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EDITORIAL

More Science

Throughout history, humankind has been the victim of severe epidemics, such as the black plague in the mid-14th century; smallpox in the mid-18th century, or the ill-named Spanish flu some one hundred years ago, among others. Thanks to the enormous progress made in the contemporary era, not only have we been able to live longer and better lives, but we have believed ourselves to be safe from attacks of many kinds, from natural disasters and, of course, pandemics. Nevertheless, quite suddenly, a minute organism – that is even unable to exist independently – has been capable of overwhelming the most advanced health systems in the world. And when the number of infected cases and deaths grows alarmingly, the best measure to adopt has been confinement; that is, to *deglobalize* our world and put trends that once seemed unquestionable into reverse. The effects of this disease have proved to be overwhelming, and here, at the ICMAT, we wish to express our solidarity and send our support in the most direct way to the families affected. It is also an opportune moment to give our thanks to all those who have been engaged on the forefront of this problem, and especially, to applaud the determination and dedication of our health workers.

Despite the devastating impact that COVID-19 has had on our society, the effect of which on our future is still uncertain, one of the most frequently heard messages has been that *this pandemic can only be beaten with more science*. Research has helped us to understand how the disease is transmitted and what can be accomplished with lockdown. In a race against time vaccinations and treatments are being sought that will help us to return to *normality*, and enable us to understand and respond to future crises faster and more effectively. Mathematics is directly to be found in all these endeavours by means of models, predictions, statistics and so on, as well as indirectly across the board by providing a language to underpin many scientific advances.

The visibility of the contributions made by this discipline is crucial, since they serve as an argument to highlight the significance of mathematics before the powers that be. Nevertheless, if all we do is emphasize this importance, we run the risk of society at large regarding the discipline as a fashionable field of study that is only useful in the short term. It is vital that we impress on governments that mathematics consists of a closely knit and complex system of ideas, concepts, theories and developments that make the lines separating its different areas increasingly more difficult to distinguish clearly. We must also stress the fact that the mathematics that we currently apply in practice is built on and underpinned by previously existing theories that often at first appeared to be of little practical use. Furthermore, there are mathematics that have never been em-

Image: José María Martell

José María Martell, director of the ICMAT

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ployed beyond the sphere of the discipline - and which we are not sure they ever will be – but which are nevertheless fundamental for the advance of human knowledge. They form part of the "useless" knowledge generated by intellectual curiosity, a subject that was addressed in the previous Newsletter on the 80th anniversary of the publication of the brilliant article by Abraham Flexner "The usefulness of useless knowledge", which appeared in *Harper's Magazine*.

It is therefore necessary for us at the ICMAT to reaffirm our commitment to excellent mathematics; mathematics that all together form part of the basic science that contributes to the development of knowledge; and with this idea, to emphasize the role of science as an indispensable means by which society may progress and overcome the challenges facing us in this new era, which will entail a multitude of changes.

Furthermore, we should think carefully about the effects that this new situation may have on the development of the scientific strategies at our Institute. Since mid-March our doors have been closed, and while much of our activity has continued via video link, we have found ourselves in a situation where in many cases it has been difficult to pursue our research work due to the increase in family responsibilities; the lack of personal contact with students and postdoc researchers; the cancellation of seminars, conferences, visits and work trips; online teaching, and so on. These are just some of the factors that have had an impact on life at the ICMAT.

After these months of lockdown, it is now the time to start thinking about emergency plans to revitalize the Institute. It is up to us to continue producing the excellent mathematics that impact on the international scene, for which it is necessary that all of our members set about the task of organizing future seminars, discussions, conferences, schools, visitor schedules and work trips.

I feel reassured in the knowledge that all the ICMAT members will contribute towards the consolidation of the Centre as a natural home of mathematics, thanks to which this process of revitalization may be successfully achieved. In this new context, I know I can count on all the researchers, managers and administrative personnel of the Institute, and especially on the new and recently appointed executive team (Eva Gallardo, as deputy director; and Javier Aramayoma and Fernando Quirós, as department heads), about whom you can read in the news pages of this latest bulletin. Needless to say, I am available to each and every one, and in close collaboration with the other institutes in the region we can work together in the endeavour to make the Institute an example of excellence in the field of mathematical research.

José María Martell is a scientific researcher at the **CSIC** and director of the **ICMAT**

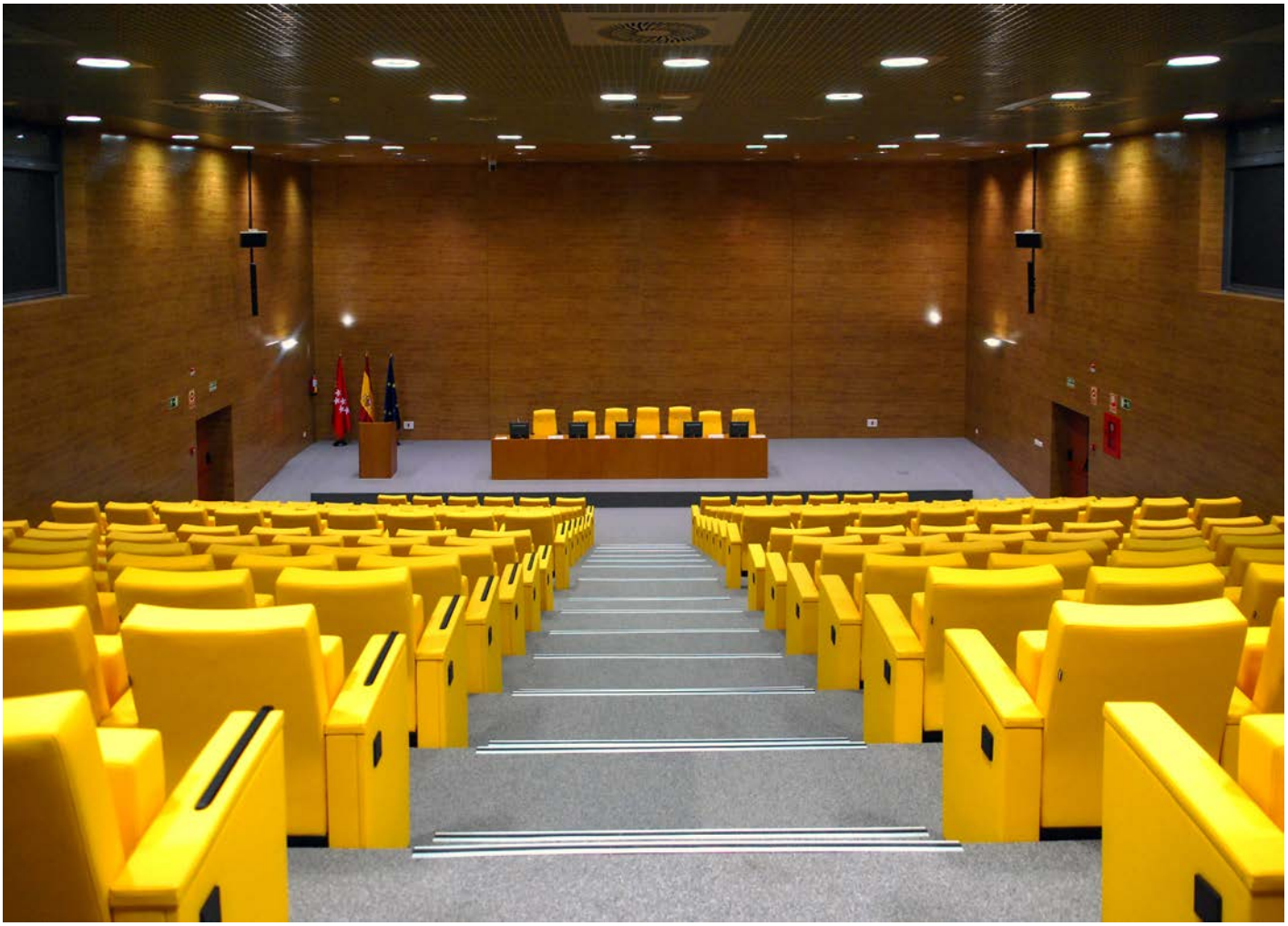


Image: ICMAT

CFTMAT auditorium

REPORT: Mathematics coming out of lockdown

The World Mathematical Year, first held 20 years ago, signalled the start of bringing mathematics closer to society at large and an emergence of outreach that has profoundly changed its popular image.

Ignacio Fernández Bayo

"We were anonymous, unknown. I travelled all over Spain giving talks on mathematics. I had a programme on Spanish television called *Más por Menos* ('More for Less') and we launched a book collection published by Nivola entitled 'Mathematics through its outstanding figures'. More colleagues of mine were involved in other initiatives, but we were able to reach only a small audience. It was regarded as something solely for nerds", recalls Antonio Pérez, one of the mathematics outreach pioneers in Spain. This was in the late 1990s, when scientific outreach was the Cinderella of the media world and cultural activities, and mathematics itself the Cinderella of scientific outreach. "Up until the year 2000, there were just a few pioneers, and one of their problems was that they were even frowned upon by their university colleagues", says Edith Padrón, from the University of La Laguna. Even mathematicians themselves, convinced that their field was of no interest to anyone but its own practitioners, and a subject that even provoked rejection, continued to inhabit their own circumscribed world, isolated in their ivory towers, or to use the phrase much employed lately, "lived in lockdown".

Twenty years later, everything has changed. Outreach mathematicians now proliferate; "some are even famous, stars of YouTube", says Antonio Pérez. "You open a newspaper today, either paper version or digital, and you're likely to find an article relating to mathematics; something that was unthinkable back then", adds Manuel de León, of the ICMAT. Whether it be by books, websites, social networks, radio, television, exhibitions, monologues or theatre, mathematics is widely and freely accessible thanks to hundreds of initiatives undertaken both individually and collectively. Its presence has become normalized to such an extent that even those sectors of the public who recoil at the mention of mathematics are now beginning to acknowledge its value and importance.

The World Mathematical Year

Image: World Year of Mathematics

Logo of the commemoration of the World Mathematical Year, in 2000

Looking back over the last two decades, it is clear that the turning point occurred in the year 2000 with the celebration of the World Mathematical Year (WMY), as some of those at the forefront of this event have testified. It is unlikely that any of the international years devoted to scientific disciplines held since then have had such a transformative impact, at least in Spain.

In 1992, the International Mathematical Union (IMU) launched an initiative to commemorate the centenary of the speech given by the German mathematician David Hilbert, in which he set out the 23 problems to be solved in the 20th century. As Manuel de León explains: "Here in Spain the idea went unnoticed until 1998, when some of us began to think about doing something ourselves. A committee was set up that was composed of representatives from scientific societies, faculties, secondary-school teachers, and agencies having something to do with mathematics. Four coordinators were appointed (Juan Luis Vázquez, María Jesús Luengo, Josechu Fernández and myself), who from the start had no doubt that it was necessary to launch a series of outreach activities". He goes on to say that the initial concern was not so much the *innumeracy* that existed in society, but rather the decline in mathematical vocation to be found in all the faculties belonging to the field, which led to the organization of a meeting of deans of mathematics. To that end, "the main measure taken was to visit schools and institutes with the aim of explaining what mathematics is and what purpose it serves", adds de León. Almost at once, after sowing this seed, outreach initiatives were set in motion that were addressed to a more general public.

