ICMAT
INSTITUTO DE CIENCIAS MATEMÁTICAS

Quarterly Newsletter
Second Quarter 2017
CSIC - UAM - UC3M - UCM

EDITORIAL

*What are the heads of the best European mathematical research centres discussing?*

# Impressions from the ERCOM meeting

***Antonio Córdoba*** *(ICMAT-UAM).* On April 28th and 29th of this year, as the representative of the ICMAT I attended the annual meeting of the ERCOM (European Research Centres on Mathematics) group, held at the university headquarters of the RICAM (Johann Radon Institute for Computation and Applied Mathematics), located in the Austrian city of Linz. The ERCOM acts as an advisory forum of the European Mathematical Society (EMS) in which experiences are shared and proposals are made and where the directors and managers of 26 renowned European Institutes participate. Some of these Institutes are as follows: the Institut Mittag-Leffler (Djursholm, Sweden); the Euler International Mathematical Institute (St. Petersburg, Russia); the Max-Planck-Institut (Bonn and Lepzig, Germany); the Weierstrass Institute (Berlin, Germany); the Isaac Newton Institute (Cambridge, United Kingdom); the Alfréd Rényi Institute (Budapest, Hungary); the Insitut des Hautes Études (Bures-sur-Yvette, France); the Centro di Ricerca Ennio De Giorgi (Pisa, Italy). In addition to the ICMAT, two other Spanish centres, the BCAM (Bilbao) and the CRM (Barcelona), belong to this group.

The busy agenda included a brief report delivered by each of the heads who attended, consisting of a ten-minute summary and five minutes for questions and clarifications. The financial crisis, the reemergence of nationalist movements, "rampant political corruption", and problems arising from Brexit were recurrent themes in many of the talks. In the case of the ICMAT, we were asked about the conditions of the Severo Ochoa project and about the benefits of our bibliographic resources, as well as those of the RSME, which are expected to be deposited soon in our library and are likely to be digitized as part of the project led by the EMS.

An important point under discussion was the role played by the ERCOM centres in the implementation of the means for promoting equal opportunities for women (IMU Committee for Women in Mathematics). Curiously, I was able to verify that the figures from the ICMAT on this issue were among the best of those presented, although they remain very one-sided as far as female researchers are concerned and still leave room for improvement. The future of publications was also discussed, and complaints were made about the misuse of the bibliometric indicators for the evaluation of mathematicians. However, on this latter subject, as in the former, no statement containing precise recommendations for the EMS was drawn up.

Image: ICMAT

Antonio Córdoba.

## CONTENTS

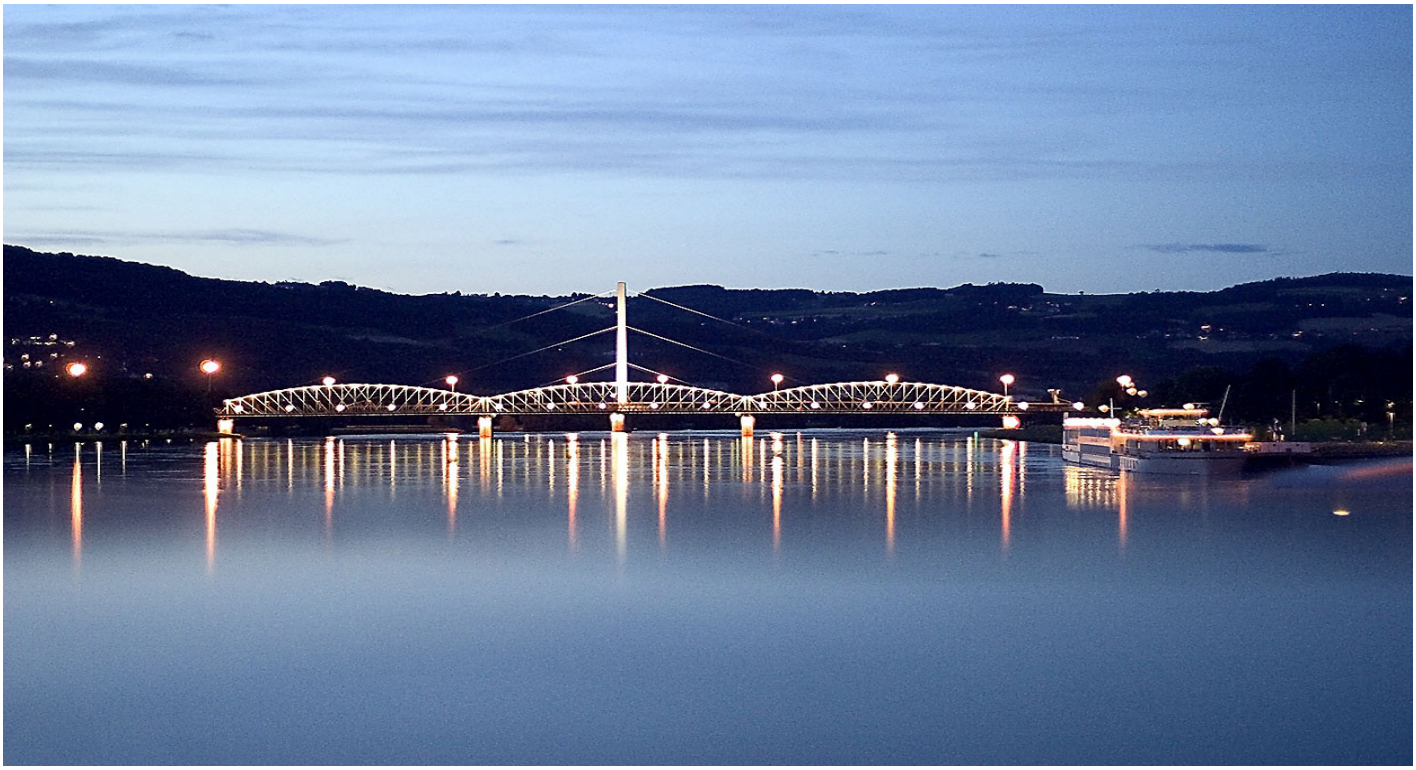
The European Research Council (ERC) was represented by its director, Jean Pierre Bourguignon, who informed us about the forecasts for the immediate future, in which it appears that no budget increase is foreseen, while as far as the ERC Advanced Grants are concerned, the opposite is likely to occur. Nevertheless, optimism was expressed about the consolidation of the programme, and we were urged to impress upon the political representatives in our respective countries the importance of scientific research for the ongoing construction of Europe.

The ERC Starting and Consolidator programme has proved crucial for our Institute, but the Advanced Grants are still far from being analogous with the National Science Foundation (USA) programme and still do not provide sufficient funding for research careers in Europe. A solution would be to subsidize all the projects of excellence, although perhaps not as generously as is done currently, with just a few selected projects. All the heads who attended the meeting agreed about the tedious nature of the present application process, which is more appropriate for experimental sciences, which require large investment in equipment and facilities, but which is far less suitable for mathematics, where the obligation to set out our future goals in every detail is rather strange and certainly counter-productive. Some of those who attended expressed their surprise at having been rejected with the excuse that their projects were "too ambitious", and that the decision was made by a commission whose chair is well-known for having repeatedly published versions of the same idea in an area over which he has control. These questions posed, as well as the suggestions made with regard to the ERC programme, were widely shared by all.

ERCOM is the European Mathematical Society committee and one of the most important bodies in the organization of European mathematics. In March 2016 the ICMAT became a member toghether with other excellence centres such as the Isaac Newton Institute for Mathematical Sciences, the Institut Henri Poincaré, the Max-Planck-Institut für Mathematik and the Basque Center for Applied Mathematics, among others.

In order to be a member of this network, among other requirements it is necessary to have an international scientific committee, a program for visits by high-level scientists, and a broad range of research lines in the field of mathematics. The purposes of ERCOM are: to constitute a forum for communications and exchange of information between the centres themselves and EMS; to foster collaboration and coordination between the centres themselves and EMS; to foster advanced research training on a European level; to advise the Executive Committee of the EMS on matters relating to activities of the centres; to contribute to the visibility of the EMS; and to cultivate contacts with similar research centres within and outside of Europe.

Image: Mwinog2777



The last ERCOM meeting took place in the Austrian city of Linz.

INTERVIEW: Leonid Polterovich, researcher as the University of Tel Aviv and an ERC Advanced Grant holder

# "I used to do mathematics under my desk during office hours"

Image: ICMAT

Leonid Polterovich at the ICMAT.

**Leonid Polterovich is smiling and affable. Despite bringing a sheet of paper to our interview filled with all the replies to the questions we had sent him the night before (after expressly asking us for all the subjects of the conversation in advance so he could talk to us about "interesting things"), it wasn't long before he relaxed, left the sheet of paper on the table and began chatting humorously about his life and his career in mathematics. Trained in the Russian school of Vladímir Arnold and Yákov Sinai, Polterovich is a world expert on symplectic topology who since 2014 has been conducting an ERC Advanced Grant project at the University of Tel Aviv (Israel) on the interaction of his discipline with other areas of knowledge: from dynamics to quantum physics. A graduate from Moscow University, in order to finish his thesis he was obliged to move to Tel Aviv after years in which his research work in mathematics was confined to the free time he managed to find while working as a software engineer. Since then, he has been a professor at Tel Aviv University. A few months ago, he visited the ICMAT in order to attend the congress on Symplectic Techniques in Hamiltonian Dynamics, organized as part of the Viktor Ginzburg Distinguished Professor programme, and it was in this context that the interview was held.**

***Ágata A. Timón García-Longoria***

**The main topic that brought you to the ICMAT is the interaction between symplectic topology and dynamic systems. Could you explain this relationship for a general audience?**

Symplectic geometry and topology are rapidly developing fields of mathematics which originally appeared as a geometric tool for solving problems in classical mechanics. Mechanical systems (such as a pendulum, a satellite, or a particle in an accelerator) can be described by a system of ordinary differential equations which, roughly speaking, generalizes Newton's second law, which we learned in high school: mass x acceleration = force. The trouble is that in most cases these equations do not admit explicit solutions, and thus a qualitative analysis is needed. At this point symplectic geometry enters the game.

**What does symplectic geometry enable us to do?**

Geometric methods lead to progress, for example, in detecting chaotic behaviour in deterministic systems; for studying surprising links between classical and quantum mechanics, a subject that has tantalized me in recent years, and for finding optimal ways of realizing a given mechanical motion, which requires the lowest possible amount of energy. To understand the difficulty of this problem, just imagine that you are standing at the foot of a hill and you want to find the shortest route to get to a point on the other side. The usual Euclidian intuition might not be too helpful; following a straight line would mean you had climb to the top of the hill. So even in this simple example you need delicate geometric methods in order to calculate the optimal route.

