even more drawn to philosophy – she is currently one of the world experts on Arithmetic Geometry. In 1975 she graduated from the University of Paris VII, where she also did her PhD, and settled in Germany one year later, where she has been living ever since. She was an invited speaker at the International Congress of Mathematicians in Beijing in 2002 and at the European Congress of Mathematics in Krakow in 2012. In July of this year she attended the Clay Institute Summer School, held at the ICMAT, where she gave a course on Galois representations in functor fields.

Ágata A. Timón.

Question: Why did you decide to devote yourself to mathematics?

Answer: One of the reasons was social, because of my background: unlike the humanities, mathematics is a field in which one does not notice where you come from. I was brought up in a working class family and for me it was important not to be restricted by my background. Another reason was intellectual: I was fascinated by the abstraction nature of mathematics. It's the art of abstraction.

Q: When did you realize that you wanted to study mathematics?

A: I didn't know what it meant to do mathematics; I just loved it, but I also liked other things such as philosophy. However, where you come from is much more noticeable in philosophy, and I knew at bottom that it wasn't something I wanted to dedicate my life to. The same goes for poetry. I don't know how old I was when I started to take special interest in mathematics. I remember that once in high school our teacher did a demonstration on real numbers in class, and it really struck me. After that I was certain that I didn't want to give up mathematics, but it dawned on me quite late. People come to mathematics in many different ways. Some arrive there via physics or computational sciences. I came to mathematics by poetry and philosophy. It's another way of getting into it.

Q: What for you is the relation between mathematics and poetry?

A: It's very personal, although I'm not the only one who can see this relation. When you do mathematics you try to construct things and sometimes find answers to questions, which we call conjectures. And to do this we use different tools. We put them into place and see if they fit together or not. If they don't, we move a sign and try again. There's also an aesthetic value to what we do. If it looks nice it gives us a good feeling and we know we're on the right path. The same thing happens when you write poetry; you put down some words and read them to see if they seem okay. After a certain point you arrive at a state of stability and you feel satisfied. Mathematics is supposed to be the oldest science, and poetry is probably the oldest form of creative writing. Of course, there are big differences: in mathematics we have a criterion of certainty; what we do has to be true according to a set of rules. Whereas truths don't exist when you're writing poetry; it's more a question of personal judgement. But in both cases you're looking for a stable aesthetic construction.

Q: Do you write poetry?

A: Yes, sometimes, but it's not for publication; I do it for personal reasons. I live in Germany, but my mother tongue is French. At some moment I realized that I was forgetting my own language, and since I've always loved poetry I thought that writing poetry in a systematic way would be a means of not losing touch with French.

Q: What was your first contact with mathematical research?

A: I suppose it was at the end of my time at the École Normale Supérieure, when I wrote my first paper. I was thinking about a particular question for a while and ended up writing about it.

Q: What did you like about this experience?

A: Well, research work is a long road and when you start you're not really doing research. You don't even belong to that world. Research means finding something new, and it takes time to develop the required intuition. When I entered the École Normale Supérieure I first opted for a philosophy course; then I decided to concentrate on mathematics because I had the feeling that philosophy was a very ideological field, while in mathematics these aspects are in a certain sense not so visible. After that I decided to take up teaching and reach a position that was not too far away from research.

Q: Which scientist has had the most influence on your career?

A: Pierre Deligne, without a doubt; his ideas on mathematics are the ones that have had most influence on me throughout my life in mathematics. But he's still alive, and if you asked me about scientists from the past I'd have to mention others.

Q: So which other mathematicians would you choose to talk about?

A: I think I'd choose Chinese mathematicians from 2,000 BC, and maybe the Babylonians, in order to understand their thought and compare it with the way we think today. That would be fascinating. Of course, the Chinese mathematicians were very close to poetry and they even wrote poems. The Chinese remainder theorem, for example, on the calculation of congruences, which we believe comes from China. It's documented in literature as a poem rather than as a mathematical text.

Q: How would you describe your research work in a few words?