"As far as I remember, very few people were involved in mathematical outreach activities before the year 2000, and those who did were mainly teachers. But what drew my attention most in that year was what was going on in countries that had much more of a tradition in the matter than us, such as France or the United Kingdom. Since then, little by little outreach has increased to an extraordinary extent, a phenomenon assisted by social networks and technological media", says Marta Macho Stadler, of the University of the Basque Country and an outreach exponent who is well-known on the social networks. For his part, Antonio Pérez points out that "a key factor was that the committee managed to involve the universities, which until that time had looked down on the idea of outreach. A circuit of mathematical talks was set up in cultural centres across Spain, and people actually went to listen!"

Among the activities organized was an exhibition at the Senate devoted to the 200th anniversary of the decimal system, which was very well received, and as Manuel de León remarks, "the Senate commissioned the book from us, which is published annually by the Institute as a gift. Another important undertaking was to establish contacts with the media. This was the first time that the mathematical community had ever issued a press release". As a result, some media began to publish news items covering the event as well as other activities that were organized.

In addition to pursuing contacts with society at large, the WMY served as a springboard for mathematicians to organize themselves and put their own strcutures into place. For example, this led to the Deans of Mathematics Conference. A further significant step in the process was the revival in 1996 of the Real Sociedad

Matemática Española (RSME, Royal Spanish Mathematical Society), one of whose main objectives was to stimulate outreach. "The level of activity in the year 2000 wouldn't have taken place without the RSME, nor afterwards for the International Congress of Mathematicians, not to mention all that happened later", says David Martín de Diego, co-director of the ICMAT Outreach Programme and vice-president of the RSME. Among other things, 1998 saw the refounding of *La Gaceta Matemática*, a vital organ of communication between Spanish mathematicians and for the dissemination of high-level outreach activities.

The RSME also played the leading role in a new milestone in 2003, when the RSME Outreach Committee was created, which constituted a continuation of the seed sown with the WMY. This committee, which is currently headed by Fernando Blasco, has since then been one of the principle promotors of many outreach schemes.

"The RSME committee took up the guantlet thrown down by the WMY and went on to roll out a national programme of mathematical outreach", says Raúl Ibáñez, of the University of the Basque Country and who is responsible for the *DivulgaMat* portal, one of the most notable outcomes of this vocation from the Royal Society. *DivulgaMat* emerged in 2004, and according to Raúl Ibañez, "became a leading light in the field and generated an enormous amount of outreach material that was very useful for all those interested in mathematics, especially those involved in education". At that time the portal had between 120,000 and 150,000 visits every month, figures that were very high at the time in question. "For years it was the portal for mathematics with the most visits in the world, including those in English", says Antonio Pérez. One of the keys to its success was that from the outset it managed to reach the entire Latin American world. Today, it is still a leader and receives many visits, although its impact has fallen off somewhat due to the proliferation of other websites of a similar nature.

Madrid, 2006

A significant leap forward for mathematical outreach occurred with the International Congress of Mathematicians (ICM), an event that had already been running for more than one hundred years. Every four years the Congress brings together mathematicians from all over the world and from every specialized field, and the 25th edition was held in Madrid in 2006. As Manuel de León, who presided over the Organizing Committee, explains: "The International Mathematical Union hinted to us that we might be in line to host the ICM, so we initiated the process by involving all the mathematical societies. We spoke to the then Spanish Ministry of Science and asked them for assistance and funding. They understood the importance of being able to host the event and helped to smooth the way for us".

The announcement that Madrid had been chosen as the host city for the Congress sparked an enormous amount of organizational activity in which communication and outreach played a leading role. Six months before the event, a weekly news bulletin began to be sent out, interviews were held and accounts of the preparations were provided for the media. At the same time, exhibitions and other activities were organized all over Spain thanks to satellite conferences and collaboration with universities, city halls and other agencies and institutions. In Madrid, the Conde Duque Cultural Centre housed three exhibitions: "Why Mathematics"; "Fractal Art, Beauty and mathematics", and "Demoscene, Mathematics in Motion". According to Raúl Ibañez, in charge of the organization: "There were more than 70,000 visitors and long queues waiting to get in. A further exhibition, devoted to "The Life of Numbers", curated by Antonio Durán from the University of Seville, was held at the National Library and was also a great success, while another, held at the ICMAT itself and entitled "The ICM through History", curated by Guillermo Curbera, also from the University of Seville, who says that "the exhibition subsequently went on tour to Seville, Madrid, Barcelona and Badajoz". This mathematician is also the custodian of the documentation that the IMU keeps of the ICMs, as well as being the author of the book *Mathematicians of the World, Unite!*

From the point of view of media coverage, the impact was so great that it surpassed the most optimistic expectations, with the presence of King Juan Carlos I at the inaugural session and the upset caused by Grigory Perelman, who rejected his Fields Medal and was conspicuously absent from the Congress. According to TNS-Sofres, the global market research and information group, it was the event with the greatest media repercussion that had been seen in recent years. Joan Ball, president of the IMU at the time, made special mention of the efforts devoted to communication and outreach at the closing session. "Every time we meet, he tells me that there has never been anything like the Congress in Madrid", says Manuel de León.

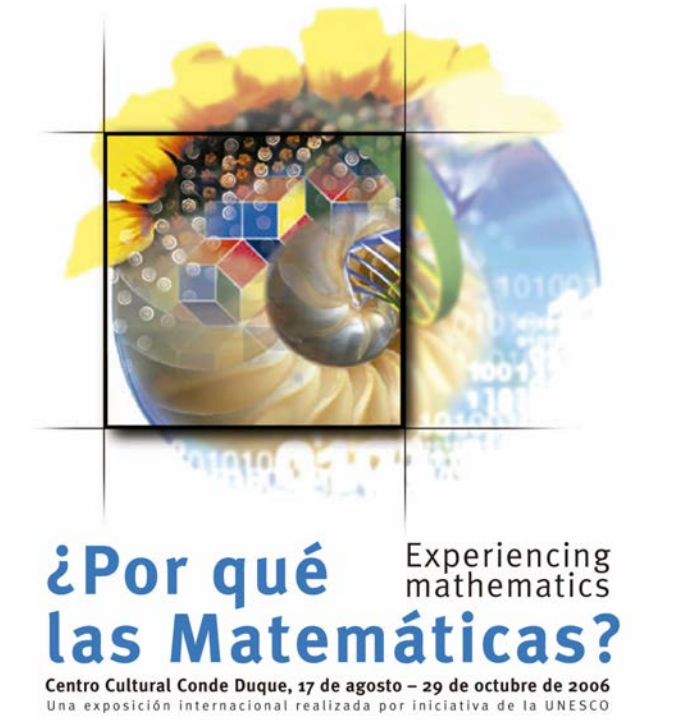
Shortly after the successful celebration of the ICM, came the arrival of the Consolider i-MATH programme, which was provided with a communications bureau with its own resources that continued to give support to outreach throughout the four years of its existence (2006-2010). The RSME also made a special effort towards communication and outreach on the occasion of its centenary in 2011.

Starting in 2012, various mathematical institutions created permanent mathematical outreach structures. The first of these was set up in 2012 at the ICMAT as part of the Severo Ochoa Excellence project. Since that time, the Institute, which has a scientific culture unit (the only one in the field of mathematics to be recognized by the FECYT), has promoted many activities, among which is worth mentioning the 'Café y Teoremas' section, published in the *El País* national daily, and the *Miradas Matemáticas* book collection (in collaboration with the Spanish Federation of Maths Teachers Societies, which is also very active in outreach, especially that aimed at teachers and students, and the collaboration of the publisher *Los libros de la Catarata*). It is also worth pointing out the series of outreach conferences called "Matemáticas en la Residencia", held in collaboration with the CSIC Vice-presidency of Scientific Culture and the *Residencia de Estudiantes*. "It began in 2009 and about two conferences are held every year. It has enabled us to bring the best popularisers of science, such as Marcus du Sautoy, Jin Akiyama, John Allen Paulos, Sylvia Nasar and Tom Crawford", says David Martín, who is in charge of organizing the series. He also emphasizes the significance of holding the conferences at the Residencia de Estudiantes, the emblematic centre of Spanish cultural life in Madrid: "It is important to stress that mathematics forms part of culture in general", he says.

Image: ICM 2006

The inauguration of the ICM Madrid was attended by King Emeritus Juan Carlos I

Image: ICM Madrid



Poster of one of the mathematics exhibitions organized on the occasion of the 2006 ICM

This cultural aspect of mathematics is shared by many. "I like hybrid activities; this cooperation among scientific and artistic entities, such as those that reconcile mathematics with literature, the plastic arts and theatre, like the experimental literature workshop at the ICMAT, the Círculo de Bellas Artes or the play *El Aumento*, a production organized by the ICMAT, in which the mathematics involved in the plot is analysed", says Marta Macho. She is an expert on the relations between mathematics and literature, and among her many activities, between 2005 and 2011 and under the direction of Isabel Marrero (University of La Laguna), she contributed decisively to the launching and running of *Matematicalia*, a digital outreach journal devoted to mathematics that is available on the Internet.

Image: ICMAT

OuLiPo experimental literature workshop organized by ICMAT and the Círculo de Bellas Artes in Madrid

The networks multiply

In the final years of the last decade, social networks dedicated to mathematics have started to grow, paving the way to individual initiatives that have multiplied to the point where they have become a torrent difficult to channel, but with great value due to their tendency to go viral. As "these channels, unthinkable just a few years ago, have become a driving force for outreach", says Marta Macho. They have also become the means of expression for hundreds if not thousands of young mathematicians. As Edith Padrón explains: "Young people regard outreach as something natural; they can't conceive of research with the outreach that goes with it". It is not all good news, however, as some commentators have pointed out: the proliferation of popularisers on the networks and the lack of any control mechanisms sometimes give rise to the dissemination of erroneous content and the loss of scientific rigour.

As Antonio Pérez once remarked, the social networks have turned some popularisers of mathematics into media stars, one of whom is Clara Grima, a woman who owes her popularity to her on-stage presence, her ubiquity on the networks, and her avatar as a comedian, which constituted her debut as a populariser of mathematics. Then there is the monologist Eduardo Sáenz de Cabezón, the presenter of the TV show *Órbita Laika*, and above all the personality behind *Derivando* on YouTube, which already has more than a million followers. These are just two examples, but there is not enough space in this article to include a very long list.

Another area that has experienced a notable surge is the world of books, where the pathfinding collection published by Editorial Nivola has been followed by many others, such as the above-mentioned *Miradas Matemáticas*, and collections available in kiosks such as *El mundo es matemático* ("The World is Mathematical") consisting of 40 books. As Manuel de León says: "If you take a look at a press kiosk, you'll always find a book about mathematics on sale".