**How is it done?**

It's closely related to one of my favourite geometric objects: the space of all the possible motions of a given mechanical system. Two and a half decades ago, Helmut Hofer (Institute for Advanced Studies, Princeton, USA) discovered a natural way of performing geometric measurements on this space (that is, measuring lengths of curves and distances between points). This infinite-dimensional unbounded space exhibits a number of paradoxical features: for instance, it is flat on small scales, but these straight lines may be locked forever in a bounded part of the space. This space is very complex and poses many interesting challenges. Revealing its structure is an intriguiging research problem. Any progress in this direction contributes to our understanding of classical mechanics. For example, the problem of finding the most economical way of performing a given mechanical motion consists in finding the shortest path between two points in Hofer's space.

**What are the next big challenges in this field?**

Ever since symplectic topology reached its phase of maturity, unlike in its heroic youth in the early 1990s, interaction with other branches of mathematics and mathematical physics has been vital for its prosperity. We've witnessed several successful examples of this type of interaction, such as in dynamical systems, algebraic geometry and geometric group theory. I hope that the scope and depth of this interaction will increase in the future.

**How did you arrive at this field?**

In 1984, my friend Misha Bialy (who's now my colleague in Tel Aviv) and I started to work under the supervision of Yakov Sinai (Abel Prize winer and professor at Princeton University, USA) on transitions to chaos in geodesic flows on two-dimensional tori, a version of the Aubry-Mather theory. In this way we naturally arrived at the following problem: how to generalize Birkhoff's second theorem, which states that a non-contractible invariant curve of a twist map on a cylinder is necessarily a graph, to systems with higher degrees of freedom. At that point it became clear to us that symplectic methods were indispensable for that task. We were fortunate that symplectic topology was one of the favourite topics of [Vladimir] Arnold's seminar. Moreover, the seminal work by [Mikhail] Gromov (New York University, USA.) on pseudo-holomorphic curves had just appeared in 1985, and Sasha Givental opened a seminar on this subject (by the way, Viktor Ginzburg, ICMAT Distinguished Professor, also participated in this seminar). That's how it started.

"My mathematics high school was a rare island of freedom in the totalitarian Soviet Union"

**What are you working on at the moment?**

Right now my favourite topics include applications of persistence modules (a beautiful subject originating in topological data analysis) to symplectic topology, with Egor Shelukhin (Institute for Advanced Studies, Princeton, USA); exploring footprints of symplectic rigidity in quantum mechanics, with Laurent Charles (Institut de Mathématiques de Jussieu, Paris, France); and symplectic approaches to instabilities in Hamiltonian dynamics, with Michael Entov (Technion, Israel Institute of Technology).

**Your work was recognized with an ERC Advanced Grant. Could you tell us about the project funded by this grant?**

The project is called "Symplectic topology and its interactions: from dynamics to quantization". One of the aspects we're working on is the interaction between symplectic topology and quantum mechanics. This interaction goes in both directions. On the one hand, some ideas from quantum mechanics give rise to new concepts and structures in the area of sympletics. For example, the origins of quasi-symplectic states go back to quantum indeterminism; more precisely, to Gleason's theorem that establishes the existence of hidden variables in quantum mechanics. Furthermore, insights into quantum mechanics led to very useful symplectic predictions where topological intuition fails, such as the lower bound for Poisson bracket invariants of open covers. On the other hand, some phenomena discovered within symplectic topology admit a meaningful translation into the language of quantum mechanics, thus revealing quantum footprints of symplectic rigidity; for instance, the noise-localization uncertainty relation for phase space localization of a quantum particle.

**It seems like a project of a highly interdisciplinary nature?**

Yes, this topic alone brings together three disciplines: "hard" symplectic topology, quantum mechanics and quantization, providing a bridge between the classical and quantum worlds.

"In my ERC project we are studying the interaction between symplectic topology and quantum mechanics"

**Now you are a mathematician of international prestige, but did you imagine such a thing when you were a child? Did you always want to devote yourself to mathematics?**

The truth is I didn't have much choice. I come from a family of mathematicians. My father trained me from childhood, very skillfully as I see now, so my talents were just a little above the average. Additionally, since 6th grade I studied in one of the best mathematical high schools in Moscow.

**Why were you sent to a high school specializing in mathematics?**

First of all, my parents sent me there because it provided a first class education. Secondly, that high school was a rare island of freedom in the totalitarian Soviet Union. As a result, after my graduation, mathematics was my only skill.

**What was the life of a mathematician like in the USSR?**

Quite hectic; on the one hand, as a Jew I was not accepted on the PhD programme at my alma mater and I had to work as a software engineer. I used to do mathematics under my desk during office hours or at home at night. On top of this, I got married during my last year at university and my first daughter was born in 1987, so I had family obligations to fulfill. I owe my mathematical career to my teachers, Yakov Sinai and Vladimir Arnold, who spent a lot of time supervising my work and very generously shared their ideas with me, and also to Kostya Khanin (University of Toronto, Canada) and Sasha Givental, who entertained me by running seminars on dynamical systems and symplectic topology, respectively, and helped me to digest these ideas. I am also indebted to my parents, who supported me morally and financially, and to my wife as well, who patiently tolerated my messy lifestyle caused by my mathematical adventures.

**Lastly, when did you decide to move to Tel Aviv?**

I always wanted to emigrate from Russia, where my future was grim. There was no chance to defend my PhD in Moscow. What's more, I had deep feelings for Israel, since my main hobby was studying Hebrew. Sinai referred me to Vitali Milman (University of Tel Aviv, Israel), who took care of me and became one of my closest colleagues. Milman's help was crucial for my mathematical career in Israel. In particular, he convinced the TAU authorities to take into account for my thesis several articles I'd published at that time, so I only had to spend about half a year on my PhD programme, writing an introduction for that collection of articles. Sinai and Milman were my formal thesis supervisors.

REPORT: The ICMAT organizes the 'ERC and Mathematics in Spain' event to celebrate the tenth anniversary of the European Research Council

# On the 10th anniversary of the ERC, the ICMAT leads the field in the number of grants obtained for mathematics in Europe

Image: ICMAT


From left to right. Manuel de León (ICMAT-CSIC), Marina Villegas (director of the State Research Agency) and José Manuel Fernández Labastida (ERC) at the inauguration of the event.

**This year marks the 10th anniversary of the creation of the European Research Council (ERC), and to celebrate the event the ICMAT organized the *ERC and Mathematics in Spain* meeting on March 13th and 14th to reflect on the impact that these grants have had on the Spanish scientific system and, in particular, on mathematicians themselves. The meeting forms part of an international commemoration involving more than 140 institutions from around the world, with the aim of highlighting the ERC as an essential instrument in scientific diplomacy and cooperation between countries.**

***Elvira del Pozo Campos.*** The story goes that the grandson of the Chinese emperor Taizong (598-649), of the Tang dynasty, gifted two pandas to Japan as a gesture of goodwill, thereby establishing a tradition that Peking has maintained to the present day with nations with which it wishes to consolidate and strengthen political ties. What has come to be known as "panda diplomacy" is an exotic version of *soft power*, which refers to the capability of a political actor to exert influence on third party countries by cultural, ideological and even scientific means. Perhaps one of the best known examples is the Pugwash Conference on Science and World Affairs, which was first organized in the middle of the Cold War, in 1957, by 22 scientists from all over the world, seven of whom were from the USA and three from the Soviet Union. The mission of these conferences has never wavered: to debate and help reduce the risk of armed conflict, for which it was awarded the Nobel Prize for Peace in 1995.

Some years later, in 2007, when the European Commission created the European Research Council (ERC) with the aim of promoting basic science of excellence in the region, it also had in mind that "scientific diplomacy at the European Union (EU) level facilitates interaction with third party countries and increases its soft power", according to a report by the European Research Service.

In the words of Carlos Moedas, European Commissioner for Research, Science and Innovation, "the ERC brand has an almost limitless potential, embodying as it does the fundamental values of scentific diplomacy and providing a solid base for establishing European networks among our international partners". The ERC accepts candidacies from any part of the world and in all fields of scientific knowledge. This flexibility and ambition, together with high levels of funding – known as ERC Grants and worth between I and 2.5 million euros, to be spent over a 5-year period- make it a powerful means for enabling scientists to go further beyond the frontiers of knowledge.

"The ERC brand has an almost limitless potential, embodying as it does the fundamental values of scentific diplomacy and providing a solid base for establishing European networks among our international partners"

This year marks the tenth year of the creation of the ERC and has been celebrated by different events all over the world. The ICMAT has participated in this commemoration with a scientific meeting held on March 13th and 14th. Since 2007, the ERC has funded approximately 7,000 researchers to the tune of 12 billion euros, seven of these researchers being Nobel Prize winners, and "has had a positive impact on thousands of Europeans as well being behind many advances in science, such as the recent discovery of seven potentially habitable planets beyond our solar system", according to Jean-Pierre Bourguignon, chair of the ERC, in a public address to the *Fundación Española para la Ciencia y la Tecnología* (FECYT - Spanish Foundation for Science and Technology).

Furthermore, the research projects funded by the ERC have led to almost 100,000 papers published in international scientific journals, 3,000 of these papers appearing in one percent of the most cited scientific journals, according to data from the *Fundación Española para la Ciencia y la Tecnología* (FECYT). As Bourguignon points out, it seems that "the ERC is fulfilling its self-assigned mission to make Europe the ideal place for the best minds in the world".

"With the ten ERC Grants obtained to date, the ICMAT leads the field in this type of funding in the field of mathematics in Europe"

Specifically, in the space of a decade Spain has received 650 million euros spread over 18 projects from a total of 336, which means 5.3%; quite a lot fewer than the 65 obtained by France, 59 by the United Kingdom and 42 by Germany. As regards the number of Spanish researchers, 400 have been awarded the grants from the 5,500 who submitted projects, and of these 400 approximately half belong to Severo Ochoa and María de Maetzu centres and units of excellence. This is the case of the *Instituto de Ciencias Matemáticas* (ICMAT – Institute of Mathematical Sciences), which with the ten ERC Grants obtained to date leads the field in this type of funding in the field of mathematics in Europe, ahead of other institutes of renown such as Oxford University. Diego Córdoba, ICMAT researcher and scientific director of the Severo Ochoa project, obtained a Starting Grant when they were first made available 10 years ago. He was the first from the ICMAT and from all the CSIC to do so. As this researcher says: "The main aim of our project is to study analytically the different models of incompressible fluids. In particular, we analyze the solutions in which singularities appear." Thanks to the research team set up around the ERC, important results were obtained that were subsequently published in leading international journals, among these results being the resolution of the problem of describing how a wave breaks.