A: My field is arithmetic geometry, and these to words together suggest interdisciplinarity. I study certain types of objects that are close to reality; that is, physical reality outside mathematics. I try to describe them mathematically by means of certain types of equations – polynomial equations. I try to study these equations by different methods, some of which come from topology, which is the art of distinguishing forms in our universe. Other methods are studied by analysis, which is what is behind the construction of bridges, and others come from number theory. What I've been doing for the last ten years lies on the borderline between very geometrical mathematics, with which one can almost draw, and discrete mathematics, which come from number theory.

Q: Are there other fields that you'd like to get to know better?

A: We specialize a lot in mathematics; there are a lot of fields I know nothing about; statistics, for example. A field a bit closer to my own is hard analysis. But I'd like to understand better some questions concerning topology. In particular, a great deal of progress has been made in recent years in the field of topology, thanks to [Grigori] Perelman, and I've attended some talks on the subject as well as writing about it, but there's a long way to go before one can understand what's being done in this field.

Q: Coming back to your specialty: what are the most important challenges in the development of this discipline?

A: In recent years I've been particularly attracted by two conjectures: on the one hand, an arithmetical question concerning geometric objects, the Lang-Manin conjecture, about whether all varieties over a finite body that is rationally connected have a rational point. I was able to find an affirmative answer for finite bodies. The conjecture has been extended to C1 bodies, and it's still not known whether this is true or not. I'd like to do some work on this question. On the other hand, I've also proved a structure theorem for projective varieties in characteristic p, Gieseker's conjecture. As an extension, I'd like to know what it is in other more general cases such as non-proper schemes. But I don't know if I'll ever get to see it.

Q: What's your experience at the Clay Institute School been like?

A: It'd be great if all the Clay Institute Schools were held in Madrid, because it's a lovely city. And the students chosen by my colleagues are really brilliant.

Q: Is this your first visit to Spain?

A: No, I adore the country. Right now I have two Spanish students. One of them is doing a Master in Berlin and the other is doing his doctorate. They're both really good.

Q: Have you collaborated with Spanish mathematicians?

A: I've done a lot of collaborations, but I don't think I've done any with Spanish mathematicians. But life's not over yet and one day I may do so.

Q: How do you view mathematics in Spain?

A: Spain is going through a difficult economic situation and I hope it doesn't affect mathematics very much. There's no guarantee of this, of course, because if investment in mathematical research dries up then the whole scientific system may collapse. I live in Germany; I'm half French and half German, and when I look at the history of the country, at what the Nazis did to the school of mathematics in Germany… German mathematics led the field; it was number one in all areas connected with algebra, and it took sixty years to rebuild the school. It's a very serious matter.

"If you really like mathematics, then you have to make the effort and try it."

Q: Do you have any message or advice that you'd like to share with young people?

A: No, I have none. A lot of young people want to come to Berlin to study with me, more than I can take on, and I only accept those who just refuse to give up. To them I say that mathematics isn't a profession. Obviously, we all need money in order to live, but if you don't love mathematics you'd better find something else to devote yourself to. On the other hand, if you really like mathematics, then you have to make the effort and try it.

Interview: Carmen Vela, Spanish Secretary of State for Research, Development and Innovation

"Mathematics is doing this country proud"

Carmen Vela Olmo (Sigüenza, 1955) is a chemist who since 2012 has been the Spanish Secretary of State for Research, Development and Innovation. Her professional career has been associated with the business world in the biotechnology sector. In 1994 she became director of Ingenasa, a company devoted to animal health and food quality. She is the author of many scientific articles and patents and was also the chair of the Association of Women Researchers and Technologists until 2010, as well as chairing the Spanish Biotechnology Society until 2012. Since then she has been responsible for managing the Spanish scientific system with a much reduced budget due to the difficult economic situation. Her objective: to guide the ship of Spanish science through difficult waters while keeping losses to a minimum and even in some respects strengthening it. Vela attended the 10th American Institute of Mathematics Congress held in July of this year in Madrid, where we were able to talk to her.