DiMa

By 2017, the proliferation and success of so many of such ventures led the outreach and communication community to think about the need to coordinate its efforts. A meeting held at the ICMAT on January 7th of that year was the first step in this direction, in the wake of the submission two years previously of a project by the ICMAT for approval from the FECYT (which rejected it). "The idea was to create a collaboration network for the unification of synergies and to highlight the many minor contributions, and thereby get ahead of the curve. It would also enable the sharing of experiences garnered by the pioneers in the domain of the new languages being used by the young", explains Edith Padrón, regarded by many as the coordinator of the network, although she herself does not consider herself as such.

Image: ICMAT

The mathematician Eduardo Sáenz de Cabezón gave the talk "The number that computers can never calculate" in the "Matemáticas en la Residencia" cycle

With the title of "DiMa", this network has been taking its first steps to build up its constitution. The first step was the conference held in Zaragoza in 2018, which brought together some fifty outreach workers who made decisions about the structure of the network and participated in round-table discussions in which they shared experiences. The second step was to set up a course for popularisers of mathematics, the first of which was conducted in Castro Urdiales in 2019. As Padrón explains: "There were about 30 students, some of them mathematicians, some young journalists and others with the desire to work in outreach. Together they discussed written and oral dissemination, social networks and other forms of outreach".

The intention is to alternate these two activities so that one year the conference is held and the next year the course. At the moment, the second outreach course, scheduled for 2021, has been postponed because of the lockdown due to the Covid-19 pandemic. As regards the consolidation of the network, the main matter that remains pending is to make it an entity in its own right by defining statutes, officially registering the association and constituting a board. "At the moment," says Edith Padrón, "we only have a website, which is run by the ICMAT, and a list of relatively active Google emails". This current situation makes it difficult to apply for the funding required to organize the events.

Given that the goal of outreach 20 years ago was to attract students to the Mathematics faculties, there is no doubt that it has been successfully achieved, both for the variety and extent of the professional opportunities available to the graduates and for how much mathematics has permeated through to society as a result of the efforts made. As Antonio Pérez points out: "More than the job opportunities, I think that the success can be measured by how much the public's attitude to mathematics has changed. Many people have seen its human face and the benefits that mathematics brings", an opinion seconded by David Martín: "Some years ago, mathematics was regarded as something arid and without practical use, but society's perception of it has changed. Today, it is seen as something useful and interesting, and that's the result of the last 20 years of all the work put in to outreach". Raúl Ibáñez adds the following: "The situation that was once a desert with one small oasis has become a lush rainforest", and explains that this is thanks to the disinterested efforts of many people and institutions.

"Proof of the progress that has been made is that the very people who were once unconvinced or resistant, some of them with an almost religious intransigence, today recognize the value of outreach. They have realized that it is important not only for mathematics and its social image, but also for their own work", concludes Edith Padrón.

Image: DiMa

Attendees at the first school of dissemination of mathematics, organized by DiMa in 2019

INTERVIEW: Manuel del Pino

"For me, mathematics means beauty and harmony"

Manuel del Pino is a professor of mathematics at the University of Bath where he holds a UK Royal Society Research Professorship. He was an invited speaker at the international Congress of Mathematicians in 2010. In that same year he was named as a member of the Chile Academy of Sciences, and in 2013 he was awarded the Chile National Science Prize. His research work is focused on the field of partial differential equations, in which he has addressed nonlinear elliptic and parabolic problems; in particular, constructions of asymptotic patterns in singular perturbation problems and the formation of singularities in time-dependent problems. He has published more than 160 papers dealing with these problems in journals of international prestige.

Del Pino completed his PhD in 1992 at the University of Minnesota (USA) under the supervision of Wei-Ming Ni. He went on to occupy postdoctoral positions at the Institute of Advanced Studies (1992-1993) and the University of Chicago (1993-1995), and later became a tenured lecturer at the University of Chile in Santiago, where some years later he was appointed to a professorship. In January of this year he visited the ICMAT to impart an ICMAT-UCM seminar on "Gluing methods for vortex dynamics in Euler flows", an occasion on which we had the opportunity to speak to him.

Ágata Timón García-Longoria

Why did you decide to study mathematics?

I was always fascinated by science. As a young man I was interested in meteorology; I was intrigued by the idea of being able to forecast weather. I was drawn to the sky, the clouds... At the age of 12 or 14 I became almost obsessed by learning how to make my own meteorological observations and trying to make predictions on the basis of these observations. I read old texts, sometimes from the 19th century, drew up tables, looked for patterns and made my own measurements with very basic instruments. There was an intellectual curiosity in mathematics behind this search for patterns.

I was also interested in astronomy – the sky again! I knew all the constellations visible in the southern hemisphere. I had a couple of books on astronomy and I learned something about positional astronomy. I was fascinated by the beauty of the sky in itself, its harmony, and the fact that you could predict and explain it. That's what mathematics is for me; beauty and harmony.

And later, as often happens, for three years between junior and high school, I had a teacher who motivated me a lot. He was a very good teacher.

Have you ever regretted your decision?

No, quite the opposite; I can't imagine myself doing anything different. I'm still attracted to meteorology, but not enough to dedicate myself to it body and soul.

If you hadn't devoted yourself to mathematics, would it have been to meteorology?

I don't think so; maybe it would have been something completely different. I've always been interested in politics. It was a major part of my life during the dictatorship in Chile. I've always liked to write as well. I think my parents thought I was going to dedicate myself to that, to the humanities. However, I can't imagine myself doing anything different from mathematical research now.

Do you remember your first contact with mathematical research?

My father was a Maths and Physics teacher, although it wasn't a subject of conversation at home. And my brother, who is 13 years older than me, did a degree in mathematical engineering, and later completed his PhD in statistics at Wisconsin. As for me, I decided to enroll in a Common Plan of engineering at the University of Chile, which could lead you to study mathematics, physics and earth sciences... The first two years were general studies, after which you had to specialize in one subject. I was best at mathematics, so I didn't have any doubts about what to choose. It was the subject I liked best by far. At the end of this degree course you had to do a final project, which went on for two years. I had a very good teacher and I chose the field I work in now. It was very fruitful; in fact, one of the papers I published at that time contained results of mine that have been most frequently cited until now.

Do you remember how you felt after solving those first problems?

Working- in mathematics requires a lot of dedication. It can be very frustrating at times; you can go over and over a problem in your head and still not come up with a solution, or maybe the conjecture you're trying to prove isn't right. You start to question your own ability. But when you manage to solve a problem you experience a kind of ecstasy, a feeling of great pleasure at having achieved something.

What's your working day like?

As you advance in your career your responsibilities increase. Academic work is mainly focused on research, but I've always done a lot of teaching, which is something I like very much. Right now, I have a grant that means I don't have to teach. In normal circumstances I devote as much time as possible to research, then to teaching, and as little as possible to administrative work. And then there are always visitors and collaborators who I have to attend to.

What do you think is your most notable achievement as a researcher?

I belong to a team that has developed a concrete methodology for the resolution of partial differential equations in asymptotic situations. With this group I've shared some achievements that have given us a lot of satisfaction. I'd single out a work we did in 2011 on the construction of a counterexample to a famous conjecture by De Giorgi in large dimensions, on elliptic partial differential equations. It was due to that result that we drew a lot of attention.

Image: CONICYT

Manuel del Pino (Bath University, United Kingdom)

What are your interests as a researcher?

A lot of our work has been about nonlinear elliptic partial differential equations, that are not time-dependent. We look for solutions to equations that have their origin in physics and biology, models of relatively simple form but which encompass complex structures that are extraordinarily interesting. Our aim is to find and rigorously describe some of these solutions.

They're solutions that involve parameters, and for the limit values of these parameters particular configurations appear. We want to construct them rigorously by employing methods coming from different areas of mathematical analysis. It's important to solve them not only numerically but also rigorously, because it's about a mathematical validation of the model, a trustworthy proof that has an internal consistency.

More recently we've addressed evolution problems and the development of singularities for limit situations in time. In this field, I'd particularly point out the analysis of singularities in the presence of variational criticality, which appears in many interesting models, and new singular configurations for the Euler equation for incompressible fluids. Specifically, we want to construct solutions. This assumes some type of collapse of the underlying model. One of the most fascinating things about this area is being able to describe this type of phenomenon.

Your seminar at the ICMAT is called "Gluing methods for vortex dynamics in Euler flows". Could you tell us what this problem is about?

The Euler equation is the most classical model in fluid motion and goes back to the mid-18th century. We're interested in understanding exactly a phenomenon that concerns the motion of highly concentrated vortices in two dimensions. Imagine that you have five tornadoes on the Earth's Surface. What's the motion taking place at the centre of these whirlwinds? What laws is this motion following? "Gluing methods" refers to being able to overlap solutions in regions of the solution and at different scales.

What has the Royal Society Research Professorship meant for your career? And the Chile National Science Prize?

They're different distinctions. The Chile National Science Prize is a highly prestigious award conferred by the state for your work and contribution on a national level. I was very grateful to receive it. I come from a middle-class family and enjoyed a state-funded education (both at school and university).

The UK Royal Society Research Professorship is a great honour from the professional point of view. It's very reassuring because it's a recognition of the work we're doing in this group. And from the practical point of view it's very important; I can devote myself 100% to research, hire people, travel and so on. I feel very fortunate.

MAY 12: Celebration of Women in Mathematics Day

For the second year running, the Day of Women in Mathematics was held on May 12th, the birthday of the Iranian mathematician Maryam Mirzakhani, the only woman to win a Fields Medal and who sadly died in 2017. Throughout the month, and with the slogan *Celebrating Women in Mathematics*, a series of activities were organized all over the world – many of which, given the circumstances, were virtual events – with the aim of highlighting the work of women mathematicians, profiling outstanding figures and helping in the struggle to close the gender gap that exists in the discipline. This second edition enjoyed a considerable following, with more than 80 events registered on the website set up for the celebration and thousands of views of the documentary *Secrets of the Surface. The Mathematical Vision of Maryam Mirzakhani* in 124 different countries, according to the organizers of the May 12 initiative.

The ICMAT itself organized a collective online viewing of this documentary devoted to Maryam Mirzakhani, which was followed by a roundtable discussion chaired by Ágata Timón (ICMAT-CSIC) in which the participants were Eva Gallardo (ICMAT-UCM) and Javier Aramayona (ICMAT-UAM). The debate was enlivened by questions from the audience through the Conecta.csic app chat line. Prior to that, at 5.00pm, a meeting open to the public was organized via Instagram Live with Carolina Vallejo, a UAM Juan de la Cierva postdoctoral researcher and a member of the ICMAT. Over a period of 40 minutes, more than 60 people hooked up to ask Carolina Vallejo questions about her career as a researcher.

For their part, the WOMAT Association and the RSME Women and Mathematics Commission shared videos on women researchers in action via their YouTube channel, where they replied to questions posted on their social networks and two student escape rooms about great mathematicians in history.

The idea for this celebration came from the Women's Committee of the Iranian Mathematical Society and was approved at the World Meeting for Women in Mathematics (WM)², one of the satellite congresses that was held at the last International Congress of Mathematicians (ICM), held in Río de Janeiro (Brazil) in 2018. We spoke with several of the collaborators involved in the May 12 initiative, as well as with members of women's committees belonging to mathematical societies throughout the world.