**Happy Birthday**

The ERC projects are not only a recognition of the best researchers in Europe, but are also a significant distinction for scientific work and an injection of funding in each area of research. Deputy Director of the ICMAT, Javier Parcet, was awarded a grant in 2010 for a study in the field of harmonic analysis on von Neumann algebras. He says that "at that time, I was the only representative in Spain, and a vital contribution of my ERC project was to give visibility to this line of research and to create an excellent group to carry it out. Attracting and training students and post-doctoral researchers in an area of this nature is frankly difficult and the ERC project has been fundamental in this regard."

"It is unmistakable proof of the quality of our scientists and the excellence of the Institute at an international level"

It is also a recognition for the research centre to which the researcher belongs. "It is unmistakable proof of the quality of our scientists and the excellence of the Institute at an international level", says Manuel de León, ICMAT member and also a member of the organizing committee for the meeting held at the ICMAT.

All the ERC beneficiaries in mathematics in Spain were invited to the meeting, where they presented their work and conducted an analysis on the significance of the programme for the Spanish mathematical community (aquí los vídeos de las jornadas). The result in mathematics in the ERC is not particularly low, but an increase would be desirable. ERC scientific director, José Manuel Fernández Labastida, expressed himself in the same terms during the inauguration of the event: "Getting bogged down in your comfort zone would be a mistake; all the researchers have stepped up their efforts to obtain these highly important grants, and if you remain where you are you'll get passed over."

"Getting bogged down in your comfort zone would be a mistake; all the researchers have stepped up their efforts to obtain these highly important grants, and if you remain where you are you'll get passed over"

During the debate, among the proposals put forward for increasing the number of European grants were: strengthening the vision from Brussels; finding ways to facilitate the management and matching of an ERC contract with the different categories of university staff in Spain; reinforcing the scientific careers of those on ERC contracts; promoting transfer and placing emphasis on public communication of the results, among others.

Efforts are being made at the ICMAT to pursue these paths. From its inception, the ICMAT has given great importance to attracting young talent and to providing the best possible conditions in which to compete internationally, such as the ICMAT European Office for supporting the application process and development of european projects with the help of a highly experienced manager. The ERC and Mathematics in Spain event, organized by the ICMAT, was one of the 140 held both within and beyond Europe during the ERC Week", celebrated on March 13th and 14th of this year, with the aim of promoting the Council throughout the world. As Moedas concluded: "It is essential to intensify our commitment with the rest of the world in supporting scientific diplomacy and international cooperation."

Image: ICMAT

**Searching for risk**

The European Research Council (ERC) fosters excellent basic science in Europe by supporting the best scientists from any field who seek to develop cutting-edge or high-risk ideas in emerging sectors. These grants are the main component of the Horizon 2020 IDEAS Programme, the seventh European Union Research Framework Programme, which complements other European formulas such as the national research funding agencies.

There are three types of ERC grants: the *Starting Grants*, aimed at young researchers with the potential to become leaders in a new research line; the *Consolidator Grants* to enable excellent researchers to consildate their own team or independent research programme; and the *Advanced Grants*, aimed at senior scientists with an exceptional track record and leadership qualities who submit pioneering and highly ambitious projects.

Only slightly more than ten percent of the projects submitted obtain these types of grants, which distinguishes them with a hallmark of excellence at an international level.


José Luis García (CSIC, national representative of the ERC) during his presentation.

Image: ICMAT


Round table with (from left to right) Manuel de León (ICMAT-CSIC), Marina Villegas (Director of the State Research Agency), Jorge Velasco (institutional coordinator of the CSIC in Brussels), José Manuel Torralba (Director general of Universities and Research of the Community of Madrid) and Alberto Enciso (ICMAT-CSIC).

INTERVIEW: José Manuel Fernández Labastida, director of the European Research Council (ERC) Scientific Department

# "The success of the ICMAT in the ERC programmes is extraordinary"

Image: ICMAT

José Manuel Fernández Labastida during his visit to ICMAT.

**After holding the post of vice-chair for scientific research at the CSIC, and later that of Director General for Research at the Spanish Minstery for Science and Innovation, in 2011 José Manuel Fernández Labastida took up the position of director of the European Research Council (ERC) Department of Scientific Management. It was in that capacity that he visited the ICMAT in March to open the congress held to celebrate the tenth anniversary of the birth of this body. Here he took stock of the activity of the ERC, especially its competitive programmes and its impact on Spanish mathematics.**

***Laura Moreno Iraola***

**The ERC is celebrating its 10th birthday in 2017 and there are celebrations all over Europe. Why was it important for you to attend the ICMAT event?**

For several reasons. The first is sentimental, because I feel closely attached to the ICMAT project, and because its emergence (physically speaking) coincided with my time as vice-chair for scientific and technical research at the CSIC, between 2004 and 2008. That was a very good period for research in Spain, the best in terms of budgets, and from the presidency of the CSIC I think we committed ourselves strongly to mathematics with new positions and Ramón y Cajal contracts, among other things. It's a pleasure for me to be here as well because I think the success that the ICMAT has had in the ERC programmes over these years is extraordinary.

**What would you highlight as the key to the ICMAT success, with a total of 10 ERC grants so far?**

This centre has always been committed to attracting the best available talent, and when this is sown you collect the harvest. What's more, the researchers have been urged and encouraged to participate in a highly competitive programme (with only a 12% success rate) in which it's not enough to be a world expert in a subject, but rather to have an idea and know how to express and explain it in order to convince the assessment committee (panels) that it's both fantastic and fundable. And the ICMAT has helped and support its researchers in this sense too.

"The ERC has become a means of measuring the quality of research and of scientists"

**Where does the importance of these grants reside?**

The ERC has become a hallmark of excellence for both countries and their institutions; it's a way of measuring the quality of cutting-edge research and of the scientists who conduct it. The fact that in 10 years it has managed to do this means that it has done a fine job in the evaluation of the projects it has chosen to fund, which are producing research results of extremely high quality.

**What impact does it have on researchers' careers?**

Above all, for the young scientists who get a *Starting Grant* (for those researchers with between 2 and 7 years experience after obtaining their PhD) it marks a turning point in their careers: it's an enormous boost, makes them more competitive and raises their standing and so on. For the *Advanced Grants* as well (for researchers active during the last 10 years) it has many colateral effects: they move to a higher level, attract more sources of funding from the private sector, public calls or calls from their own universities; they can even choose the institution where they'd like to work. The fact that the ERC grants are portable [from one institution to another] has generated a competitive dynamic, which is one of the goals of the scheme. So in Europe, in general, this has shaken up the system, which is moving towards a much more competitive model.

**Now that we're at the half-way point of Horizon 2020, the eighth European Union Framework Programme for Research and Innovation (2014-2020), could you assess the effects of the ERC grants awarded in our country?**

Since 2007, when the ERC was created, Spain has obtained approximately 5.6% of the funding distributed by the Council. In my opinion, there's room for improvement; pioneering research in Spain should be aiming at the 8% that is exceeded at a national level in other H2020 programes.

"Spain has some room for improvement in the ERC projects"

**What do you think is needed in Spain to reach that level?**

It's necessary to keep on working in order to compete better, to propose more ideas and, above all, to attract talent and try to retain the talent you already have.

**At the moment, the success rate of the activities belonging to the H2020 framework programme is around 14%, which is less than that of the seventh framework programme, which had a success rate of about 20%. Fewer and fewer high quality projects are being financed due to lack of funds. What do you think can be done about this?**

It's true that this figure has fallen in comparison with the previous programme by about 11% or 12%, and we hope this can be improved. The comparison is as follows: in the previous programme, FP7 (from 2007 to 2013), we began with 300 million euros annually for the ERC and ended up with 1,600 million in 2013 alone, which means a total of 7,500. Now, in H2020, we have 13,000 million for seven years, which may seem like a large increase, but compared with the previous programme, and taking into account that applications have grown, this does not amount to the same exponential increase. What has happened with this eighth framework programme is that there have been years in which the volume of funding has not remained stable, and has even fallen, because of the economic situation in various European countries. From now on, a 5% to 6% annual increase until 2020 is foreseen.

**Another big concern for European science is the gender gap. What's the current situation in the ERC programmes?**

Women are applying for fewer grants: as regards the Advance Grants, the average number of applications made by women is around 15%, and for Starting Grants it's about 30%. As their careers move forward, female representation tends to fall by the wayside. Mathematics is one of those areas where this disparity is greater. Overall, the number of women with ERC grants in this area does not reach 15%, but in Spain this figure is a resounding 0%; the 18 grants awarded are all for men. It's curious that in fields where there are fewest women, in physical sciences and in engineering, is where the success rate is more evenly balanced between the sexes; there have even been years in which women have overtaken men. However, in life sciences, where more women researchers are involved, the success rate is typically greater in men, although we don't know why. In social sciences and the humanities, the figures fluctuate from one year to the next.

"Fewer women are applying for grants, and mathematics is one of the areas where this disparity is greater"

**Given this situation, the ERC is operating a gender balance scheme. Could you outline the main features of this plan?**

A series of measures are included in the calls in order to avoid a possible interruption in the careers of women researchers. For example, in the case of childbirth, women with Starting Grants, which normally are awarded for a 5-year period, can have this period extended by a year and half for each child. Male researchers also have this option, but the extension is the same as the time made available for paternity leave, if they have indicated that they have enjoyed it. Furthermore, we're trying to take special care when it comes to evaluations. We encourage the panels to be very careful about this, because there may be an unconscious bias attached to their decisions. In fact, just lately we've been showing them a video before they join the assessment panels created by the CERCA research centres in Catalonia. What's more, when deciding on the composition of the panels, which is done by the scientific council, we try to arrive at a balance based not only on gender, but also on geography, excellence, etc.


Image: ICMAT

Labastida next to Manuel de León (ICMAT) and Marina Villegas (director of the State Agency of Investigation) in the inauguration of the congress.

**As far as the ninth framewok programme, the FP9, is concerned, which starts in 2021, have you begun any developments in terms of changes or improvements?**

The latest development is a return to the Synergy Grants in 2018, a funding scheme that was in operation in 2012 and 2013 as a pilot venture. The scientific council has evaluated it, has visited the 24 projects that were funded in this way at that time, and has come to the conclusion that it's a worthwhile scheme. It's important to promote this type of ambitious research in a highly interdisciplinary area that might not be accessible with a grant for a single researcher. Thanks to this, between two to four leading researchers can work together with their respective teams, thereby complementing each other, exchanging knowledge and sources, and so on.

**Are any changes to the evaluation system being contemplated?**

I don't think there are going to be any major changes, because a model has been created that is being followed by other agencies and institutions, such as the NIH (National Institutes of Health) in the United States. It's true that evaluation for a Synergy Grant is going to be slightly different, and the scientific council is still working on the details, but eventually it'll still be done by peers, with the leading experts worldwide. And as far as improvements are concerned, we subject it all to a constant scrutiny. For example, when the panels are finalized, the so-called panel reports are drawn up, with recommendations and suggestions to the agency and the scientific council, for analysis and classification.