Lorena Cabeza.

Question: What's the latest news on the budget?

Answer: The 2014 budget contains signs of improvement, because for the first time in Section VII (devoted to subsidies) there's been a net increase of 140 million euros, which is what people receive. This increase has enabled us to put out all the calls we had to issue this year. Then the government approved an extraordinary loan of 95 million in R+D, which has allowed us to issue calls again for the projects in the State Plan, as well as setting the Annual Plan of action in motion. Next year we expect to return to normal, and I hope with some improvements as well.

Q: What improvements would you point to?

A: The Ramón y Cajal call is much better. Each researcher now has 40,000 euros when he or she starts working, when before only 15,000 were available. And on completing their contracts researchers have direct access to funding of about 100,000 euros, which before went to the autonomous communities. There are also projects with room for two main researchers. Too many Ramón y Cajal researchers have spent their five years without ever having a project. These new projects also have different lengths, so if a project ends after three years researchers can go on with another for a further two years, whereas before things just stopped. These changes make the system more effective.

Q: One of the most important things lacking in our system is private investment. Partly it's a question of circumstances, but there's also a structural problem.

SINC

Carmen Vela, Spanish Secretary of State for Research, Development and Innovation.

"We've also begun to define a new research career"

A: We've now adopted some measures over the medium and long-term. The paradigm within the Spanish Strategy for Science, Technology and Innovation has changed. Previously we had research on one side and then innovation. The universities complained that companies were asking for things that were different from what the universities were doing, and companies complained that the universities weren't doing what they asked for. Now we've put in place a continuous R+D strategy to avoid separate compartments, so that research can generate knowledge, which is vital, and also orient that knowledge towards applications. We've also developed instruments, for example, the Challenges-Collaboration scheme, where companies and public bodies work together. We're going to create industrial doctorates, because we believe that people provide an excellent way for the business and academic worlds to get along well together. We want to encourage mobility, so people from universities can go to companies and then return, and vice-versa, which is something that happens in most countries.

"We want to encourage mobility which happens in most countries"

Q: What schemes do you have in mind for young people?

A: The first was to make the replacement rate for researchers 10%, because in the 2012 budget it was 0%. Then we've established an exceptional period for the Ramon y Cajal appointments so that the universities and the OPIs can continue with their contracts for two more years without incurring penalties, with the aim of these people being able to settle into a position. And we've also begun to define a new research career, which is also something that happens abroad, where not everyone is a public servant.

Q: The Severo Ochoa program, to which the ICMAT belongs, is one of the Secretary of State's crucial tools for attaining excellence; isn't that so?

A: Yes, this has been a fundamental criterion. When we find ourselves with cuts in our budget, the money available is not so much shared out as prioritized, and we prioritize according to excellence, quality and human resources.

"An excellent way for the business and academic worlds to get along well together"

Q: What's your assessment of this program now it's been running for three years?

A: Very good; the Severo Ochoa is a great program; in fact we've continued with the official certifications because we believe that quality and excellence must come first. Now we intend to issue a new call, which will probably be a little different, opening it up to university departments and units and hospitals; we believe there's a great deal of value there.

Q: Is the continuance of the project guaranteed?

A: Yes, and next year it comes up for renewal.

Q: What would you particularly like to mention about this congress?

A: It's an extraordinary congress. The number of people attending has doubled in comparison with former occasions; there are four women among the main speakers … and mathematics is doing this country proud. I'm very satisfied to be here and glad I made the effort to come.

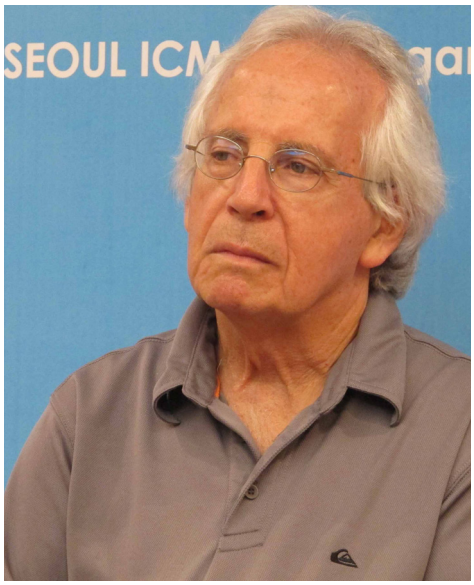
Carmen Vela welcoming AIMS attends duringa ICMAT cocktail.