Laura Moreno Iraola

Interview with Mojgan Mahmoudi

Mojgan Mahmoudi, a professor at the Shahid Beheshti University (Tehran, Iran), a member of the Women's Committee of the Iranian Mathematical Society (IMS) and the representative of her country in the coordinating committee of the May 12 initiative

Where did the idea of establishing May 12th as the International Day of Women Mathematicians come from?

We at the ISM Women's Committee, of which I am a member and a former president, were convinced that with the celebration of a day dedicated to women mathematicians we would be giving them our support and encouraging them to achieve their goals.

"Maryam Mirzakhani is an inspiration for the women of Iran; her example motivates us to be more active in the mathematical community"

In honour of the memory of Maryam Mirzakhani, we proposed the declaration of her birthday as the Day of Women mathematicians. We did so at the (WM)², a satellite conference held at the last ICM held in Río de Janeiro in 2018, and the motion was approved by a majority of those attending the event. That's how we came to hold the first "May 12, Celebrating Women in Mathematics" Day in 2019.

What's the significance of Mirzakhani for Iranian women mathematicians?

She's a symbol of hard work and intelligence as well as kindness and happiness. She has become a role model for our young women and girls. Her success is an inspiration that mo-

Still from the documentary *Secrets of the Surface. The Mathematical Vision of Maryam Mirzakhani*

Image: Women's Committee of the Iranian Mathematical Society (IMS)

Iran's First Women's Committee. First from right: Mojgan Mahmoudi

tivates us to work hard and become more active in the mathematical community.

What's the current situation for women mathematicians in your country?

The number of women in Iran who study mathematics at university at different levels is higher than men. In fact, in our culture, women who study science and engineering subjects at university have a lot of self-confidence.

Interview with Marie Françoise Ouedraogo

President of the African Women in Mathematics Association (AWMA), professor at the Université Joseph Ki-Zerbo (Ouagadougou, Burkina Faso) and representative of the African continent on the coordinating committee of the May 12 initiative

What does the Women in Mathematics Day mean for you?

I think a special day like this is necessary, because the gender gap in mathematics is still very wide. Women in this field are constantly coming up against obstacles throughout their university studies and professional careers, and studies exist that verify this fact. One of the most recent is "A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences: How to Measure It, How to Reduce It?", a project undertaken by the International Science Council and 11 scientific organizations. The main aim of this study is to investigate the gender gap in STEM (science, technology, engineering and mathematics) disciplines from different angles and on a world scale.

What's the current situation of women mathematicians in your own country, Burkina Faso, as well as Africa in general? And do any schemes exist to tackle the gender problem?

The gender gap in Burkina Faso is pretty serious. As in the rest of Africa, very few women are active in the field of mathematics for many reasons; cultural and socio-economic barriers, the lack of role models, the lack of self-confidence in women themselves, work and family balance problems and so on. Until just a few years ago, studying mathematics was a lonely experience for women on the African continent. That's why we decided to create the African Women in Mathematics Association (AWMA). One of the main aims of the Association was to set up a contact network for women mathematicians for the purpose of generating mutual collaboration, as well as for tutoring young women and for promoting mathematics in Africa. We regularly organize activities such as conferences and debates on the situation of women mathematicians, and we also try to raise awareness of women mathematicians in Africa by means of profiles on the Association's website, because we believe they would be good role models for young women. Since the Association was set up, we have managed to bring together many women who formerly worked alone at their respective institutions. What's more, many of them have created their own national associations of

Image: Marie Françoise Ouedragogo

Marie Françoise Ouedragogo

women in mathematics. For its part, the AWMA has managed to situate African women mathematicians on a more or less equal footing with similar international organizations.

You represent the AWMA, of which you are the president, on the May 12, Celebrating Women in Mathematics coordinating committee. How did you come to join the committee?

As president of the AWMA, I was also a member of the International Mathematical Union's (IMU) Committee for Women in Mathematics between 2015 and 2018, and that's how I came to be elected as one of the May 12 coordinators.

"Until only a few years ago, studying mathematics was a lonely experience for African women"

I think it was important to belong to that because it gave me the opportunity to help organize activities in which the gender gap in mathematics could be addressed, and where women mathematicians could achieve recognition or act as examples to be followed, whether through conferences or meetings, etc..

I also believe that it's necessary to pay tribute to Maryam Mirzakhani, and that's why her birthday was chosen as the day to celebrate women mathematicians. She has been the only woman to be awarded a Fields Medal, the highest honour in the discipline of mathematics, and her experience and contribution to mathematics are an inspiration for thousands of girls and women around the world.

Interview with Andrea Vera

An academic at the University of Valparaíso and Chile's representative for May 12

What's the significance of a celebration like May 12, the Day of Women in Mathematics?

It's part of a series of initiatives that have been in operation for several years in order to make the presence and work of women in the mathematical community more visible, as well as to fight against the gender stereotypes in our culture, and therefore in science.

You represent your collective in the May 12, Celebrating Women in Mathematics, initiative. What are your main tasks as part of the organization?

Last year, the first year when we celebrated May 12, our first task in the Organizing Committee was to publicize the date and to encourage our male and female colleagues to organize their own activities for the event on that day (or dates close to May 12th) in their respective towns and institutions. In addition, we had already prepared a website (https://may12.womeninmaths.org) where all the events taking place in the world were registered. We also had to be sure that the organizers of each local event kept some kind of record (photographs, videos, etc.) that they would send to us later. The 2019 celebration was a success, and more than 100 events were held all around the world. Then we wanted all the members of the worldwide coordinating group to keep a record of the organizational process, and later we wrote an article about it for the journal *Notices of the American Mathematical Society* entitled "May 12: Celebrating Women in Mathematics From One Idea to One Hundred Events".

Image: Andrea Vera

Andrea Vera

Likewise, for this year's celebration some of us belonging to the collective participated in the "Women Mathematicians in Chile. Sociology in the scientific field from the perspective of gender" research Project. At the media outreach team for this project, we organized five virtual activities about mathematics for boys and girls at home. Furthermore, we were also in charge of the Spanish subtitles for the film *Secrets of the Surface*, so that it could enjoy some exposure in Latin America as well.

"In Chile, only about 20% of those involved in teaching or research in mathematics are women"

What's the situation in your country regarding the gender gap in the field of mathematics?

The situation in Chile is similar to that in many other countries. For example, there's a big gap between boys and girls in the results of international tests in mathematics, such as PISA, as well as in national tests such as the University Entrance Exam. This gap also exists when it comes to choosing a university course and becomes even more pronounced as the academic career unfolds. At present, only around 20 % of all the teaching and research staff in mathematics in Chile are women.

Interview with Laura Calaza Díaz and Elena Camacho Aguilar

Members of the RSME Commission for Women in Mathematics

Why is a Day for Women Mathematicians necessary?

A day like this enables us to increase the visibility and celebrate the fine achievements of women mathematicians as well as to maintain awareness of these mathematicians throughout history. In other words, it helps us to occupy the place in people's mind that we deserve. Unfortunately, we're still invisible in many areas , in textbooks for example, where references to women is round about 5 % in science and 1 % in technology. This invisibility translates into a lack of role models for girls and young women, which is far below that for boys and young men who take up STEM studies.

What is the most prominent factor for you in the current gender gap in the field of mathematics in Spain?

Although there are more women per year enrolled in universities (around 55 %), less than 6 % opt to study a subject in pure sciences (Physics and Mathematics), and in particular only 0.7 % choose Mathematics in comparison with 1.4 % of men. These figures show that an invisible barrier still exists, created by the stereotypes imposed by society, and which make many women and girls think that a university course in mathematics is not for them. The number of women enrolled in degree and master courses in mathematics is slightly lower than for men, but the gap becomes even more noticeable as these courses progress. If we look at the figures for the 2017-2018 academic year, we see that women amount only to 35 % of the teaching and research staff in the field of mathematics. The percentage becomes even more troubling in the highest academic positions, such as university professorships, where it falls to 13 %.

"As a society, we need to rethink many gender issues"

This gender gap doesn't just exist in universities, but is also found in the field of technology, where the average salary of women mathematicians is 10 % lower than that of male mathematicians, four years after graduating.

It has been observed over recent years that this gender gap has increased sllghtly, and there has been a decrease in women enrolling in Mathematics Degrees (and related subjects) as well as Master Courses. How do you account for this?

If we look at the percentages, we see that female presence is still lower than male presence in Mathematics degrees, and is about 40 % falling to 30 % in double degrees. As we've said before, we believe that these differences are due in part to the invisible barrier created by stereotypes imposed by society.

Image: Elena Camacho Aguilar

Elena Camacho Aguilar

Image: Laura Calaza Díaz

Laura Calaza Díaz

PROFILE: Alexandre Anahori

"I think it's almost mystical that you can predict the future with reasoning"

Alexandre Anahory was born in Lisbon, Portugal, in 1993. Throughout his education, he developed a special interest in the mathematical description of the universe and decided to study Physics at the University of Lisbon. However, after completing his degree he began a master in Mathematics at the same university, which later led him to the ICMAT. In October 2017, thanks to a grant from the Portuguese Ministry of Science Foundation for Science and Technology, he began his PhD on geometric mechanics under the supervision of David Martín de Diego (ICMAT-CSIC). For Anahory, this was just the first step towards achieving his objective of becoming a university teacher of mathematics.

Image: Alexandre Anahori

Alexandre Anahori has been a predoctoral researcher at ICMAT since 2017

Nuria Chamorro Díaz

Alexandre Anahory has just a few months left before he completes his PhD at the ICMAT. He has spent the last three years under the supervision of David Martín de Diego (ICMAT-CSIC) conducting research in geometric mechanics, an area of mathematical physics in which geometric methods for studying the motion of physical systems are used. In particular, Anahory is devoted to the study of non-holonomic systems, a class of mechanical systems. "We study the properties of these systems from a theoretical point of view, but we are also trying to develop some applications in engineering, such as the development of simulations for robots and drones".

In Martín de Diego's group, Anahory has found a nexus between mathematics and physics. He says that as soon as he was introduced to this group he was eager to come to the ICMAT. His interest in these disciplines began when he was still a child. "From childhood I've been interested in the laws of physics. I felt something almost mystical in the idea that in some way you could predict the future by reasoning". He says that was why he decided to enrol in a Physics degree, during which he discovered his passion for the mathematics that lay behind these laws. This was also what eventually brought him to the Institute after completing his Master studies at the University of Lisbon. During this phase he began studying dynamical systems, although as he says: "I still needed this component of geometry involved in the work carried out in the group led by my thesis supervisor".

His time at the ICMAT constitutes his first academic experience outside Portugal and he finds it highly satisfactory, since research work at the Center is extremely active. "Many people here are devoted entirely to research, which creates a very good atmosphere for working and the discussion of ideas with other colleagues. Furthermore, the Institute is full of young people and the experience is proving to be very good". However, Anahory does not want to dedicate himself exclusively to research, because his true vocation is teaching. He says that, for him, it is a pleasure to be able to share the knowledge he is acquiring, and what he really finds exciting is learning about and understanding new things that he can pass on to others later. It is for that reason that in a few years' time he would love to teach classes at a university.