"The scientific council has debated a lot about reducing these amounts [for some ERC grants], and in the end has opted not to do it"

**Have you ever thought about creating some light ERC grants (with lower endowments) for projects that are good but receive no financial assistance?**

This is a regular subject for debate at the scientific council. In fact, to take the example of the PE 1 (Physical Sciences and Engineering - Mathematics), the average funding per project is much lower than that for other more experimental projects, because less equipment, material and so on is required. The scientific council has debated a lot about reducing these amounts, and in the end has opted not to do it. It's true that there was a corrective element; now, for instance, particularly in life sciences, additional funding is often provided for equipment. However, the council has always opted for being unique and having general rules for all, although later each panel may adopt its own for the detection of excellence.

**Collaboration: Andrés Ballesteros and Patricia Benito (Oficina ICMAT Europa).**

Image: Alicia A. Cortés

Nastasia Grubic in front of her ICMAT blackboard.

## SHE DOES MATHS: Nastasia Grubic

# Nastasia Grubic

**Nastasia Grubic is a post-doctoral researcher at the ICMAT, with an ERC contract for a project led by Alberto Enciso, together with whom she is working on the study of interfaces between two fluids; in particular, when the curve defining the surface touches itself. Grubic obtained her PhD from the Université de Pierre et Marie Curie de Paris (France) with a thesis entitled "Mathematical models for the Einstein equations of general relativity" in which she studied gravitational waves in compressible fluids and the phenomenon of elasticity in non-Euclidean space, which presents a characteristic curvature.**

**Research field:**

**Fluid mechanics, partial differential equations and equations in physical mathematics.**

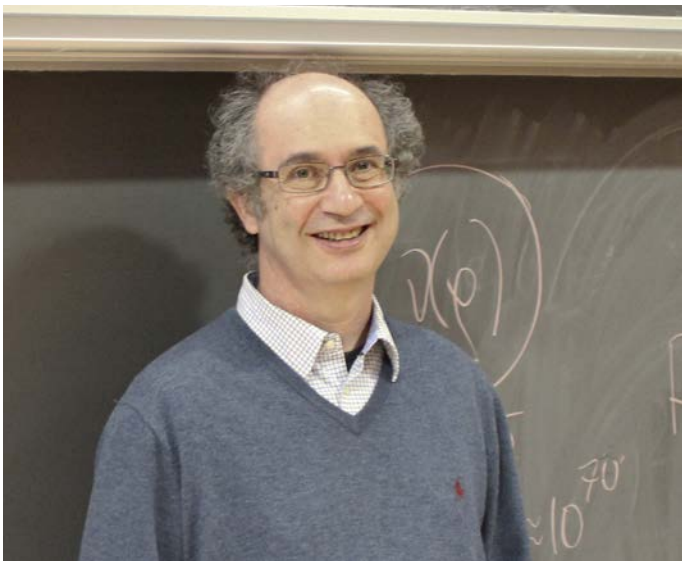
***Alicia A. Cortés***. Nastasia Grubic (Šibenik, Croatia, 1986) has been pursuing her post-doctoral studies at the ICMAT since 2013. She was first part of the team led by Diego Córdoba (ICMAT-CSIC) thanks to a Severo Ochoa post-doctoral contract, and is currently a member of the ERC project headed by Alberto Enciso (ICMAT-CSIC). The main problem she is tackling at the moment is found within the field of incompressible fluid dynamics; in particular, splash phenomena, that is, what happens when the surface of a fluid touches itself, leaving a space, an empty drop or one from another liquid, delimited by the curve itself. When the surface is not in contact with anything and the study is conducted from the empty zone, the splash appears to be dynamically possible. The problem becomes more complicated when the study is conducted from the fluid or when there are two fluids in contact. Together with her team, Grubic managed to demonstrate that this type of splash is also possible by approaching the problem through the study of stationary or travelling waves. This succession of identical waves makes it impossible to distinguish one from the other and enables the elimination of the time variable in the equation.

Grubic completed her PhD studies in Paris (France) at the prestigious *Université Pierre et Marie Curie* with a thesis entitled "Mathematical models for the Einstein equations of general relativity", in the field of compressible fluid dynamics and within general relativity. In particular, she conducted research into contraction and expansion phenomena of the fluid due to gravitational waves. In order to tackle the problem of working in Einstein-Euler space-time, she established symmetries with the aim of reducing the number of spatial dimensions from three to one. At that time, she also had the opportunity of studying the elasticity of bodies within a non-Euclidean curvilinear space.

ICMAT QUESTIONNAIRE: Mikhail Sodin, an ERC Advanced Grant researcher at the University of Tel Aviv (Israel)

# "I was never able to solve a single problem in mathematics competitions"

Image: ICMAT



Mikhael Sodin after the colloquium he gave at ICMAT.

**Mikhail Sodin was born in 1957 in Kharkov, Ukraine (formerly Soviet Union). He is currently a professor at the School of Mathematical Sciences at Tel Aviv University. He studied Mathematics at the State University of Kharkov (1974-79). Although he received his degree from the Institute of Mathematics of the Armenian Academy of Science, Yerevan, in 1985, he was only there for three days to present his thesis. Its director was Anatolii Grishin, of the State University of Kharkov.**

***Ágata A. Timón García-Longoria***

**Q: Why did you decide to study mathematics?**

A: It was easy for me. When I finished high school, I was far more interested in history than in mathematics, but I was brought up in the Soviet Union and there in the mid-seventies all history was false. It made no sense to have a career in history. What's more, in the city where I was studying, Jews were not allowed to enter some university departments, one of which was history. On the other hand, there was no restriction in the maths department. In other cities like Moscow and St. Petersburg there were very severe restrictions, but not in the Ukraine. So I decided to study mathematics for these reasons, and though it wasn't my first option I liked it and found it easy.

**Q: Do you remember your first contact with research in mathematics?**

A: In the Soviet Union there was a long tradition of maths competitions for young people in high school and university. I was very bad at it. I was never able to solve any of those problems. When the competition ended, someone explained the solutions, but even then I didn't understand them. They were very complicated for me. The same thing happened at the university; some courses I found very difficult, while others I found very easy. I got good results in all of them, but only as a result of great effort.

**Q: So... how did you end up devoting yourself to solving problems?**

A: In my second year at university we had a special subject called "student research project" that was taught by Naum Akhiezer, an excellent teacher and a famous mathematician, although when he taught me he was already old. He assigned some problems to students who were interested, and we had some months to think about them before writing a short essay on the topic. That was my first contact with research. I never came up with anything that was publishable, but it started me thinking like a mathematician.

**Q: And that was when you started to enjoy mathematics?**

A: I'd say that was in my fourth year at the age of 21. That same professor gave me some hints about which direction I might go in, and that's what I worked on with my thesis supervisor, Anatoly Grishin. My supervisor gave me a few open problems and I was able to resolve one of them. It was an incredible feeling; just ten minutes before I hadn't even been able to understand the question, and then suddenly it all made sense. The transition from not understanding to understanding is very quick, and it's only afterwards when you need time to sit down and write and see how everything is formalized. After writing it down, I decided to spend the rest of the year in the mountains, or something like that, because I'd done my homework. Then I met a post-doc student who turned out to have solved exactly the same problem as me and had sent it off for publication. So I had to solve another of the problems, because I wanted my thesis to be really good. It couldn't be based on a result that was already known. So then I spent the next three or four months working every day instead of going away to the countryside.

**Q: Did you manage to solve the problem?**

A: Yes.

**Q: And after that, how did you continue your career?**

A: It wasn't the usual kind of career by western standards. I graduated with the Master Degree in 1979, at the age of 22. I was never a PhD student because it was very difficult for a Jew to get on a PhD programme in the USSR. Don't ask me why; there's no logical explanation. There was a way to circumvent these restrictions and in 1985 I defended the PhD theses and got the PhD degree without being a PhD student. Until 1987 I worked in an engineering company where they used applied mathematics, statistics, equations, and so on. From there I carried on my research work in a parallel way. That was pretty normal situation in the Soviet Union; there were high school teachers and engineers solving interesting problems in mathematics. It's not like that now, of course. In that period I hated it sometimes, because some of my friends were "professional" mathematicians who could devote all their time to what they liked doing, while I had to work on math problems at my spare time. But the truth is that I think that in some way it was much better for me like that. I was under no pressure. I wasn't expecting any job to come out of it, either there or abroad; that wasn't going to happen. So I could dedicate myself to problems I liked. It was fun. I was able to learn new things. At work I enjoyed very good relations with my colleagues and was able to be absent for several days or skip a day in the week... It's odd, because at that time I had two young children, but in a way I felt that I had the time to do mathematics.

"The transition from not understanding to understanding is very quick"

**Q: Did you conduct your research on your own?**

A: No, I formed part of a mathematical community. There was a very good tradition of mathematics in the Ukraine, and there was a large group of people devoted to complex analysis, my research topic at the time. Once a week we held a seminar that was often attended by 25 people. Normally, after the seminar we met in a café to carry on with the discussion. I had a lot of friends of the same age with whom I could talk about mathematics and collaborate. In fact, we wrote a lot of articles together.

**Q: Then in 1996 you moved to Tel Aviv: why did you decide to do that?**

A: In 1987, when the *perestroika* started, all obstacles disappeared overnight. Very soon I received an offer of a job at the excellent research centre (Mathematical Division of the Institute for Low Temperature Physics at Kharkov, Ukraine) where I worked until 1996, which is when I moved to Israel, but I'm still in regular contact with that centre. What I like about Tel Aviv is that our department is small. There are about 27 or 29 of us, and we cover different areas of pure mathematics. Since there's no concentration on any particular area, people from different fields are used to speak with each other about what they're doing, and that's a good thing.

**Q: Do you find any difference in the way mathematics is done in different countries?**

A: I've travelled a lot throughout my career. I was visiting professor in the USA for about six months, and in Copenhagen for a year. I've got collaborators in France and in the north of Europe whom I visit on a regular basis. And yes, I see peculiarities in each place. In Tel Aviv there's a very pleasant atmosphere, because people from each speciality discuss things together beyond their own fields. In France, they organize thematic labs that bring together people specialized in each particular subject, and obviously they form relationships between themselves.