Profile of Standley Osher, Gauss 2014 Prize winner

Mathematics for animation in films and the fight against crime

Jezabel Curbelo One of the prizes awarded by the International Mathematical Union is the Gauss Prize for the application of mathematics. It is presented every four years at the International Congress of Mathematicians (ICM), held this year in Seoul (South Korea), where the winner was Stanley Osher (University of California Los Angeles). "Osher is a good example of an applied mathematician", said Chi-Wang Shu (Brown University), a former PhD student and current collaborator of Osher, when the Gauss Prize was presented during the ICM on August 16th of this year. "His algorithms are based on profound abstract and technical concepts, with special emphasis on efficacy and simplicity. His work has often motivated subsequent research in mathematics. In order to extend the applications, he collaborates with engineers and other scientists from different branches".

The prize is awarded by the IMU and the German Mathematical Society (DMV) to that scientist whose mathematical research has had a great impact outside of the discipline: in technology, finance or simply in people's daily lives. The prize arose as a result of the budget surplus of the ICM in Berlin (1998) and was announced on April 30th, 2002, to coincide the 225th anniversary of the birth of Carl Friedrich Gauss, the Prince of mathematicians, after whom the award is named. The announcement stated that "Gauss combined scientific theory and practice in a way that no one had done before". Three mathematicians have received the prize so far: Kiyoshi Itō (ICM Madrid 2006), Yves Meyer (ICM India 2010) and Stanley Osher, this year at the ICM Seoul 2014.



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Standley Osher, Gauss 2014 Price winner.

Osher has always been particularly interested in the applications of the mathematical tools he develops. As he says, "usefulness makes the beauty of mathematics even more enjoyable, although you often have no idea beforehand of what use they may have". While he did his doctoral thesis, under the supervision of Jacob Schwartz, in the field of pure mathematics (functional analysis), he soon changed to a more applied field – numerical analysis. His early work was on the development of high resolution schemes, which have turned out to be extremely useful in the study of fluid dynamics and other related fields.

"Usefulness makes the beauty of mathematics even more enjoyable"

His mathematical tools are behind the animation of films from Pixar, Disney, Warner and Dreamworks

His mathematical tools are behind the animation of films from Pixar, Disney, Warner and Dreamworks, such as "Pirates of the Caribbean", "Star Wars", "Harry Potter" and "Terminator 3". One of his students, Ronald Fedkiw, received a special Oscar for Scientific and Technical Achievement for the technology deriving from the so-called level set method. This method provides the means of determining how surfaces move, combine and merge in 3D, which enables different fluids, bubbles or explosions to be simulated for the cinema.

Osher has also made vital contributions to image processing. His techniques for improving video images, developed in conjunction with L. Rudin, are successfully used by police forces all over the world for the apprehension of criminals. These tools have also played an important part in astronomy for improving the quality of photographs that are often dim or blurred, as well as in medicine for understanding how the shape and topology of the brain affect its function. Stanley Osher is an extraordinary mathematician whose contributions have influenced the daily lives of many people and are noticeable in the world around us. The next time you go to the cinema and see and animated film, think about the mathematics that lies behind it; it probably carries Osher's signature.

Jezabel Curbelo is a postdoctoral researcher at the UAM and member of the ICMAT.