When asked about the future, this researcher says he prefers to take things little by little. He is currently considering the possibility of moving to another country to study his postdoctorate, although at the moment he remains undecided. One thing about which he is sure, however, is that he feels happy and comfortable working in his current field of mathematics. "I think I've found what I want to do", he concludes, "although it's true that in the future I'd also like to devote myself to finding applications. Scientists sometimes don't like to dedicate much time to the practical side of their work, but it's an enjoyable way of finding new problems and interacting with the world we live in, rather than remaining isolated".

SHE DOES MATHS: Evelyne Miot

Research fields: Differential equations, fluid mechanics, Euler equations, Vlasov-Poisson equations.

Laura Moreno Iraola

Since 2014, Evelyne Miot has been a permanent researcher at the Institut Fourier which belongs to the Centre National de la Recherche Scientifique (CNRS) and the Université Grenoble-Alpes. In March this year, she was scheduled to participate as a speaker at the ICMAT's Special Session on Vortices in Classical and Quantum Fluids, organized by the researcher Daniel Peralta, but the pandemic prevented her from attending. This would have been her first visit to the Centre, and she was expecting to make the most of her visit by working alongside Peralta for a few days in the field of three-dimensional fluids, an area they both share. Despite the postponement of this visit, we were able to talk to her via video link.

Until she was 16 years old, Miot was convinced that she would study medicine. However, a teacher of mathematics persuaded her to change her mind. "He set us the task of reading a detective story, *Le Théorème du Perroquet,* by Denis Guedj, in which the author introduces the history of mathematics in a fascinating way. It impressed me so much that I ended up studying mathematics", says Miot. She subsequently took up research in order to go deeper into the subject, and little by little became fully immersed in the discipline.

This researcher is a specialist in partial differential equations belonging to the field of fluid mechanics – 2-dimensional and 3-dimensional Euler equations – and kinetic equations – Vlasov-Poisson equations – as well as dispersive equations such as Schrödinger equations. In particular, she studies solutions to these equations when singularities appear, which generally correspond to vortex points or filaments that are defined by the Euler equation – to charge points in plasmas, determined by the Vlasov-Poisson equation, or to quantum vortices in quantum fluids, bounded by Schrödinger equations.

Miot has made important contributions to the fields mentioned above. She has obtained results on the Euler equation in 2-dimensions and on the Vlasov-Poisson System with or without singularities. In the case of 3-dimensional fluids, in collaboration with Valeria Banica she has conducted research into the interaction of nearly straight and parallel vortex filaments. To that end, they based their work on a system proposed by Rupert Klein, Andrew J. Majda and Kumaran Damodaran in 1995, and thereby managed to establish results of existence and uniqueness under the conjecture of symmetry in the configuration of the filaments.

But if Miot had to choose the results of which she is most proud, she would probably opt for those obtained with Banica and Faou on the problem of finite-time collapse of vortex filaments, better known as vortex reconnection. As Miot herself

Image: Evelyne Miot

Evelyne Miot works at the Institut Fourier (CNRS) and at the Université Grenoble-Alpes (France)

remarks: "I like these results because they have provided a partial rigorous verification of a phenomenon that has in fact also been observed in numerical experiments and in physics thanks to analytical tools". This research work was published in the prestigious New York University Courant Institute of Mathematical Sciences journal *Communications on Pure and Applied Mathematics.*

In addition to her research work, Miot is also deputy director of Mathdoc. This platform is a documentary centre belonging to the CNRS and the University of Grenoble that provides different resources: Numdam, a digital mathematical library; Portail Math, a portal providing access to mathematical calendars as well as home directories and databases of French Institutions, among others, and Ceadram, a platform by which one may access French mathematical outreach journals. Furthermore, in 2018 they also launched Mersenne, an open access publication platform of which Miot is one of the collaborators.

Additionally, she is assiduously involved in outreach activities, as she herself explains: "The best experience I've had has been in 'Mat' les vacances', a summer camp devoted to mathematics that is held in the Alps for high school students with learning difficulties. We combine math lessons with mountain bike sessions and hiking". She also often participates in gender equality activities, such as debates with other mathematicians or talks with young high school or PhD students, in which she speaks about her career and experiences.

SCIENTIFIC REVIEW: Resolution of non-local equations

Original title "On higher dimensional singularities for the fractional Yamabe problem: a non-local Mazzeo-Pacard program".
Authors: W. Ao, H. Chan, A. De la Torre, M. Fontelos, M. González, and J. Wei
Source: *Duke Math. J.* Volume 168, Number 17, 3297-3411
Date of publication: 2019
Link: https://projecteuclid.org/euclid.dmj/1572422464

Summary

The paper under review falls within the frontier between differential geometry and the analysis of partial differential equations. It consists of 115 pages and is devoted to the construction of *n*-dimensional singular manifolds with constant fractional (or non-local) curvature. This is a problem that arises in geometrical analysis, since a common method in the geometric classification of manifolds is the search for a manifold equivalent to that we wish to classify, with some type of constant curvature. We say "some type of curvature" because the curvature of the/a sphere is not the same as that of the/a hyperbolic space, which are two basic types of geometric modelling.

Non-local curvatures are defined according to the fractional Laplacian in the manifold, which is a non-local operator. From the point of view of analysis, a non-local operator is that which not only *sees* what is occurring in its immediate surroundings, but that which also takes into account interactions with distant points. The canonical example is the fractional Laplacian, an integro-differential operator that is defined for *s* in (0,1) as

$$(-\Delta)^s u(x) = \int_{\mathbb{R}^n} \frac{u(x) - u(y)}{|x-y|^{n-2\,s}}\, dy$$

In this formula one may observe that, in order to determine the value of the operator in *u*(*x*), it is necessary to know the value of *u*(y) for every *y* of R^*n*. The fractional Laplacian derives its name from the fact that for *s*=1, by a pass to the limit, the usual Laplacian operator is obtained:

$$\Delta u = \partial_{x_1 x_1} u + \cdots + \partial_{x_n x_n} u$$

The usual Laplacian Δ*u* is an operator that models elastic reactions; its value at a point seeks to average the value of the function in its immediate surroundings, therefore it is local. The fractional Laplacian has this same property, but it also averages distant points. It has many applications in physics, geometry probability and even financial mathematics – basically in any process in which this type of non-local effect is found. In particular, they are associated with the Lévy process, a type of stochastic phenomenon that generalizes the Brownian process but which allows abrupt jumps. Some physical examples include the Benjamin-Ono equation (which describes internal unidimensional deep-water waves) or the interaction of quantized electrons with the nucleus. It is also employed in other fields, such as financial models for the valuation of ecological and biological evolution that describe, for example, how a species adapts to its environment by means of genetic mutations.

With the fractional Laplacian, it is possible to formulate equations in which the solution depends only on one variable; for example, the radial coordinate. The resulting equation may be regarded as a non-local ordinary differential equation (ODE). However, while the usual ODEs can be resolved by studying their phase planes (that is, by looking for tangent trajectories at each point of the vector field generated by the equation), in the non-local case this is not possible because the trajectory at a point depends on what occurs very far away.

If the fractional Laplacian is known, from the geometric perspective one can define the non-local curvature of order s of a manifold of dimension *n,* for any *s* between 0 and *n*/2. It possesses many conformal properties (i.e., it preserves the angles) and provides a definition of general convexity. This notion of curvature comes from the study of the scattering theory in Einstein manifolds, which is originally based on work by John von Neumann, Roger Penrose and Claude R. Le Brunn in 4-dimensional gravitational physics, in connection with Juan Martín Maldacena's AdS/CFT correspondence. Thus, our curvature is deeply connected with the geometry of the Einstein equations.

Without entering into great detail, we will say that our new non-local curvature constitutes a uniparametric family of curvatures that interpolates the usual curvatures (for *s*=1, it is the known scalar curvature, for *s*=1/2 the mean curvature, and for *s*=2 the curvature associated with the Paneitz operator). Each one of these in turn provides different geometric and topological information about the manifold that helps in its classification.

As we stated at the outset, in the paper published in the *Duke Mathematical Journal* constant curvature manifolds with singularities are sought. For this construction, the classical "gluing" method is used; that is, a good singularity model is built and glued to the original manifold. In the local case, considered in the classical paper "A construction of singular solutions for a semilinear elliptic equation using asymptotic analysis". *J. Differential Geom*. 44 (1996), no. 2, 331–370], by Mazzeo-Pacard [R. Mazzeo, F. Pacard], the glued region is easy to control. However, this constitutes the first great difficulty in the non-local case, since the gluing process affects the whole manifold and may disrupt the geometry we are seeking.

The second major obstacle is the construction of the basic singularity model. One starts by looking for radial solutions that have a singularity exactly at the origin. And here we come up precisely against the resolution of a non-local ODE, as explained above. No existence, uniqueness or continuous dependency theorems of the initial conditions for these types of equations, which constitute a completely unexplored field. In the result we have obtained, the general theory for certain types of these equations is developed, including Frobenius' Theorem, which characterises the asymptotic development of the solution near the singular points; the study of a quantity with properties similar to the Wronskian of two linearly independent solutions to the homogeneous equation; or the construction of a Green function for the reconstruction of a particular solution to the non-homogeneous equation.

The innovatory idea in the demonstration is the characterization of a non-local ODE as a system of coupled second-order infinite dimensional equations. As a result, if one can manage to control this coupling, it is possible to use the classical ODE theory for a non-local problem.

In short, the fractional Laplacian (and generalization to other non-local operators) has many applications, although they are technically complex precisely because of this characteristic of non-locality, since the classical demonstrations no longer hold.

SCIENTIFIC REVIEW: Fourier series in BMO with number theoretical implications

Original title: "Fourier series in BMO with number theoretical implications".
Authors: Fernando Chamizo (Universidad Autónoma de Madrid e ICMAT), Antonio Córdoba (UAM-ICMAT) y Adrián Ubis (UAM)
Source: *Mathematische Annalen* volume 376, pages 457–473(2020)
Date of publication: July 31st, 2019

Summary

Our ears break down any sounds into pure tones and each tone corresponds to a certain frequency and intensity. Mathematically speaking, the sound is represented by a function, and the pure tones by sinusoidal waves whose size is known as amplitude and is related to its intensity. In this paper, the authors study functions that also oscillate and whose frequencies grow polynomially. This oscillation depends on how the corresponding amplitudes decay.

The BMO (Bounded Mean Oscillation) space contains the functions whose mean oscillation over any interval is bounded by a constant, which does not depend on the interval. The least of these constants would be its norm, which measures how much the function oscillates. Thus, any bounded function is found in this space, but it also contains non-bounded functions, such as the logarithm. In fact, Fritz John and Louis Nirenberg demonstrated that this is the maximum permitted growth; that is, any function in this space must have peaks that are at most logarithmic.

This space plays an important role in the field of analysis, because on certain occasions it is the natural substitute for bounded function spaces, which help to understand the behaviour of solutions to partial differential equations. On the basis of an inequality proposed by Godfrey Harold Hardy, it was known that if a function possesses as frequencies w, all the naturals are then in BMO when its amplitudes decay as w^{-1}. It was also known that the lacunary series (whose frequencies grow exponentially) are found in BMO if they are in L^1, and therefore in L^2, which is equivalent to the sum of the squares of the absolute values being finite.