**Q: What are your main interests as a researcher?**

A: Before coming to Tel Aviv, I was interested in one-dimensional complex analysis and in all types of applications to spectral theory and harmonic analysis. I'm still interested in these topics, mainly with my PhD and post-doc students. But now I concentrate on a topic at the frontier between probability theory and analysis. I'm not an expert in probability; in fact, I had to learn all that I know about it at the age of 50, but it interests me a lot. What's more, all this has to do with important connections with mathematical physics, which makes it even more attractive. In the Ukraine, mathematical physics was one of the big areas. I don't know why. Maybe because in the Soviet Union physicists were very highly regarded, more than other scientists.

**Q: Your conversation at the ICMAT is about the topology of zero sets of smooth random functions. Could you tell us what this problem consists of?**

A: It's one of the topics I've been working on for some years. The question is as follows: if you have zero sets of smooth random functions (that is, the set of points in which the function has the zero value), you can try to understand what type of topological object they generate, what shape they have, where they are located... Hilbert posed this problem for non-random polynomials in real two variables (it's number 16 on his famous list of problems). In Hilbert's original formulation it has been solved. Now we're considering a random version of this problem, and instead of looking for upper or lower bounds of functions for all the polynomials, we're asking what is that that happens typically. These questions have many applications in many areas of modern mathematics – in quantum chaos, in statistical mechanics... All these topics form part of my ERC project.

"In my department, people from different fields are used to speak with each other about what they're doing, and that's a good thing"

**Q: What has the ERC project meant for your career?**

A: Partially, I applied for it because of administrative pressure. It's very good for institutions, because they get money through indirect costs for the project and additional funding from the state, so if they spot the chance of getting it they apply pressure on you to apply for it. It affords me a lot of freedom, in particular, for being able to invite people to work on it with me. Grants in Israel allow you to contract students, but not to invite scientists. Having the ERC grant, I can also send my students to conferences and workshops important for their education, without having to worry about funding their trips. This also quite important.

**Q: This year is the ERC 10th anniversary. How do you see the evolution of the program?**

A: I note a tendency to reduce the number of grants and increase the amounts, and I don't think that's positive. Maybe in other areas like experimental chemistry or biology, it's better to have one strong group with better equipment, but I don't think that's good in mathematics. I think it would be better to increase the number of the ERC grants in mathematics, possibly at the expense of some decrease in their amounts.

PORTRAIT: Francisco Torres de Lizaur

# "Mathematics gives expression to the sciences"

Image: Residencia de Estudiantes

Francisco Torres in the vicinity of the Residencia de Estudiantes.

## Francisco Torres de Lizaur

**Francisco Torres de Lizaur was born in Seville in 1989. He began to study Industrial Engineering, but realized that what really attracted him were more theoretical subjects, so he decided to combine these studies with a degree in Mathematics. In 2011 he took a further step and moved to the *École Normale Supérieure de Paris* (France) to redirect his career towards the field of mathematical physics, and it was there where numbers eventually seduced him. His first contact with the ICMAT took place in 2012 through an introduction to research grant that enabled him to join the group headed by Óscar García-Prada (ICMAT-CSIC). It was then that he met his present thesis supervisor, Daniel Peralta (ICMAT-CSIC). In 2014, he received a grant to do his PhD within a Starting Grant project, awarded to Peralta by the European Research Council (ERC). Torres' thesis is focused on the study of invariant manifolds in dynamical systems and partial differential equations.**

***Alicia A. Cortés.*** Francisco Torres de Lizaur began his journey towards mathematics in its most applied form, engineering, and little by little was drawn to the most fundamental form. As this researcher explains: "My motivation was a desire to understand things better." He has always liked to play with abstract concepts and study them from different angles, and as he says, "mathematics gives you a lot of freedom to do that, because the concepts you work with are so subtle and varied."

He is currently completing his doctoral thesis under the supervision of Daniel Peralta (ICMAT-CSIC) as part of the Starting Grant project obtained by Peralta from the European Research Council (ERC). Torres began by studying periodic orbits of vector fields, which represent the motion of ideal fluids, incompressible and without viscosity; that is, he studies how particles move inside this ideal fluid and what path they follow before returning to their initial position. He progressively explored the intersection between geometry, dynamical systems and analysis. "In particular, I study the dynamical properties of vector fields in differentiable manifolds using partial differential equations," explains Torres. "The Seiberg-Witten equations (a system of partial differential equations coming from theoretical physics), at a certain limit, provide invariant measures of vector fields, which are very useful for determining, for example, what their dynamics are like". One of the points that makes his research work more interesting is that these periodic orbits are believed to be related to the turbulent behaviour of fluids.

The most interesting aspect for Torres is the possibility of working with different concepts and trying to relate them together. "This enables you to understand the mathematical universe better," he says. Furthermore, this field of knowledge provides the other sciences with a lanaguage and with concepts to underpin his research work.

The stereotypical notion that the work of a mathematician is conducted in the isolation of an office is far from the truth in Torres' experience, since he has also studied in places like Harvard University (USA). "Mathematics is often learned by talking with other people, and then after through work and personal assimilation". While his sojourn on the other side of the Atlantic only lasted for four months, it was for him truly enriching, because it gave him the opportunity to meet and interact with mathematicians from all over the world.

> "Your way of thinking changes a little when you meet people who are doing things so different from you"

His way of understanding and living mathematics has to some extent been enhanced by his experience at the *Residencia de Estudiantes* in Madrid, thanks to a grant he obtained in 2014. As Torres tells us, "it's a grant covering accommodation, which means I don't have to worry about anything except work." A small number of students and creative people – nine or ten every year – from very different backgrounds, such as arts and sciences, are provided with accommodation at the *Residencia*. The idea is to continue with the dialogue between science and the arts experienced here in the years 1910-1936, when this scientific and artistic interchange fostered the emergence of such outstanding figures as the poet Federico García Lorca, the painter Salvador Dalí and the scientist Severo Ochoa. "It's an intense experience," says Torres. "You live alongside people who are doing very interesting things. This motivates you a lot and it's highly stimulating for my own research work".

This grant has also provided him with the opportunity to undertake collaborations that otherwise would have been very difficult to carry out, and Torres has made the most of it. I've given some talks on the relation between mathematics, music and poetry," he explains. He has also given a workshop on creative writing with the writer Paula Zumalacárregui, which consisted in writing pieces using strict rules, such as the "N+7 transformation", where each noun is replaced by the seventh noun that follows it in the dictionary. These rules are based on work done at the French Oulipo literature workshop, founded in 1960 by writers and mathematicians.

So, in the search for different concepts and relations between fields that at first seem unrelated, Torres is continuing his career, which has only just begun.

# SCIENTIFIC REVIEW: A new approach to KAM theories

**Title:** Rigorous Computer-Assisted Application of KAM Theory: A Modern Approach

**Authors:** Jordi-Lluís Figueras (University of Uppsala), Alex Haro (Universitat de Barcelona) and Alejandro Luque (ICMAT)

**Source:** Foundations of Computational Mathematics

**Date of publication:** 17th of november 2016

**doi:** 10.1007/s10208-016-9339-3

As a result of this work, in June of this year the authors were awarded the "Barcelona Dynamical Systems 2017" Prize by the *Societat Catalana de Matematiques* (SCM).

The so-called *KAM theory* consists of a series of methods for studying the persistence of certain types of solutions for systems of equations arising from problems in physics. Specifically, these methods are used for solving Hamiltonian systems, which are employed for modelling problems in classical physics, such as those in celestial mechanics, astrodynamics and particle accelerators. It is often very complicated (or very expensive) to find general solutions for these systems, so the appearance of certain types of specific solutions are studied instead, such as the so-called quasi-periodic solutions. These solutions correspond to motions that oscillate with more than one (linearly independent) frequency and are confined to one geometric space: a manifold with toroidal geometry (invariant torus) in the phase space. These solutions play a fundamental role because they represent the type of stable motion one may observe in this type of problem, and thus enable the dynamics of the other solutions to be organized.

The origin of KAM theory dates back to the work carried out by Andrey Kolmogorov (1954), Vladimir Arnold (1963) and Jürgen Moser (1962), whose initials form the acronym KAM. At that time, it was widely known that the phase space of integrable systems is organized by quasi-periodic invariant tori. KAM theory establishes conditions sufficient for guaranteeing the persistence of such structures when considering perturbations of the problem. These conditions are highly generic and are expected to be fulfilled in general, but verifying them in a particular system involves great difficulty. This is because the natural coordinates for describing a mechanical system are not sufficient for interpreting the hypothesis of KAM theory. Furthermore, problems in celestial mechanics present degenerations that make this task difficult.

Moreover, in addition to a theorem for guaranteeing the persistence of invariant tori for small perturbations, it is important to determine the *validity threshold* of the theorem (that is, the size of the perturbation to be taken into account). This is important because, while it is true that many problems arising in nature are close to an integrable problem, it is not true that we can model them by means of arbitrarily small perturbations. KAM theory was for a long time the object of criticism regarding its practical applications, since its validity threshold appeared to be ridiculously small. This observation was made by the French astronomer, Michel Hénon, who obtained a validity threshold of the order of $10^{-333}$ at the beginning of the theory. Hénon himself, in analogy with Galileo's hypothetical phrase *eppur si muove*, remarked that his numerical observations indicated that the invariant tori continued to exist under greater perturbations. Consequently, in order to obtain useful and realistic applications of the KAM theory, it is necessary to consider particular systems as well as to determine specific values of the parameters for which the result applies.

In the article "Rigorous Computer-Assisted Application of KAM Theory: A Modern Approach", a general methodology is presented for applying KAM theory to specific systems for realistic values of the parameters (that is, allowing for large perturbations). To that end, Jordi-Lluís Figueras (University of Uppsala), Alex Haro (Universitat de Barcelona) and Alejandro Luque (ICMAT) have developed a broad range of analytical and computational results: a KAM theorem in an a-posteriori format with explicit constants; a computer-assisted analysis; rigorous methods of fast Fourier transform; explicit determination of diophantic constants, improved Rüssmann estimates and very accurate numerical approximations of invariant tori.

Obtaining KAM tori for realistic parameter values is a problem that has aroused great interest in recent decades. The first attempts were made in the late 1980s in the study of some Celestial Mechanics as well as the *Chirikov standard map*. This latter is a simple model for understanding the behaviour of Hamiltonian systems with two degrees of freedom. However, these methods, based on perturbation theory and on normal shapes, led to computationally expensive algorithms and relatively pessimistic estimates of the validity threshold (despite being specifically implemented for the applications under consideration).

The new methodology proposed by the authors in their work, published in "Foundations of Computational Mathematics", enables the KAM theorem to be applied to the Chirikov map up to a value that differs by 0.004% of the numerically observed threshold value (previous attempts yielded a figure of 6%).