Interview: Ángel Castro, ICMAT researcher and 2013 José Luis Rubio de Francia prize-winner

"The problems I work on arise naturally"

Ángel Castro Martínez (Madrid, 1982) is the latest winner of the José Luis Rubio de Francia Prize, which is awarded every year by the Real Sociedad Matemática Española to young mathematical researchers of less than 32 years of age. Castro is a postdoctoral researcher at the Autonomous University of Madrid (UAM) and a member of the ICMAT, where he works on the European Research Council (ERC) project headed by Daniel Faraco (UAM-ICMAT). He specializes in fluid mechanics and partial differential equations, and this year has obtained one of the five Ramón y Cajal contracts awarded in the area of mathematics by the Spanish Ministry of the Economy and Competitiveness. He graduated in Physics at the Complutense University of Madrid in 2005 and obtained his doctorate in Mathematics at the same university in 2010 under the supervision of researcher Diego Córdoba (UAM-CSIC). He subsequently continued his postdoctoral work at the ICMAT and the ICMAT in Madrid and the École Normale Supérieure in Paris. The panel that awarded the prize to this most outstanding young Spanish researcher singled out his results on the problem of the appearance of singularities in incompressible flows, which is vital for understanding the process of how turbulences are formed.

Ágata A. Timón and Lorena Cabeza.

Question: You are a physicist. Do you think that this provides you with a different approach to posing problems in mathematics?

Answer: I suppose so. I have the intuition that comes from practice. A part of theoretical physics consists in trusting that the equations you're studying will explain the behavior of the world that surrounds us. This may be harder for a mathematician, because physicists tend to say to themselves, "if these equations model this phenomenon and I can see this phenomenon in nature, I'm bound to find a way of demonstrating it". That's why sometimes I'm more of an optimist than others about whether something can be demonstrated or not.

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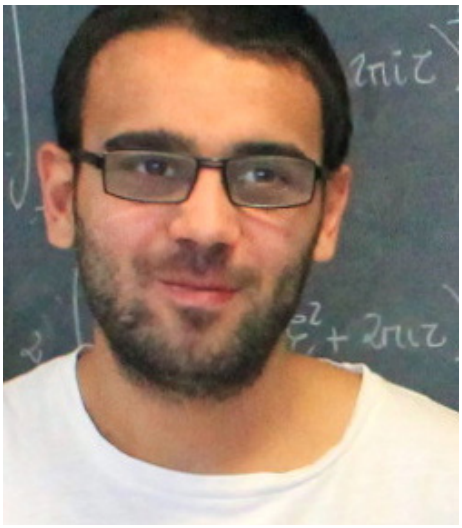


Angel Castro, the latest winner of the José Luis Rubio de Francia Prize.

Q: How was your move from physics to mathematics?

A: I've always like mathematics a lot. In fact, at university I was on the point of switching to mathematics, although I didn't do it. However, the moment arrived when I realized that mathematics interested me more than physics, and when I was thinking about doing a PhD the chance of working with Diego Córdoba on a project somewhere between the two disciplines arose. I saw it as an opportunity of doing something I'd always wanted to do, which was mathematics, as well as making the most of my background as a physicist.

Q: Was the move difficult?

A: No, because I had a good grasp of mathematics. I don't recall it being something difficult.

Q: The panel remarked on your work on the problem of the appearance of singularities in incompressible fluid flow. How would you explain this question?

A: One of the big open problems in fluid dynamics is whether the solutions to incompressible flow equations are regular or not. For the sake of simplicity, suppose we take water and we want to find out how it moves. One way of doing this is to ask what its velocity field is. If it's steady it means that there are no abrupt changes in the intensity or the direction of its motion. The question is as follows: if you start with a field that is steady, will it continue to remain so over time or will abrupt changes appear at some given moment? This is a big question today in fluid dynamics for equations like the Euler or Navies-Stokes equations. But other interesting equations also exist, and you could ask for example how a fluid moves in a porous medium, which is the Muskat problem.

"An important part of our work is proving that something exists that resolves this equation"

Q: What's the Muskat problem about?