The intermediate case, which includes series with frequencies that grow polynomially, was analyzed by William Tazwell Sledd and David Allan Stegenga from a result by Charles Fefferman that characterizes when a series is found in BMO. In order to prove this theorem, an inequality similar to those known as large sieve inequalities (much used in number theory) and two deep results on BMO are employed. The first result is that BMO is the dual space of the so-called Hardy space H^1, which are analytic functions $u(z)$ on the unit disk, such that the integrals of its absolute value in circles of radius less than one, centered on the origin, are uniformly bounded. The second result states that any function of H^1 on the edge of the disk may decompose into *atoms*, which are zero-mean functions that take non-null values only in one interval and are bounded by the inverse of the longitude of the said interval.

Now, Chamizo, Córdoba and Ubis essentially prove the same result, although their argument is elementary and their bound on the norm is more precise. In particular, they deduce that if the frequencies w grow as a polynomial of degree d, then the amplitudes must decay as $dw^{-1/d}$ in order for the function to be in BMO.

The difficulty of proving this statement resides in the fact that the function is typically much more chaotic than in the Hardy case, but unlike what occurs in lacunary series, its frequencies continue to interact. This new proof starts by decomposing the function into two parts; one with low frequencies and the other with high. This division depends on the interval in which the oscillation of the function is being analyzed. The low frequency part is a smooth function in the interval selected and therefore its oscillation is always small.

While the part with high frequencies is small, on average it is more irregular, so it is more difficult to control its mean oscillation. What is done in this case is to employ the well-known Cauchy inequality in order to evaluate the mean oscillation of the square of the function in the said interval. This is simpler because its Fourier series can be used to expand the square and average each term of the sum separately.

Consequently, the authors arrive at a bilinear oscillatory sum that it is necessary to bound. Here, they apply a large sieve type of inequality that converts this oscillation into decay. Perhaps the simplest way to understand this inequality is to return to the average of the square; it is possible to bound this by means of a smoothed average, and after expanding the series again, this smoothing will have converted the oscillation into decay.

In the second part of the paper, these researchers study the particular case of the function whose frequencies w traverse the squared integers and whose amplitudes are $w^{-1/2}$. From the previous result, the said function is in BMO, but now they are able to state much more about it. Given that its frequencies are just the squares, its behaviour is more arithmetical than that of a generic function space.

In fact, at rational points it has a special behaviour, and at any irrational its size is determined by the ease with which it can be approximated by rationals. On the basis of this information, it can be demonstrated that it is impossible to draw a graph of the said function, since it possesses an uncountable number of logarithmic peaks. Furthermore, the authors are able to estimate, in any interval, both the mean oscillation and its precise growth on the dominant logarithmic peak. Both quantities will depend on the rational with the least denominator in the interval. The greater the said denominator, the less the oscillation and growth the function will have in that zone.

TELL ME ABOUT YOUR THESIS: Ángela Capel Cuevas

Thesis title: "Quantum logarithmic Sobolev inequalities for quantum many-body systems: An approach via quasi-factorization of the relative entropy".
Author: Ángela Capel Cuevas
Supervisors: David Pérez-García (UCM) and Angelo Lucia (Caltech)
Date of defence: December 16th, 2019

Ángela Capel and Nuria Chamorro Díaz

Ángela Capel's thesis concerns quantum information theory and quantum many-body systems, two fields with many connections, at the intersection of which interesting problems arise. One such problem, which has become a major challenge in current research, is the design and development of a quantum computer. Despite the important progress made in this endeavour, certain significant obstacles need to be overcome before such a computer can be built. Mathematics plays a key role in understanding and tackling these problems; in particular, the study of certain phenomena known as *dissipative quantum evolutions*, a subject on which Ángela Capel and her thesis supervisors, David Pérez García and Angelo Lucia, have been working in recent years.

Dissipative quantum evolutions enable some types of noise in quantum many-body systems to be modelled. External noise is one of the main obstacles in the large-scale construction of quantum computers, and modelling is required in order to control or eliminate such noise.

A further major hurdle to be overcome in the building of a quantum computer is the design of lifetime quantum memory. In 2009, a (theoretical) proposal was made to use these same dissipative quantum systems to build robust quantum systems capable of preserving coherence over longer periods of time (the so-called dissipative quantum state engineering). This proposal is based on the dissipative nature of noise, which causes a dissipative quantum system always to converge towards a fixed stationary state that is independent of the initial state.

The study of how a dissipative quantum thermal evolution converges towards its state of thermal equilibrium (the thermalization problem) is one of the main current problems in this research field. In what does it consist? If we take an analogy from classical physics, it concerns the study of systems that behave like a cup of hot coffee in a room. After a certain period of time, the coffee gets cold and its temperature comes into equilibrium with the temperature in the room. The thermalization problem poses two important problems: What conditions must exist for thermalization to occur? And how quickly does it occur? Ángela Capel's thesis is focused on this latter question.

The *speed of thermalization* can be studied on the basis of the time it takes for the system in dissipative evolution to pass from its initial state to another state that is almost indistinguishable from the state of thermal equilibrium (the so-called mixing time). In particular, physical systems for which convergence is sufficiently quick are especially interesting. This property is known as rapid mixing and has numerous implications in quantum information theory, since systems with rapid mixing are stable against external perturbations.

Different values that delimit the mixing time are sought in order to identify systems that possess this property. These bounds are obtained on the basis of optimal constants for certain quantum functional inequalities, such as the spectral gap for Poincaré's inequality and the log-Sobolev constant for logarithmic Sobolev inequality. Capel addresses the latter constant in her thesis, because when the log-Sobolev constant is positive the mixing time of a dissipative evolution is sufficiently short; that is, its convergence is exponentially faster in relation to the size of the system than in the case of the spectral gap.

Image: ICMAT

Angela Capel with the court of her thesis, read last December

In this regard, the main objective of her thesis is to provide sufficient conditions at the point of equilibrium of a dissipative quantum evolution in order to affirm that the system has a positive log-Sobolev constant. This, in turn, provides conditions under which a system satisfies rapid mixing. Thus, the authors provide static conditions at the point of equilibrium that imply a dynamic property of dissipative evolution; in other words, something that does not depend on time is capable of implying something that is time-dependent.

To that end, the first step was to design a strategy to prove that a quantum system possesses a positive log-Sobolev constant, based on the results previously obtained for the analogous classical case. A positive log-Sobolev constant is indeed obtained in the classical case, as was shown by using a three-step strategy, on the assumption of mixing conditions and proving results of the quasi-factorization for the entropy. This led them to the development of an approach similar to that employed in the quantum case, based on the results of the quasi-factorization for the relative entropy. This method consists of five steps, three of which constitute quantum versions of the three points of the classical case, with the addition of two new steps thanks to the definition of new concepts.

Once the strategy had been completely defined, they applied it to the concrete case of two previously studied dynamics, for which positive results from the spectral gap had already been obtained: the heat-bath dynamics and the Davies' dynamics. The results obtained thereby defined in what equilibrium conditions it was necessary to implant these systems in order for the log-Sobolev constant to be positive, and thus for convergence to equilibrium to be rapid.

These results constitute the initial non-trivial conditions on the state of thermal equilibrium of a quantum system for which the log-Sobolev constant is positive, and therefore the existence of rapid convergence. Consequently, a new field of study is opened up, with many possible applications as well as numerous open questions, which constitute the main lines of investigation that Ángela Capel is pursuing in her postdoctoral research at the Technical University of Munich and the Munich Center for Quantum Science and Technology. In particular, she is seeking specific examples of physical systems that verify these conditions, as well as working on the study and improvement of the speed of convergence of algorithms and the estimation of the noise that appears in a quantum circuit.

Institutional

For the third time running, the ICMAT receives accreditation as a "Severo Ochoa" centre of excellence

On July 15th, the Agencia Estatal de Investigación (AEI – State Research Agency), part of the Spanish Ministry of Science and Innovation, published the provisional resolution proposal of the 2019 call for the "Severo Ochoa" and "María de Maeztu Units of Excellence" accreditations and public funding. The ICMAT is one of the ten "Severo Ochoa" centres of excellence, which confirms its position as one of the leading Spanish research Institutes that, in the words of the Ministry of Science and Innovation, "are among the best in the world in their respective scientific fields".

The accreditation includes funding of four million euros for a programme of institutional consolidation over the next four years, to which are added 14 postdoctoral contracts. According to the Institute, this "will enable various scientific projects to be undertaken that will help the ICMAT to maintain its standing as one of the leading international research centres in mathematics".

The ICMAT initially obtained this distinction in the first call for the scheme in 2011, which was renewed in 2015, and thus the accreditation awarded as a result of the 2019 call constitutes the third consecutive renewal for the Institute. The calls are issued on a competitive basis, and in 2019 fifty-five funding applications were made for these "Severo Ochoa" and "María de Maeztu" Centres and Units of Excellence, which according to the Ministry have been evaluated "independently by an international scientific committee consisting of researchers of recognized prestige and impact".

In this latest call, and in addition to the ICMAT, the following Spanish institutes have received the "Severo Ochoa" distinction of excellence: The National Centre for Oncological Research (CNIO), the Institute of Photonic Sciences (ICFO), the Institute of Biomedical Research (IRB), the Barcelona Graduate School of Economics (BGSE), the Canary Islands Institute of Astrophysics (IAC), the Centre for Research in Agricultural Genomics (CRAG), the Barcelona Institute of Materials Science (ICMAB), the Catalan Institute of Chemical Research(ICIQ), and last bit not least the Institute of Marine Sciences (ICM), which joins the programme for the first time.

To this list must be added the six "María de Maeztu" units of excellence: the IMDEA Energy Institute, the University of Córdoba Agronomy Department and the Catalan Institute of Human Paleoecology and Social Evolution, accepted for the first time in the programme, and the University of Valencia Institute of Molecular Science (ICMol), the Autonomous University of Barcelona Institute of Technology and Environmental Sciences (ITCA), and the Barcelona Central University Institute of Cosmos Sciences (ICC).

The purpose of the "Severo Ochoa" Centres of Excellence and the "María Maeztu" Units of Excellence awards is to fund and accredit research centres and units in any scientific field, which demonstrate their scientific impact and leadership at an international level and collaborate actively with social and business sectors.

For further information:

News and the Ministry of Science and Innovation proposal of provisional resolution.

Image: Spanish Ministry of Science and Innovation

The ICMAT receives the third accreditation as a "Severo Ochoa" centre of excellence

The ICMAT to collaborate in the third edition of the STEM MatEsElla leadership programme

The third edition of the *MatEsella* programme for boosting the careers of young women doing degree and master courses in STEM disciplines (science, technology, engineering and mathematics) will get under way in the third trimester of the current year, 2020. On this occasion, the ICMAT will be collaborating with the project, a joint initiative by the Royal Spanish Mathematical Society (RSME) and EJECON (Asociación de Ejecutivas y Consejeras).