The article also takes other examples into consideration: the case of curves with meanders (which are not graphs and may have relative complicated topologies) in the standard non-twist map and the case of bi-dimensional tori in the Froeschlé family (which is a simple model for understanding the behaviour of Hamiltonian systems with 3 degrees of freedom). This is the first time that these objects have been rigorously validated for specific (and large) parameter values. In any event, it should be pointed out that the KAM theorem and the methodology presented, as well as the algorithm described, are sufficiently general to be employed a wide variety of problems.

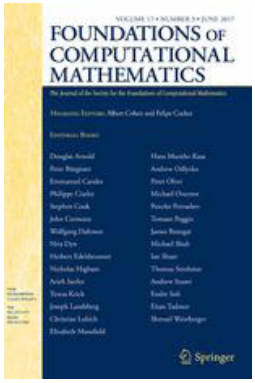
One of the main difficulties when it comes to verifying the hypothesis of the KAM theorem consists in controlling the analytical norm of certain functions that are obtained using algebraic operations and the derivation, composition and inversion of objects defined on an approximation of an invariant torus. This means that it is necessary to rigorously determine bounds to the size of these functions in a complex domain. To that end, a rigorous computer-assisted methodology is presented in which a fast Fourier transform (FFT) is used in combination with a theorem that enables the error to be controlled when approximating functions using FFT. The strategy put forward far outstrips the use of symbolic manipulators, thereby facilitating operations with millions of Fourier coefficients. In addition to proposing a validation algorithm with great computational performance, this work also presents new theoretical tools for studying small divisor problems which, for example, allow the diophantic properties of a given frequency vector to be characterized.

**About the authors:**

**Jordi-Lluis Figueras** is an associate senior tenure-track lecturer (Biträdande Lektor) at the University of Uppsala. His research work is focused on the study of breakdown in hyperbolic invariant tori, computer-assisted proofs in dynamical systems, rigorous numerical methods for PDEs and skew-product systems.

**Alex Haro** is a lecturer at the Universitat de Barcelona. He conducts research in different branches in the field of dynamical systems, ranging from normally hyperbolic manifolds to KAM theory as well as connections with spectral theory.

**Alejandro Luque** is a post-doctoral researcher at the ICMAT. His research work concerns the area of dynamical systems with special attention given to Hamiltonian systems. His work is based on the characterization of stabilities and instabilities using analytical, geometric and numerical methods.




## SCIENTIFIC REVIEW: The existence of Engel structures

**Title:** Existence h-principle for Engel structures

**Authors:** Roger Casals (Departament of Mathematics, Massachusetts Institute of Technology), José Luis Pérez (ICMAT), Álvaro del Pino (ICMAT), Francisco Presas (ICMAT).

**Source:** Inventiones mathematicae

**Date of publication:** 12th of May, 2017

**doi:** 10.1007/s00222-017-0732-6.

**Summary**: *Contact structures* are non-integrable distributions (a continuous selection of "admissible" directions at each point in space) defined in odd-dimensional geometric spaces; they are constructed in spaces or manifolds of dimension 2n+1 and select a linear subspace of 2n directions at each point. For instance, in a manifold of dimension 3, a plane is chosen at each point; one example is the mechanical system modelling a skateboard, which has three degrees of freedom: the two coordinates of its position on the plane, and the angle at which its axis is pointing. The distribution of "admissible" motions at each point is given by the line defined by the axis (one degree of freedom) and the angle (a second degree of freedom). The fact that it can reach any point in the space (moving by admissible motions from one triplet of coordinates to another) is a measure of the non-integrability of the distribution. The analogous objects in dimension 4 are *Engel structures* and are non-integrable 2-dimensional distributions.

Non-integrable distributions are related to control theory, an interdisciplinary field of engineering and computational mathematics dealing with the behaviour of dynamical systems (those systems that evolve with time, such as the motion of a skateboard or a particle in a fluid) under a series of "controls" that correspond to the admissible directions. The theory studies geometric properties of the set of admissible trajectories and seeks to optimize observables such as the time spent and the energy consumed. Furthermore, non-integrable distributions represent classes of mechanical systems, and thus are closely related to symplectic geometry, which is the field of geometry arising from the study of Newton's equations under the formalism of differential geometry.

It is for those reasons that non-integrable distributions are placed at the intersection of symplectic geometry, the abstract formalism of mechanical systems, and control theory, which studies the pathways and efficiency of the admissible trajecto-

ries of the distributions. A further important actor in play is the *h-principle*, a set of topological-geometric tools used for determining the existence and subsequent classification of certain classes of geometric structures. The h-principle or homotopy principle emerged in the 1960s for the study of geometric structures that are locally equivalent or isomorphic, but which globally may not be so. This field of research found its initial inspiration in theorems of isometric Euclidean embeddings with low regularity by John Nash (USA, 1928) and was extended to the theory of differentiable immersions by S. Smale (USA, 1930). Mikhail Gromov (Russia, 1943) formulated the general principle underlying these apparently different results. In his book "Partial Differential Relations", Gromov employed the h-principle to find solutions to many types of partial differential equations.

*Contact structures* are also related to the theory of relativity and Hamiltonian dynamical systems. Their history goes back to Élie Cartan (France, 1869), who was the first person to study them locally and compare them with other classes of distributions.

This research work took off as an independent field 40 years ago, although it was not until the 1980s that a leap forward was made in their understanding, specifically in the case of 3-dimensional spaces. Since then, interest in this area has continued to grow. Progress in the remaining dimensions began in 2015, when the group led by ICMAT researcher Fran Presas published a paper in the journal "Annals of Mathematics", which showed that at least one contact structure existed in every 5 dimensional manifold satisfying an obvious necessary condition. This work was a wake-up call that a few months later led to the proof of the existence of contact structures in any odd-dimensional spaces satisfying the obvious necessary topological condition.

What motivated the development of contact geometry is that in quite a few spaces there are more than one contact structure, thereby posing the question of their classification. With that in mind, in the 1980s Gromov and Andreas Floer (Germany, 1956) developed the theory of pseudo-holomorphic curves and their associated invariants, a tool enabling different distributions to be distinguished. The zoology or classification of contact structures is currently a highly active research field because of the large number of examples found in these geometric spaces.

This year, together with Rogel Casals, José Luis Pérez and Álvaro del Pino, Fran Presas has published an article entitled "Existence h-principle for Engel structures" in *Inventiones Mathematicae*. This work contributes the first theorem on the existence of Engel structures in manifolds of dimension 4. These types of geometric spaces possess special characteristics and constitute the less understood class of topologically stable distributions, a concept introduced by E. Cartan, and the study of these authors has applications in general relativity. The first pointer towards a possible application of the h-principle in Engel geometry was provided by T. Vogel in 2009, although it was not until 2017 when Roger Casals, José Luis Pérez, Álvaro del Pino and Fran Presas proved a totally general existence result by employing the homotopy principle. At present, the classification of Engel structures is still an emerging field. As in the case of contact geometry, maturity in the area would be reached if examples of spaces with at least two different Engel structures were to be found.

**About the authors:**

**Roger Casals** is a *CLE Moore Instructor* at the Massachusetts Institute of Technology Department of Mathematics. He completed his PhD thesis at the ICMAT under the supervision of Fran Presas, for which he received the José Luis Rubio de Francia Prize from the Royal Spanish Mathematical Society in 2016. His research field is focused on symplectic and contact topology, the rigidity-flexibility dichotomy, the h-principle and groups of contactmorphisms.

**José Luis Pérez** is a graduate student at the ICMAT. He graduated in mathematics from the University of Seville and is currently engaged in his PhD studies at the ICMAT, under the supervision of Fran Presas. His research field focuses on the area of symplectic topology, contact structures and Engel structures.

**Álvaro del Pino** is a postdoctoral researcher at the University of Utrecht, Holland. He completed his PhD at the ICMAT under the supervision of Fran Presas. He studies phenomena of flexibility in contact and symplectic topology. He is also interested in applications of the h-principle.

**Fran Presas** is a Senior Scientists at the CSIC and a member of the ICMAT. He gained his PhD in mathematics from the Complutense University of Madrid in the year 2000, and completed his post-doctoral studies at Stanford University. He works in the fields of high-dimensional contact topology, symplectic topology, geometric quantization, the general theory of foliations and the classification of Engel structures.

# PROFILES: Meet the new ICMAT post-doctoral researchers

**In its constant search for and desire to attract new talent, the ICMAT devotes a considerable part of the Severo Ochoa project to funding post-doctoral contracts by issuing an annual, international and competitive call. In 2016, six mathematicians joined the Institute, one from the United States and the rest from Europe: Jared Aurentz, from the USA; Jerry Buckley, from Ireland; Daniele Casazza and Stefano Marò, from Italy, and Javier Ramos and Carolina Vallejo, both from Spain. We spoke to all of them (except Marò, who has recently been contracted by the Institute through the Juan de la Cierva programme) to find out about their careers and their interests in the world of mathematical research.**

***Laura Moreno Iraola***

Image: ICMAT

Jared Aurentz.

## JARED AURENTZ

Jared Aurentz (Minnesota, USA) was not sure if he wanted to dedicate himself to mathematics until he began his university studies at the faculty of enginneering at the University of Minnesota (USA), the state where he was born. Various topics on numerical methods awakened his curiosity for algorithm theory, and it was then when he opted for applied mathematics.

Aurentz completed his PhD in numerical analysis at the Washington State University (USA). From there he upped sticks in order to continue his career as a post-doctoral researcher at Oxford University (United Kingdom), where he worked before joining the ICMAT late last year. He decided to move to Spain for personal reasons and eventually arrived at the Institute, "where I feel very much at home". His research centres on the development of numerical methods used for solving systems of linear equations and computing matrix eigenvalues; types of problems that frequently appear in simulations of physical processes.

## JERRY BUCKLEY

Jerry Buckley (Cork, Ireland) says there was no specific day when he decided that he wanted to devote his professional career to research in mathematics. His vocation emerged gradually throughout his education, although he had always liked science subjects and eventually chose to study mathematics and physics when he went to the University of Cork (Ireland), because it was the broadest option.

When the time arrived to choose what course to study for his PhD, he opted for mathematics, which he did at the University of Barcelona under the supervision of Xavier Massaneda and Joaquim Ortega-Cerdà. As a postdoctoral researcher, he has also spent time at the University of Tel Aviv (Israel), where he collaborated with Mikhail Sodin and Ron Peled, and at King's College of London (United Kingdom), where he worked with Igor Wigman. For his next postdoctoral stay he chose the ICMAT, motivated by the recommendations he had received and also because of his desire to move to Spain.

His research work is focused on zero sets of random functions. In particular, he studies the nodal set of Laplacian eigenvalues, a subject originating in the study of vibrating plates conducted by the German physicist Ernst Chladni in the 18th century, a scientist regarded as the founder of acoustics.

Image: ICMAT

Jerry Buckley.

Image: ICMAT

Daniele Casazza.