A: This is where a new phenomenon appears, because the medium with the fluid in it tries to slow its motion down. In real-world terms, for instance, this would correspond to the draining of a dam or the motion of crude oil inside the earth. And when you introduce a medium where the fluid is found the equations are modified. Under certain conditions, you arrive at the Muskat problem, which models how two fluids with different densities move through a porous medium; for example, water and oil or water and air. In the Muskat problem we study the interface separating the two fluids. Previous work by Diego (Córdoba) and Paco (Francisco Gancedo) show that a solution for the interface does exist.

Q: And what does that mean?

A: A solution exists for the equation $x+2=0$, because -2 satisfies the equality. If you ask if there's a solution for $x^2+1=0$, because you know that, unless you go into to complex numbers, there is no real number that satisfies this condition. In this sense, the equations that model fluids are equations that seek an object – in previous cases it was a number, but they might be more complex structures – that satisfies certain conditions. Maybe it exists and maybe it doesn't. You observe the physical principles, you make certain assumptions and you arrive at the equations, but nobody is saying that they have a solution. An important part of our work is proving that something exists that resolves this equation.

Q: What other questions have been asked about this equation?

A: You can ask whether this solution exists for all the time or only for a short period. It's often very complicated to prove that there's a solution for all the time, because at some moment it could cease to exist. In the work I've been doing with Diego (Córdoba), Paco (Francisco Gancedo), Charlie (Charles Fefferman) and María (López Fernández), we prove that in the Muskat problem regularity can be lost; that is, it starts from a steady surface but deforms over time until it creates a singularity, in this case a corner. That's something we didn't expect at first.

Q: What have you all been working on besides the Muskat problem?

A: We've been working on water waves, which is also a water-vacuum interface problem, but not in a porous medium. We show a type of singularity exists that we've called the splash-type. Basically, this means that waves can break; but this, which is a highly elementary physical phenomenon, was something that couldn't be proved mathematically until our work.

Q: Have these results led to new questions?

A: Yes, we're trying to do the same for Navier-Stokes equations, which is when viscosity is introduced. We're also interested in proving other types of behavior in the Muskat solutions. And I've also been looking into water waves, but in the long-wave regime; in other words, shallow waters. These equations allow you, for example, to model the behavior of tsunamis.

Q: Is this applied research work?

A: Yes, oceanographers are very interested in this type of long-wave regime, because you arrive at much more manageable equations with this regime that enable you to obtain real information about how oceans move.

Q: How do you decide which problems to work on?

A: The problems arise naturally because you talk to people, and also many of the questions you ask are a continuation of other questions you've already asked, such as "we've proved this, but it would be interesting to go a little further". Then again you see that work by other researchers exist that have demonstrated interesting things and you react in the same way.

Q: Now you've obtained a Ramón y Cajal contract, how do you see your research career?

A: I'm aware that you have to try and enjoy what you've got. When you start your thesis you can't be thinking all the time that one day you're going to finish and you'll have to look around for a post-doc. Then when you're doing your post-doc, you have to concentrate on what you're doing at the time, even though the contracts are short-term. I'm going to devote the next five years to research, which is what I like, and I'll worry about the rest later.

"I'm aware that you have to try and enjoy what you've got"

Mathematics Today

ICMAT news

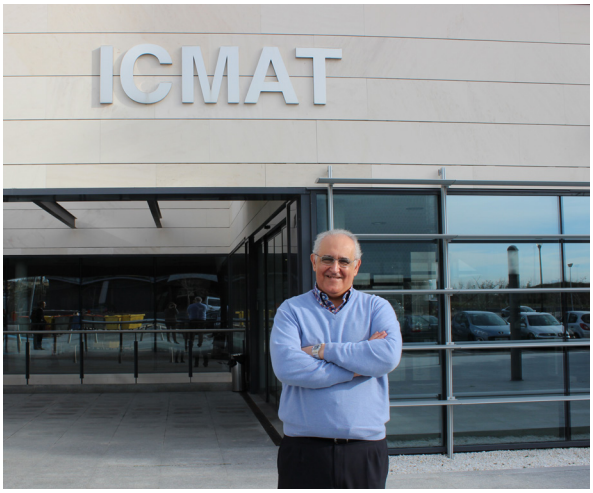
Manuel de León joins the International Council for Science (ICSU) Executive

During the General Assembly of the International Council for Science (ICSU), which was held in Auckland, New Zealand, between August 30th and September 3rd, it was announced that Manuel de León, director of the ICMAT, would become a member of the Council's Executive Committee. The ICSU consists of 31 Scientific Unions and 121 national members from 141 countries (various federations of member countries exist), which makes it the largest scientific organization in the world. Although Spain has belonged to the Council since it was first set up, this is the first time that the ICSU has had a representative of Spanish mathematics on its board.