A new Steering Committee has been named to direct this new edition, as well as for the closing event of the previous edition (concluded in 2019), and is composed of members belonging to EJECON and the RSME, and, on behalf of the ICMAT, Ana Bravo, tenured lecturer at the UAM and head of the Institute's Gender Commission, together with Eva Gallardo, vice-president of the RSME and deputy director of the ICMAT, and Ágata Timón G. Longoria, in charge of communication and outreach at the centre.

Image: free

ICMAT will collaborate in the STEM MatEsElla leadership program, together with RSME and EJECON

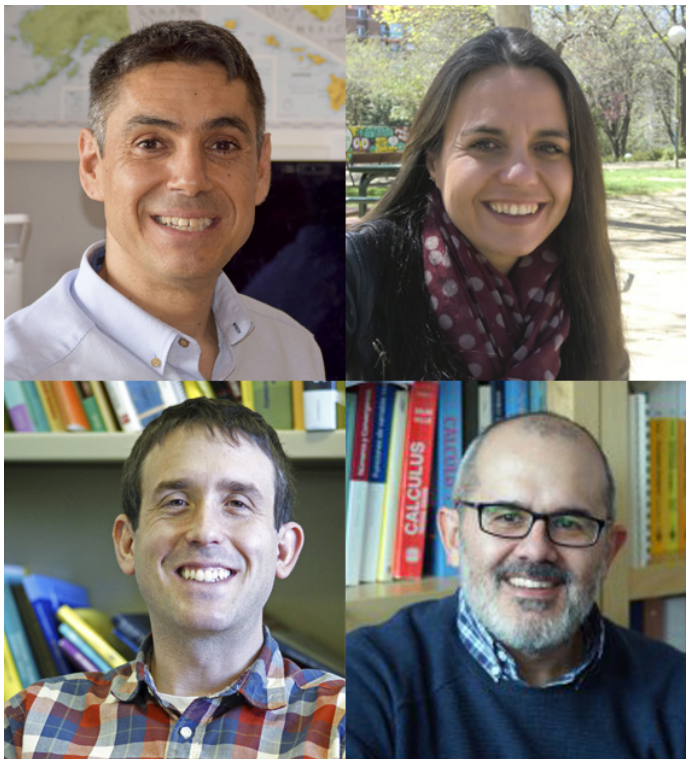
José María Martell, new director of the ICMAT

The ICMAT has a new executive team, headed by José María Martell, a scientific researcher belonging to the CSIC who was awarded a Consolidator Grant by the ERC European Research Council) in 2013. His research fields are harmonic analysis, partial differential equations and geometric measure theory.

The team itself consists of Eva Gallardo, tenured lecturer and vice-dean of Research at the Complutense University of Madrid Faculty of Mathematics, and vice-president of the RSME (Real Sociedad Matemática Española). She is joined on the board by Javier Aramayona, CSIC researcher at the ICMAT, and by Fernando Quirós, tenured lecturer at the UAM and also an ICMAT member, each of whom is head of the Departments of Fundamental and Applied Mathematics, respectively. Furthermore, the new ICMAT External Scientific Committee was set up in late 2019, consisting of eight mathematicians of international prestige.

The main objective of this new committee is to promote the science of excellence undertaken and the Institute, and its role is to energize mathematical research at a national level. In addition, one of its goals is to extend mathematics beyond the academic sphere by means of collaboration with researchers from other fields and with companies, as well as in a cultural context, among others. A further aim is to highlight the work of women mathematicians and to establish mechanisms for narrowing the gender gap at the ICMAT as well as in the sphere of mathematical research.

Image: ICMAT



New ICMAT management team. From left to right and top to bottom, José María Martell, Eva Gallardo, Javier Aramayona and Fernando Quirós

More than 2,000 people ask for Mathematics to be a compulsory subject in Baccalaureate courses

A request by than 2,000 individuals, among whom are Spanish researchers and representatives of different institutions, have stated in a manifesto their opposition to the withdrawal of Mathematics as a compulsory subject from Baccalaureate courses, as proposed in a new Education Draft Law (which would modify the Organic Law of 2/2006) announced by Isabel Celaá, the Spanish Minster for Education and Professional Training.

The manifesto was signed by members of the executive boards of more than 130 research centres and other scientific societies, such as the Spanish Confederation of Scientific Societies (COSCE) and the Royal Academy of Sciences, as well as the Severo Ochoa-María de Maetzu alliance and some twenty winners of the National Prize for Research. This manifesto is still open to the public for further signatures on a web form.

A few days after the manifesto appeared, a meeting was held with the education minister and representatives of the Spanish mathematical and scientific community, during which they agreed to work together to draw up new curricula and plans for teaching-training.

Awards

María Ángeles García Ferrero, chosen as the best young Spanish mathematician 2019

The Royal Spanish Mathematical Society (RSME) and the BBVA Foundation awarded the José Luis Rubio de Francia Prize for 2019 to María Ángeles García Ferrero, a postdoctoral researcher at the University of Heidelberg Institute of Applied Mathematics (Germany). García Ferrero completed her doctorate at the ICMAT under the supervision of Alberto Enciso in the field of partial differential equations; specifically, on the heat equation. The jury made special mention of her ability "to prove something really new and general on such a simple and classical object as the heat equation".

This researcher, who had already in 2019 been awarded in 2019 one of the RSME-FBBVA Vicent Caselles Prizes, is only the second woman to have won the José Luis Rubio de Francia Prize since 2004, after María Pe Pereira, also a former ICMAT PhD researcher at the ICMAT, who won this prize in 2012.

This prize is awarded as a distinction for work "that recognizes and stimulates scientific endeavour and contributions in the field of mathematics" by researchers of both sexes under the age of 32, including Spanish scientists and those who have undertaken their work in Spain. It is endowed with a cash prize of 3,000 euros and also includes a BBVA Foundation Start-up grant worth 35,000 euros to enable the winner to pursue research work over a period of three years.

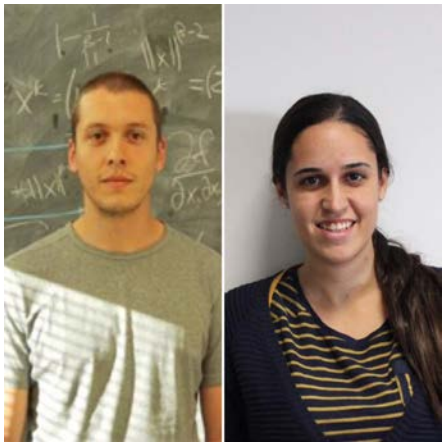
Image: María Ángeles García Ferrero

María Ángeles García Ferrero is only the second woman to have won the José Luis Rubio de Francia Prize (RSME-Fundación BBVA) since 2004

Jezabel Curbelo Hernández and Rafael Granero Belinchón receive the SeMa Antonio Valle Prize for young researchers in the field of applied mathematics

Every year, the Spanish Society of Applied Mathematics (SeMA) awards its Antonio Valle Prize to young researchers in recognition of their work in the field of applied mathematics. This year, and for the first time in the 22 years of its history, two researchers were awarded the prize *ex-aequo*: Jezabel Curbelo Hernández and Rafael Granero Belinchón. Both researchers completed their doctoral theses at the ICMAT: Curbelo –assistant lecturer doctor at the Autonomous University of Madrid and a member of the ICMAT – in 2014 under the supervision of Ana María Mancho (CSIC-ICMAT), and Granero – assistant lecturer doctor at the University of Cantabria – in 2013 under the supervision of Diego Córdoba (CSIC-ICMAT) and Rafael Orive-Illera (UAM-ICMAT). In addition, both of these mathematicians have also been distinguished with Vicent Caselles prizes awarded by the Royal Spanish Mathematical Society and the BBVA Foundation.

Images: UC and ICMAT



Rafael Granero Belinchón and Jezabel Curbelo, SeMa Antonio Valle Prize winners

Diego Alonso Orán, one of the winners of the RSME and BBVA Foundation Vicent Caselles Prizes

Diego Alonso Orán, a postdoctoral researcher at the University of Bonn Institute for Applied Mathematics, with an Alexander von Humboldt grant, is one of the six Vicent Caselles prize-winners announced this year by the Royal Spanish Mathematical Society (RSME) and the BBVA Foundation. Before taking up his post at this prestigious European university, Alonso was a postdoctoral researcher at the ICMAT, where he completed his thesis under the supervision of Antonio Córdoba (ICMAT-UAM). Alonso's work is focused on the study of equations and models coming from geophysics and fluid dynamics, such as the surface quasi-geostrophic equation. He has also made contributions in the field of stochastic partial differential equations.

The other winners of this award are Alessandro Audrito (University of Zürich); Rubén Campoy García (University of Massachusetts-Laval, USA); María Cumplido Cabello (Heriot-Watt University, Edinburgh); Ujué Etayo (Institute of Analysis and Number Theory in Graz, Austria) and Judit Muñoz Matute (BCAM).

Image: ICMAT

Diego Alonso Orán

Results

Algorithms to protect self-driving cars against hoaxes and to detect fake news

Many applications these days are based on the ability of computers to think for themselves. However, this process can lead to errors and even to hidden biases, especially if data are deliberately introduced to mislead the machine. As the director of the ICMAT AXA Chair of Adversarial Risk Analysis, David Ríos explains: "Self-learning algorithms may be subject to malicious attacks that jeopardize their operation by confounding them with data they are unable to recognize". Ríos is the principle researcher in a new project dealing with Adversarial Machine Learning that has been chosen in the 2019 call for funding issued by the BBVA Foundation to Scientific Research Teams in the field of Big Data.

The aim of this research work is to forestall situations such as that caused by a team of scientists who designed a type of printed fabric that prevented a self-driving car from recognizing people who wore it and was therefore unable to brake or stop. A further example that was the object of greater media interest was that of an artist who devised a supermarket trolley full of mobile phones that Google Maps mistakenly identified as a large traffic jam in a deserted street.

This new project aims to tackle these dangers by developing new robust and reliable algorithms capable of preventing such attacks using an alternative approach. With Ríos at its head, the research group, which includes 18 mathematicians and IT specialists from a dozen Spanish, North American, Italian and Chinese institutions, will study several different scenarios. One of them, how to protect autonomous vehicle algorithms against attacks such as those described above. "We'll also be working on the detection of malware and fake news", adds Ríos.

Image: ICMAT

ICMAT researcher David Ríos is the principal investigator of the adversary machine learning project selected by the BBVA Foundation

The ICMAT awarded two Marie Curie grants

The purpose of the Marie Curie grants is to promote the mobility of men and women researchers throughout Europe. Funding for projects of this nature are awarded jointly to the receiving institution and to the researcher. In the last call for applications for such funding, the ICMAT was successful in obtaining two of these grants for projects in two fields of mathematics: algebraic geometry and Hamiltonian dynamics.

First, Amna Shaddad, a graduate from Imperial College London who completed her doctorate at the University of Manchester. She will undertake a project concerning Hamiltonian dynamics with applications to problems in engineering; in particular, the movement of vehicles and robotics. She will study the momentum application, "an extension of the concepts of linear and angular momentum from classical mechanics to Hamiltonian systems that possess symmetries", explains Manuel de León, ICMAT researcher and tutor for Shaddad's project.