## DANIELE CASAZZA

Diophantic equations were the reason why Daniele Casazza (Italy) took up mathematics and dropped music, another of his passions. He completed his degree at the University of Milan (Italy) and in Bordeaux (France), and his end of course project was devoted to elliptic curves. Fascinated by research, he decided to study masters and later do a PhD, which he studied half and half between the Universidad Politécnica de Cataluña (UPC) and Bordeaux University, thanks to a grant from the French minstery. He was co-supervised by his master supervisor, Jean Gillibert (University of Toulouse 2, France), and by Victor Rotger (UPC).

Since November, 2016, he has been at the ICMAT, a place to which he says that "I didn't expect to have access", since little work was done at the Centre in his research area. This situation gives him enough time for his work and provides him with the opportunity to address these problems on his own account. Even so, within this short space of time he has already organized several seminars and has collaborated with other researchers such as Daniel Macías (UAM), a former member of the Institute.

His research line is "fairly modern", even though he is motivated by a classical problem, which furthermore is one of those chosen by the Clay Foundation on its list of Millennium Problems: the Birch and Swinnerton-Dyer conjecture. This concerns finding rational solutions to the diaphantic equation defining an elliptic curve as a geometric object. Some of the recent work carried out by his former thesis supervisor and his collaborators tackles the problem with the so-called p-adics techniques; in particular, using Euler systems. These tools reveal new and very deep relations between mathematical objects that until now were unlinked, and promise new developments and interesting applications of this theory in the near future.

## JAVIER RAMOS

Javier Ramos (Spain) says that he often asks himself why he chose mathematical research, especially when he comes up against a tough problem. However, when he eventually arrives at the result, he finds an affirmative answer to that question. This feeling of a puzzle whose pieces finally fall into place, of extending into new areas of knowledge, overcomes all doubt.

After graduating in mathematics and computer engineering, Ramos gained his PhD from the Autonomous University of Madrid (UAM) under the supervision of Keith Rogers (ICMAT-CSIC) and Ana Vargas (UAM). On completion of his thesis, he moved to Río de Janeiro (Brazil) to work for several years as a postdoctoral researcher at the Institute of Pure and Applied Mathematics. Wishing to return to Spain, he applied for a position at the ICMAT, motivated by the "high quality research conducted there".

He works on one of the central problems of harmonic analysis, the so-called restriction conjecture, which seeks to understand in what spaces of L^p functions the restriction of the Fourier transform to surfaces with non-null Gaussian curvature, such as the sphere, makes any sense. His main collabortaor on this and other related problems is Keith Rogers.

Image: ICMAT

Javier Ramos.

Image: ICMAT

Carolina Vallejo.

# CAROLINA VALLEJO

Carolina Vallejo (Spain) never doubted for a minute that she would stop studying mathematics when she finished her course at the University of Valencia. So she decided to put this desire for further knowledge into action by entering the world of research and seeking to understand as far as possible the nature of things and their implications. She says that while she found algebra hard at first, in her fourth year she became captivated by the Galois Theory. These groups fascinated her because of how they modelled the concept of symmetry in nature; for example, the symmetries of a square for a group known as dihedral. From there she came into contact with the field of group theory and representation theory, and with experts in the area such as the mathematician Gabriel Navarro, who became the supervisor of her master and PhD theses.

Before arriving at the ICMAT, Vallejo worked as a postdoctoral researcher at the University of Manchester. She joined the Institute at the end of 2016, motivated by the excellent references from colleagues and by her personal impressions gained from her participation in courses and congresses. She now forms part of the team headed by Andrei Jaikin (ICMAT-UAM), with whom she is studying representations of finite groups. More specifically, she is working with Representation Theory in an attempt to understand the representations of a group, with special attention to those of the so-called local groups, which are smaller and have particular characteristics. These types of problems are known as global-local problems.

ICMAT
INSTITUTO DE CIENCIAS MATEMÁTICAS

## Thematic program

## ORTHOGONAL POLYNOMIALS AND SPECIAL FUNCTIONS IN APPROXIMATION THEORY AND MATHEMATICAL PHYSICS

**Instituto de Ciencias Matemáticas**
**septiembre-noviembre, 2017**
**Madrid**

This thematic program aims to promote research on ortogonal polyomials and special functions and their connections with related fields such as approximation theory, Fourier analysis, operator theory, random matrices and number theory, numerical analysis, integrable systems in mathematical physics, etc.

The program is jointly organized by ICMAT and the Orthonet network that comprises 14 research groups working in Spain in the field of ortogonal polynomials and special functions, covering a wide range of topics ranging from the fundamentals of orthogonality, to applications in diverse fields and numerical aspects of approximation.

The program includes the following activities:
**-Conference "Integrable systems, symmetries and ortogonal polynomials" (18-22 Sep 2017)**
**-II Orthonet School (23 - 27 Oct 2017)**
**-Research in Groups (16 Oct – 19 Nov 2017)**
**-Seminar cycle (23 Sep – 15 Dic 2017)**
**-IV Orthonet Workshop (17-19 Nov 2017)**

## An ICMAT project helps to warn against cyber attacks like WannaCry

Image: ICMAT

David Ríos.

For many companies, institutions and administrative bodies that handle large amounts of information and which are increasingly interconnected, cyber security is a key question that remains unresolved. Proof of this is the recent WannaCry ransomware attack whose hackers "kidnapped" more than 360,000 infected computers in 180 countries and then demanded ransome payments for their release, according to data from the *Instituto Nacional de Ciberseguridad* (Incibe – Spanish National Cybersecurity Institute). With the aim of alerting against these types of attacks, CYBECO (Supporting Cyberinsurance from a Behavioural Choice Perspective) has been set up, a European research project which includes the participation of scientific director David Ríos, researcher at the *Instituto de Ciencias Matemáticas* (ICMAT – Institute of mathematical Sciences) and holder of the AXA Chair.

"The main aim is to develop new mathematical models in order to produce tools and products, particularly insurance policies, to help build a safer network and safer communcations systems," explains Ríos. "We want to transfer the mathematical models that are being successfully applied in the field of physical security to the world of cyber security". To that end, through its Horizon 2020 programme, the European Union has assigned two million euros over a period of two years.

"With mathematics you can build risk analysis and adversarial risk analysis models capable of anticipating these types of attacks and their consequences in the virtual world," says Ríos. The project employs techniques for predicting behaviour in the decisions made by individuals, whether they are cyber attackers, for determining possible risks, or whether they are those in charge of computer and insurance infrastructures, for improving their choice and offer of services.

In addition to the ICMAT, other institutions are participating, such as Intrasoft International S.A. (Luxembourg), Devstat Servicios de Consultoría Estadística S.L. (Valencia), AXA Technology Services (France), Technische Universiteit Delft (Low Countries) and Northumbria University Newcastle (United Kingdom). The project is coordinated by Trek Development S. A. (Greece).

## The ICMAT celebrates Darryl Holm's 70th birthday with a congress

Image: ICMAT

Darryl Holm.

From July 3rd to July 7th the *Instituto de Ciencias Matemáticas* (ICMAT) paid tribute to Darryl Holm (Imperial College) on the occasion of his 70th birthday with the congress *New trends in applied geometric mechanics*, which was held at the centre and was attended by more than 70 experts from all over the world. Holm's relations with the ICMAT go beyond the strictly professional; as he says: "I've gotten to know many members of the ICMAT at congresses all over the world, so I have many friends and colleagues at the Institute".

Darryl Holm started out at the Los Alamos National Laboratory (LANL), where he contributed with his studies towards the USA and the USSR signing in 1990 an agreement that established a power threshold for nuclear tests. In 2005, Holm went to live in London, where he is a professor of Geometric mechanics at Imperial College. That same year he was awarded the Wolfson Prize by the Royal Academy of London for his scientific career. Since then he has been behind important projects such as *CardioMath*, which studies cardiac arrythmia from the mathematical point of view. Furthermore, in the field of health he developed the *Five Challenges in Computational Anatomy*, a project for which in 2011 he was distinguished by the *European Research Council* (ERC), and thanks to which models were developed for eliminating noise and interpreting images for clinical diagnosis.

Image: ICMAT

Assistants to the congress.

## The ICMAT launches a collection of books to bring mathematical research into the classroom

Mathematics often appears to pupils as a self-contained body of knowledge without evolution over time or relation to the rest of the world. Given this situation, the ICMAT and the Federación Española de Sociedades de Profesores de Matemáticas (FESPM – Spanish Federation of Mathematics Teachers), together with Los Libros de la Catarata publishing company, are launching a collection of books called Miradas Matemáticas, which combine outreach with teaching in order to present mathematics as a living science to teachers and students of secondary education and baccalaureate. Advances in mathematics are introduced in these books on the basis of the fundamental concepts taught in schools, in an enlightening and informative way and with a historical perspective, thereby connecting maths with other sciences and technological developments.

The first book in the collection, "La engañosa sencillez de los triángulos" ("The Deceptive Simplicity of Triangles"), is authored by Manuel de León (CSIC-ICMAT) and Ágata Timón (CSIC-ICMAT), who are also members of the Editorial Committee of the project. The target readership for these books consists of Secondary School and Baccalaureate teachers of mathematics. According to the authors, "the aim is to provide them with new ideas for developing material for bringing mathematics into the classroom in an interesting and attractive way". However, all these books can be enjoyed by a much wider readership as outreach texts in which the exercises they contain become challenges for all age groups.

All the topics addressed in the collection correspond to the maths curriculum at different educational levels, so the contents can be introduced into the lessons with ease. The first book in the series is devoted to one of the most basic elements in geometry, triangles, which have been studied from the earliest times, and despite their apparent simplicity, have given rise to modern developments in mathematical research.


Image: ICMAT

"La engañosa sencillez de los triángulos" es el primer título de la colección 'Miradas Matemáticas'.

*"Miradas Matemáticas"* is co-produced by the ICMAT, the FESPM and Los *Libros de la Catarata* publishing company. The editorial committee for this collection is composed of Onofre Monzó (FESPM), Agustín Carrillo (FESPM), Manuel de León (CSIC-ICMAT), Ágata Timón (CSIC-ICMAT), Marco Castrillón (UCM-ICMAT), Juan Martínez Tébar (FESPM), Javier Senén (Libros de la Catarata) and Fernanda Febres-Cordero (Libros de la Catarata).