The main aim of this organization is to strengthen international science in benefit of society. Its actions are thus centered on promoting international scientific collaboration, integrating science into international politics and the universal nature of science, all on the basis of equality and non-discrimination.

According to De León, "the ICSU plays a decisive role in identifying the major challenges posed by the sustainability of the planet, and is the ideal interlocutor for states and organizations such as the UN and UNESCO. The flagship program for the coming decade is Future Earth, which deals precisely with defining the measures required to achieve a sustainable world. The credibility of the ICSU and its ability to mobilize scientists from all disciplines, as well as politicians, will be key factors for determining our future."

Among the 31 scientific unions that make up the Council is the International Mathematical Union (IMU), to whose executive committee de León belongs until the end of this year. It was precisely the IMU that decided to present De León's candidacy. The representation of mathematics on the ICSU therefore receives an important reinforcement. "In recent years I have worked to make the ICSU one of the main objectives for the IMU, and now I will try to make education and mathematical research increasingly more present in this organization", said this researcher. "The IMU has extensive experience in the promotion of mathematical education that can be extended to other disciplines, and furthermore it is impossible to fulfill the objectives of the ICSU without mathematical research".



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Manuel de León, the director of the ICMAT.

Shigefumi Mori,the first Asian to be appointed president of the International Mathematical Union

On the weekend before the International Congress of Mathematicians (ICM) was due to begin in Seoul (South Korea), the General Assembly of the International Mathematical Union (IMU) was held. It was there that Shigefumi Mori, a professor at the University of Tokyo (Japan) Institute of Research in Mathematical Sciences, was elected president of this Union. He is the first Asian to occupy the post, which he himself stated was a great honor both for the continent and for his native land, Japan, where he currently works.

Mori had already served on the Executive Committee of the IMU from 1995 to 2002, so he came to the post with experience of how the institution is run. In the words of ICMAT director, Manuel de León, this "was one of the most decisive arguments in favor of Mori's election". However, it was not the only one; the quality of his scientific work had already earned him a Fields Medal, which he was awarded in 1990 for his work on algebraic geometry, a field in which he has worked throughout his career.

The new Executive Committee was also elected at the Assembly, where it was also announced that Rio de Janeiro (Brazil) would host the XVIII International Congress of Mathematicians in 2018. "This is the first time in a century that the ICM will have been held in Latin America", said León, "which is an indication of the substantial improvement achieved in mathematical research in the zone during recent years."

Agenda

SCIENTIFIC ACTIVITIES AT ICMAT

A Two-day Meeting on Mathematical Biology
Date: 29th- 30th October 2014

ICMAT-China Exploratory Workshop
Date: 17th - 21st November 2014

DISSEMINATION ACTIVITIES

Science & Tecnology week

Conference "Matemáticas Experimentales"
Date: 3rd - 4th November 014
Madrid and Alcobendas

Round table: Young mathematicians
Date: 10th November 2014
Alcobendas

Matemáticas en la Residencia Francisco Casal de Rey
Date: 1st December 2014

"Matemáticas del Círculo" - OuLipo Literature Workshop
Date: 1st -4th December 2014

ICMAT news

The Summer Course on 'Art in Mathematics: Mathematics in Art'

Science and beauty came together in the Complutense University of Madrid (UCM) summer course, 'Art in Mathematics: Mathematics in Art", which was held between June 30th and July 4th at El Escorial and organized with the participation of the ICMAT. The purpose of the event was to show how much these two spheres of human thought, apparently so far apart, have in common, and how this relation can sometimes be seen in music or the plastic arts, which often unintentionally use mathematical tools in order to achieve a greater complexity and aesthetic quality. To that end, each day of the course was devoted to the relations that mathematics has with different artistic pursuits: music, creative writing, architecture and so on. Researchers from the ICMAT and the UAM, together with high school teachers and members of the artistic community, participated in these activities with talks and round-table discussions.