In the case of researcher Alberto Navarro Garmendia, a graduate from the Complutense University of Madrid who completed his PhD at the same university, he will study problems in the theory of motives, a relatively modern concept consisting in the study of the shape of objects by means of algebraic and arithmetic geometry. "This is a theoretical framework that remains largely unproven", explains José Ignacio Burgos, an ICMAT member who will be supervising Navarro's work. "However," he goes on to say, "it has already yielded significant results, such as those from the work by Vladímir Voevodsky in the 1990s, which earned him a Fields Medal in 2002". Within the field of the theory of motives, Navarro will be working on the Riemann-Roch theorem and its entire variants.

Scientific activities

Expert in number theory, Samir Siksek (University of Warwick), gives a UAM-ICMAT colloquium

Samir Siksek (University of Warwick, UK), an expert in number theory, held a UAM-ICMAT colloquium at the Autonomous University of Madrid on February 7th this year. His talk, entitled "Which numbers are sums of seven cubes?", was devoted to the solving of the Waring/Jacobi problem.

In 1770, the English mathematician Edward Waring conjectured that every natural number is the sum of not more than nine cubes (but may be fewer than nine), and can be written as 19 fourth powers. In general, Waring's problem establishes that, given a natural number k, it is possible to write every natural number as the sum of at most s natural number to the power of k (where s depends on k). The problem was solved affirmatively by David Hilbert in 1909. Nevertheless, Hilbert provided not a constructive but a theoretical proof. Sisek recently proved this conjecture and presented his proof at the colloquium.

Image: Samir Siksek

Samir Siksek gave the UAM-ICMAT colloquium "Which numbers are sums of seven cubes?"

International experts on financial mathematics debate crisis management

The ICMAT, together with the UAM and the National University of Distance Education, hosted the online conference "Virtual Workshop on Financial Mathematics and Stochastic Analysis" on June 22nd and 23rd this year.

Among the participants was Austrian Stephan Sturm (Worcester Polytechnic Institute, USA), an expert in evaluation methods for financial derivatives in markets where periods of crisis exist. For her part, Isabel Figuerola-Ferreti (Pontifical Comillas University) spoke about credit risk in the energy sector with a focus on oil prices. The programe of talks concluded with interventions from Tomoyuki Ichiba (Department of Statistics and Applied Probability, and Center for Financial Mathematics and Actuarial Research at the College of Creative Studies, University of California, Santa Barbara, USA) and from Ionannis Paraskevopoulos (Bankia).

According to Mauricio Elizalde, a predoctoral researcher at the UAM and co-organizer of the event with Carlos Escudero (UNED), "the main challenge in this research field is to make the models and the hypotheses flexible in order to adapt them to changing situations".

Enrollment open to the ICMAT JAE School of introduction to mathematical research

Enrollment to the 2020 JAE School of Mathematics, organized by the ICMAT, is now open and can be accessed via the website devoted to this activity. Attendance at the school is available either by direct physical presence or, should the current health situation prevent it, online, and will as usual provide final-year degree and master students with initiation into mathematical research and its applications.

Over a two-week period, between September 1st and 11th, sessions will be held to address subjects of interest in current research, but which are usually left out of degree curricula. Furthermore, the students enrolled in the school will have the opportunity to interact directly with first-rank men and women researchers.

Image: ICMAT

JAE School 2018

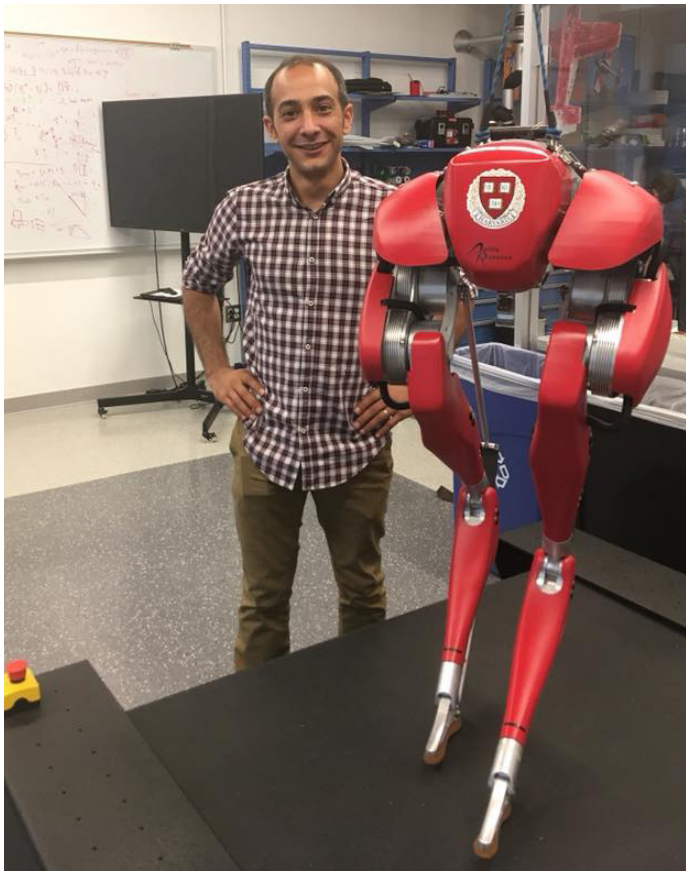
Outreach

ICMAT researcher Leonardo Colombo participates in the "We're scientists. Get us out of here!" competition

Students from more than 50 schools had the opportunity to get to know at first hand the work of researchers in different fields. By means of a chat, they asked questions of the more than 30 male and female scientists taking part in "We're scientists. Get us out of here!", which was held on virtual media between May 4th-15th. One of the scientists participating in the competition was the ICMAT member Leonardo Colombo, who currently heads a La Caixa Foundation Junior Leader Project for the coordination of drone teams.

This researcher spoke to the students about his work with drones, devices that are becoming increasingly familiar to many people although few understand how they really function. Among other things, mathematics enables drones to remain stable, soar smoothly through the air, obey the instructions issued by their controllers, and distribute power through their motors so they can fly. In his talk about these features, Colombo demonstrated the interdisciplinary research aspects of the project undertaken at the ICMAT.

Image: Leonardo Colombo



Leonardo Colombo is a postdoctoral researcher at ICMAT, where he directs a Junior Leader project of the Fundación la Caixa

June 28th, LGTBIQ+ Pride International Day

The ICMAT Gender Commission, together with CSIC Institutes on the Cantoblanco Campus, came together on June 28th to celebrate the LGTBIQ+ Pride International Day, which was held to call, in different media, for diversity and inclusivity in mathematics. The ICMAT published a news report on the event in which the role of various men and women researchers belonging to the LGTBIQ+ collective featured prominently.

Live broadcasts on Instagram of meetings held to discuss university education in mathematics

In June of this year, the ICMAT organized a series of meetings via its Instagram profile with young researchers of both sexes who shared their experiences with students of mathematics. The series began on Wednesday, June 24th, with Patricia Contreras Tejada (UCM-ICMAT), who was introduced by Laura Moreno Iraola (ICMAT); on Thursday, June 25th, it was the turn of Emilio Franco (University of Lisbon, Portugal), who was interviewed by Ágata Timón (ICMAT); and he was followed on Friday, June 26th, by Álvaro del Pino (University of Utrecht, Holland), who spoke with David Martín de Diego (ICMAT).

These live sessions enjoyed a large number of followers who were able to ask questions and make their own comments. The videos are available on the ICMAT (@icmat_) Instagram profile.

Mathematical education, a first-order challenge

On July 2nd of this year, the ICMAT organized a meeting called "The future of mathematical education", in which the heads of the Royal Spanish Mathematical Society (RSME) and the Spanish Federation of Societies of Maths Teachers (FESPM), Francisco Marcellán and Onofre Monzó, respectively, took part. According to Marcellán, president of the RSME and a professor at the Madrid University of Carlos III, "mathematical education, not only in schools but also at the heart of society at large, is a challenge of the very first order".

"Maths in the educational system, from primary school to university level, presents many and varied challenges that have dragged on for years and have to do with the curriculum and the methodology, as well as with changes in society – which are outstripping changes introduced in educational practice – not to mention globalization and the impact of technology, among other things", adds Monzó, chairperson of the FESPM and a professor of Mathematics in Secondary Education.

One of the interventions in the debate, which was moderated by ICMAT director José María Martell, came from Javier Aramayona (ICMAT), who summed up the issues addressed in the discussion. A video of the meeting, which was attended by 130 people who participated actively in the chat set up in the broadcast, is available on the ICMAT YouTube channel.

Images: RSME and Onofre Monzó

Francisco Marcellán and Onofre Monzó took part in the "The future of mathematical education" debate

Start of the new season of the outreach series "Mathematical Revolutions"

Mathematical Revolutions is a cartoon series about the key events and personalities in the history of mathematics that have brought about paradigm shifts with significant consequences for society at large. In this second season, the project is included in "Science City", a scientific outreach programme in a local setting coordinated by the CSIC (Consejo Superior de Investigaciones Científicas) and the FECYT (Fundación Española para la Ciencia y la Tecnología).

This new season consists of four episodes, each lasting approximately two minutes and featuring Emmy Noether, Leonhard Euler, Ada Lovelace and Henri Poincaré. They are available on the ICMAT YouTube channel and produced by the Institute, together with Divermates.

In addition, as a complement to each episode, a recreational mathematical workshop is available in which some of the concepts addressed in the series are explored in greater depth. The target audience consists of teachers and students of mathematics, with the aim of stimulating them to see the discipline through different eyes.

The style of the series has been modified in this season by the use of a collage-type animation designed by the Beyond production company.

Image: Beyond

Protagonists of the second season of Revolutions Mathematics

The ICMAT joins the activities for February 11th, 2020 International Day of Women and Girls in Science

On the occasion of the 2020 International Day of Women and Girls in Science, held on February 11th, the ICMAT hosted the workshop-talk "Women Mathematicians" given by Ana Bravo (lecturer at the UAM, member of the ICMAT and chairperson of the ICMAT Gender Commission). The work done by women mathematicians in the fields of arithmetic and geometry was presented during this event, which was attended by 30 4th-grade students from the *Juan de Herrera de San Lorenzo del Escorial* (Madrid) secondary school.

In addition, and together with other CSIC centres on the Cantoblanco Campus, the ICMAT participated in the Escape Road: "In search of Nobel and non-Nobel women scientist prize-winners", held at the Biology and Science Faculties between February 3rd and 14th.

Image: ICMAT

Ana Bravo gave the workshop "Women mathematics"

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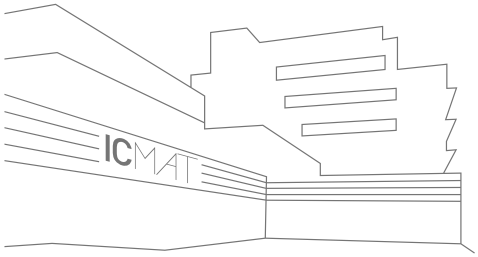

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