## Diego Córdoba, the ICMAT 2018 invited speaker for his contributions towards solving the Sixth Millennium Problem

The Navier-Stokes problem – the system of equations governing the motion of fluids and for which it is not yet proven that has solutions for all times and whether these solutions are unique – was in the year 2000 declared as one of the seven Millennium Problems for its importance and one million dollars was offered for its solution. A researcher belonging to the *Instituto de Ciencias Matemáticas* (ICMAT – Institute of Mathematical Sciences), Diego Córdoba, is one of the few who has taken the first steps towards resolving the question, and has been invited as guest speaker at the most important mathematical event in the world, the ICM (the International Congress of Mathematicians), which is to be held in Brazil next year. He thus becomes the twelfth Spanish scientist to have been given the opportunity to speak at this forum since it was first held in 887. "This recognition shows that the ICMAT is firmly on the map of cutting-edge research in the world," says Córdoba.

Every four years, the ICM scientific committee convenes the mathematical researchers who have obtained the most outstanding results in their fields to present these results to the mathematical community. On this occasion, Córdoba will speak about his work in the area of partial differential equations. As Córdoba explains: "We are the first to prove that singularities exist in the equations that model the dynamics of incompressible fluids in certain contexts. If we manage to resolve the Navier-Stokes case, we will have solved this Millennium Problem". At the moment, the one million dollars is still out of reach, but what he and his team has done is "to situate the ICMAT at the forefront of the researcher centres that lead in this line of research".

Image: ICMAT

Diego Córdoba.

## Razvan Iagar (ICMAT) publishes his book "What do we know about Mathematics and Chess?"

Image: ICMAT

Razvan Iagar.

**Number 84 in the scientific outreach collection 'What do we know about?' (CSIC-Catarata) is devoted to mathematics; in particular, the relation between this scientific discipline and a millenial game: chess. Its author is Razvan Iagar, an ERC post-doctoral researcher at the ICMAT who is an expert in nonlinear parabolic partial differential equations and a chess player.**

In the world of chess many mathematicians can be found, such as Claude Shannon or Alan Turing, and engineers devoted to both playing and researching the game. The new book in the '¿Qué sabemos de?' ("What do we know about?") collection, published by the CSIC and Los Libros de la Catarata, explains the influence of mathematics on the development of chess.

Razvan Iagar, a researcher at the Instituto de Ciencias Matemáticas (ICMAT) and author of the text *Mathematics and Chess*, recounts the first attempts by chess players in the 19th and 20th centuries to establish rules for the game on a mathematical basis, up to the current powerful algorithm-based programmes whose expertise has defeated the world's leading chess masters. Apart from being a scientist, Iagar is also a chess player who is active in international competitions, and in his book poses the question whether machines can outdo human beings. In other words, if with current computer modules it is possible to find a perfect strategy for white pieces and black pieces from the first move to the end of the game; that is, to see if the "perfect game" really exists.

Razvan Iagar graduated in Mathematics from the University of Bucharest and gained his PhD in Mathematics and Applications from the UAM. He is currently an ERC post-doctoral researcher at the Institute of Mathematical Sciences (ICMAT) in Madrid. He is a winner of the Gheorghe Lazar Prize for Research from the Romanian Academy.

## Manuel de León receives the Royal Spanish Mathematical Society medal

Image: ICMAT

Manuel de León.

The Real Sociedad Matemática Española (RSME – Royal Spanish Mathematical Society) has awarded one of its Medals to CSIC researcher and ICMAT founder, Manuel de León. This is the third year of the prize by which the RSME distinguishes "people who have done outstanding work for the mathematical society in all its different facets: research, outreach, teaching, gender equality, etc.", says David Martín de Diego, deputy director of the ICMAT and vice-chair of the RSME. The resolution, which was announced on Sunday, June 25th, in the society's official bulletin, has also distinguished Antonio Campillo, a professor at the University of Valladolid and exchair of the RSME, and Marta Sanz-Solé, a researcher at the University of Barcelona and ex-chair of the European Mathematical Society.

The Medal jury emphasized de León's energizing role in the RSME, and in its refounding, as one of the creators of the La Gaceta and one of the promotors of DIVULGAMAT and the Women and Mathematics Commission. In its communcation, the Society stated that, "in this sense, the jury wishes to remark on his great commitment to gender equality in all spheres and his untiring work in outreach activities".

## Javier Gómez Serrano, former PhD student at the ICMAT receives the Vicent Caselles Prize from the RSME and the BBVA Foundation

The *Real Sociedad Matemática Española* (RSME – Royal Spanish Society of Mathematics) and the BBVA Foundation have announced the result of the third edition of the Vicent Caselles Prizes, which have been awarded annually since 2015 to young mathematicians who have completed their PhD theses at a Spanish university or scientific centre. Among the seven prize winners this year is a former member of the ICMAT, Javier Gómez Serrano (Madrid, 1985), who gained his doctorate at the Institute in 2013 under the supervision of Diego Córdoba (ICMAT) and who still maintains a close relation with the centre thrugh the Charles Fefferman Laboratory, of which he forms part. Gómez Serrano is an assistant professor at Princeton University (USA), where he works in the area of fluid mechanics and singularities.


Image: ICMAT

Javier Gómez Serrano.

## ICMAT researcher Jared Aurentz awarded the Society for Industrial and Applied Mathematics (SIAM) prize

Image: ICMAT

Jared Aurentz.

Finding the roots of a polynomial is a common activity in high school mathematics classes. As the number of variables and their degree increase, the more difficult it becomes to find the roots, and depending on the type of equation it may be impossible, so approximations are used instead. This is a task that requires the help of computers.

Post-doctoral researcher at the Instituto de Ciencias Matemáticas (ICMAT), Jared L. Aurentz, has been distinguished with the 2017 SIAM Prize for developing a "very fast" algorithm "with a guarantee of precision" for the resolution of polynomial roots. Specifically, the Society for Industrial and Applied Mathematics (SIAM) chose an article entitled "Fast and Backward Stable Computation of Roots of Polynomials", also co-authored by Thomas Mach (KU Leuven, Belgium), Raf Vandebril (KU Leuven, Belgium) and David S. Watkins (Washington State University, USA), as one of the most outstanding articles to be published last year in the "SIAM Journal on Matrix Analysis and Applications" (SIMAX).

## Alejandro Luque receives the Barcelona Dynamical Systems Prize 2017

The *Societat Catalana de Matematiques* (SCM – Catalan Mathematical Society) has awarded the 2017 Barcelona Dynamical Systems Prize to Alejandro Luque (ICMAT), Jordi-Lluís Figueras (University of Upsala, Sweden) and Àlex Haro (University of Barcelona) for their article Rigorous Computer-Assisted Application of KAM Theory: A Modern Approach, published in the journal Foundations of Computational Mathematics late last year, 2016, and reviewed in this issue of the ICMAT Newsletter.

The jury highlighted the new strategies in computational mathematics (in particular, the so-called KAM theories) contributed by these researchers for the construction of invariant tori. The SCM stated that, "these advances consist of improvements in the theoretical and computational methods that yield more robust results in specific examples, such as the standard map, the non-twist standard map and the Froeschlé map".

Image: ICMAT

Alejandro Luque.

## The future of mathematical education, under debate

Image: ICMAT


Marco Castrillón (ICMAT-UCM) was in charge of presenting the plenary lecture of the Brazilian Rute Borba.

"We view the future of mathematical education with optimism". This is the phrase that presided over the 8th edition of the CIBEM, the *Congreso Iberoamericano de Educación Matemática* (Ibero-American Congress of Mathematical education), held between July 10th-14th at the Complutense University of Madrid. It was organized by the Federación Española de Sociedades de Profesores de Matemáticas (FESPM) through the Sociedad Madrileña de Profesores de Matemáticas "Emma Castenuovo" (SMPM), and convened by the Federación Iberoamericana de Sociedades de Educación Matemática (FISEM). Among other institutions, it was also supported by the collaboration of the ICMAT.

The congress was a meeting between teachers and others from the world of mathematics interested in teaching. It was attended by about 1,600 people from 16 different Ibero-American countries. The CIBEM has been held every four years in different Ibero-American cities since 1990.

Federación Española de Sociedades de Profesores de Matemáticas (FESPM – Spanish Federation of Teachers of Mathematics)

Sociedad Madrileña de Profesores de Matemáticas "Emma Castenuovo" (SMPM – "Emma Castenuovo" Madrid Society of Teachers of Mathematics)

Federación Iberoamericana de Sociedades de Educación Matemática (FISEM – Ibero-American Federation of Societies of Mathematical Education)

# AGENDA

## ICMAT Scientific activities

**The third Japanese-Spanish workshop on Differential Geometry**
**Date:** September 18th - 22nd, 2017
**Venue:** ICMAT, Madrid (Spain)

**Thematic program `Orthogonal polynomials and Special functions in approximation theory and mathematical physics` - Integrable systems, symmetries, and orthogonal polynomials**
**Date:** September 18th - 22nd, 2017
**Venue:** ICMAT (UAM)

**The music of numbers a 3-day conference in honour of Javier Cilleruelo**
**Date:** September 20th - 22nd, 2017
**Venue:** ICMAT (UAM)

**Thematic program `Orthogonal polynomials and Special functions in approximation theory and mathematical physics` - School on Orthogonal Polynomials in approximation theory and mathematical physics**
**Date:** October 23rd - 27th, 2017
**Venue:** ICMAT (UAM)

**Thematic program `Orthogonal polynomials and Special functions in approximation theory and mathematical physics` - IV encuentro de la Red de Polinomios Ortogonales y Teoría de Aproximación (Orthonet 2017)**
**Date:** November 17th and 18th, 2017
**Venue:** San Lorenzo de El Escorial (Madrid)

ICMAT
INSTITUTO DE CIENCIAS MATEMÁTICAS

**Quarterly Newsletter**
**Instituto de Ciencias Matemáticas**
#15 – Second quarter 2017

**Production:**
Instituto de Ciencias Matemáticas (ICMAT)
C/ Nicolás Carrera nº 13-15
Campus de Cantoblanco, UAM
29049 Madrid ESPAÑA

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

**Editorial Committee:**
Jared Aurentz
Antonio Córdoba
Alberto Enciso
Daniel Peralta-Salas
Ágata Timón

**Coordination:**
Ignacio F. Bayo
Laura Moreno Iraola
Ágata Timón

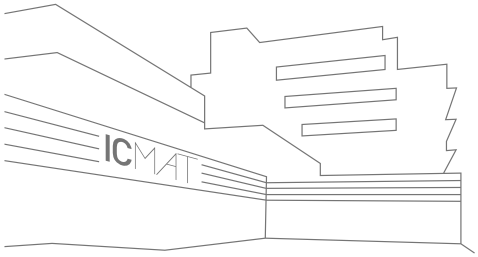
**Design:**
Fábrica de Chocolate
**Layout:**
Equipo globalCOMUNICA

**Translation:**
Jeff Palmer

**Editorial department:**
Elvira del Pozo
Laura Moreno Iraola
Alicia A. Cortés
Ágata Timón

ICMAT

INSTITUTO DE CIENCIAS MATEMÁTICAS




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