"Generally speaking, mathematics is not regarded as an art, but there is a great deal of art involved in mathematical creation. Mathematics is a science that uses a very strict language, but it leaves a lot of freedom for creativity and requires a large amount of imagination, qualities that have much in common with the way that artists work", says Daniel Azagra (ICMAT-UCM), co-director of the course together with Juan Ferrera (UCM). On the other hand, when Bach was composing his works he was probably not thinking about mathematics. Nevertheless, mathematics is very present in his compositions, to the extent that, according to Azagra, "one could argue that in a certain sense he was doing geometry".

Special attention was also given to the concept of mathematical beauty. As Azagra says, "Sometimes theorems have no known application, but one of the criteria for their success is that they should be 'beautiful'. It's often an aesthetic criterion that makes them more perfect, more fully rounded; they provide an answer to questions that arise naturally or open up new avenues of exploration within a theory, and these are aesthetic qualities that mathematicians know how to appreciate".

One hundred students participate in a day devoted to crystallography and mathematics

One hundred 4th grade secondary school and 1st year baccalaureate students from schools in the Community of Madrid took part in a day-session on "Mathematics, crystallography and chemistry: an exciting and necessary relation!" at the CSIC Química Física Rocasolano Institute on September 23rd.

Throughout the day's activities, which were undertaken at the proposal of the ICMAT and organized by this Institute, together with the Instituto de Química Física Rocasolano and the Instituto de Química Orgánica General, in collaboration with the CSIC Assistant Vice-presidency for Scientific Culture, the students attended talks entitled "Tell me how it happened – A crystalline story!" and "Kepler and the Symmetry of Snowflakes", given by Martín Martínez Ripoll (Instituto de Química Física Rocasolano) and ICMAT director Manuel de León, respectively.

In addition, the students visited the laboratories of this research center, where they had the opportunity to follow the crystallization process of proteins conducted by researchers.

Within the framework of the International Year of Crystallography, and 400 hundred years after symmetry was first observed in ice crystals by the German mathematician and astronomer, Kepler, the purpose of this activity was to demonstrate the importance of crystallography, as well as to make science more closely accessible to 16-17 year-olds and introduce them to the work of researchers in this field and the impact of scientific investigation on society. A 4th grade student at the Alameda de Osuna Secondary School in Madrid, Nadia González, said: "I enjoyed this day very much. Studying these things in a book is not the same as seeing them done by people devoted to this subject".

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Editorial Comitee:
Manuel de León
Ágata Timón
Kurush Ebrahimi Fard

Production:
Divulga S.L
C/ Diana 16-1º C
28022 Madrid

Coordination:
Ignacio F. Bayo
Ágata Timón
Lorena Cabeza

Design:
Fábrica de Chocolate

Layout:
Andrea Jiménez

Collaboration:
Jezabel Cerbelo
David Fernádez
Giancarlo Breschi
Álvaro Navarro
Guixiang Hong
Giussepe Negro

Traducción:
Jeff Palmer

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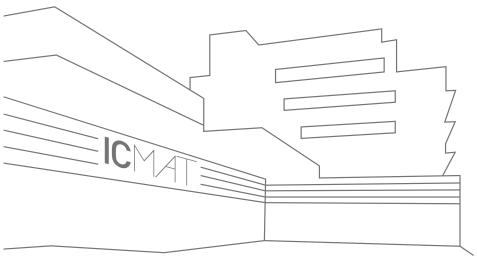

C/ Nicolás Cabrera, nº 13-15
Campus Cantoblanco UAM
28049 Madrid, Spain
www.icmat.es