



# annual report 2020 www.icmat.es













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## ICMAT Annual report 2020



The Institute of Mathematical Sciences (www.icmat.es) is a joint research of the Consejo Superior de Investigaciones Cientificas (CSIC, Spanish National Research Council) and three Madrid universities: Universidad Autónoma de Madrid (UAM), Universidad Carlos III de Madrid (UC3M) and Universidad Complutense de Madrid (UCM).

The ICMAT is a leading international research center in mathematics, recognized by the <u>Spanish accreditation of excellence Severo</u> <u>Ochoa</u>. Our annual report is a summary of the ICMAT activity during the year 2020.

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#### 2020, the year we wish we could have dodged

#### José María Martell, director of the ICMAT

There is little doubt that many of us would have liked to have omitted 2020, when we were hit by the worst scenario forecast by some scientists. In a matter of days most of our world went into lockdown, an event that will go down in history, and not exactly for the best reasons. Faced with an enormous social challenge, science has created a remedy in a record time, not only as a result of the latest scientific advances developed in laboratories, but also thanks to the body of knowledge underpinning these. Specifically, these advances are founded on basic science such as mathematics, which while not necessarily leading to immediate practical applications, has been vital for understanding the physical, biological and sociological phenomena involved in the propagation and cure of infectious diseases.

2020 should have been a relatively tranquil year for the ICMAT, which after having completed the second Severo Ochoa programme was expecting a period of low activity, during which we would find out whether the centre would be awarded a further recognition. At the beginning of 2020, the CSIC provided us with a grant for the continuation of some of the projects we had in the pipeline. Although at that time we had no large conferences planned, and no research schools or trimesters in view, this grant nevertheless enabled us to extend management contracts, continue with the master grants, organize the JAE School and keep seminars running, etc.

However, this relative calm abruptly turned into an imposed slowdown, as a general lockdown with no historical precedent, forced to remain indoors for many weeks. All travel, visitors, meetings with students, discussions in front of the blackboard were suspended. Some people fell ill while others worried over the illness of their loved ones; some had to look after their children or relatives who depended on them, and our vital social lives and livelihoods became digital and remote.

During the months of lockdown, the ICMAT was practically deserted and we had no choice but to get used to the new reality of life online and via video-link. Throughout that time, the centre was subject to a restricted access, and only those with a justified cause were allowed in. This was enforced by the reception and security personnnel, who remained at their posts even when the epidemic was at its height. The centre opened again when the lockdown measures were eased and a strict Contingency Plan was introduced in order to guarantee the health and safety of all personnel.

Since then, we have had to adapt to the "new normality" and to mobility restrictions, and the ICMAT has entered a period of hybrid operation, with very little physical presence or activity at the centre and a considerable number of online seminars. This virtual way of operating is not without its advantages, such as extending the impact of meetings to the public, as well as a better work-family life balance. But it also has its disadvantages, since it reduces the spontaneous interaction between colleagues and leads to a great deal of digital tiredness. In any case, it is thanks to these technological tools that activity at the ICMAT has been able to continue, and in 2020 the institute was able to hold five virtual conferences, as well as seminars and other informal meetings. Furthermore, we have succeeded in providing administrative and ICT help and service for researchers as well as for the development of projects and the maintenance of communication and outreach activities.

The provisional resolution of the Severo Ochoa programme was published early last summer, with the decision to award the seal of excellence to the ICMAT for the third consecutive time. We had to wait until the end of the year for the decision to be confirmed, with a starting date on January 1<sup>st</sup>, 2020, and for a fixed period ending in late 2023. An Executive Committee was appointed after the official announcement, and since then has been drawing up a programme for the next few years, allocating the four million-euro funding to the different areas. The centre is now embarking on a new stage in which some well-established activities will be maintained, some others will commence, all with the ultimate aim of continuing with the excellent research done at the institute.



José María Martell, director of the ICMAT



## 2. The ICMAT in figures

#### Personnel



#### Scientific activities

- Workhops and schools: 7
- Courses, conferences and working groups: 2
- Colloquia: 3
  - UAM-ICMAT Colloquium: 1
  - ICMAT-UCM Colloquium: 2
- Seminars: 93
- Theses: 14 •
- JAE School 2020: 1

- Press releases: 9
- News items: 50
- Articles:
  - 'Café y Teoremas': 47
  - ICMAT Blog: 20
- ICMAT Newsletter: 2
- Followers on social media (December 2020)

Facebook: 30 408 followers, 29 305 'likes' f

- Twitter: 27 750 followers y
- Instagram: 3190 followers 0
- YouTube: 2072 subscribers; 55 700 views

Outreach activities: 13

Outreach materials: 16

#### **Publications**





## Women at ICMAT

#### ICMAT Funding 2020

- Sources:
  - 1. Private company: 683 853,41 €
  - 2. Europe: 160 932,48 €
  - 3. Out of EU: -
  - 4. Spain: 4 681 665 €
  - 5. Regional: 20 700 €
  - 6. Others: 612 425,07 €
- Total public funding: 5 855 876 €

#### ICMAT Expenditure 2020

- Personnel expenditure: 614 603,96 €
- Activities:
  - Workshops, conferences and schools: 7163,38  ${\ensuremath{\varepsilon}}$
  - Thematic research programmes: 19 599,76 €
  - Seminars: 4874,76 €
- Others (infrastructure, subscriptions, library, fungible, material inventory, training, representation): 178 403,06 €
- Communication and outreach: 29 437,16 €
- Master scholarships: 108 178,75 €
- ICMAT Labs and Distinguished Professors: 14 045,22 €
- Travel expenses: 65 336,69 €
- Introduction to research scholarship programmes: 3503,11 €
- Visitors programme: 24 059,89 €

#### Total expenses: 1 069 205,74 €





### 3. Personnel

At the beginning of 2020, and after the process for the election of a director held in the autumn of 2019, José María Martell (ICMAT-CSIC) was appointed as director of the ICMAT. At his proposal, Eva Gallardo (ICMAT-UCM) was appointed as deputy director, and Javier Aramayona (ICMAT-CSIC) and Fernando Quirós (ICMAT-UAM) as head of the Fundamental Mathematics and Applied Mathematics departments, respectively.

Likewise, the new committees were formed in the following areas: Scientific, External and Internal Institutional Relations, Equality, Internal Procedure, Postgraduate, Library, ICT and the Unit of Scientific Culture. This structuring of activity at the centre into different work groups is aimed at coordinating the efforts and guidance of the management team as well as enabling ICMAT personnel to become more involved in the decision-making process.

Renewal of the personnel representatives on the ICMAT Board also took place in the autumn. Voting resulted in the reelection of Daniel Peralta (ICMAT-CSIC) and the election of two new scientists, José María Arrieta (ICMAT-UCM) and José Manuel Conde (ICMAT-UAM). Ana María Mancho (ICMAT-CSIC) and Javier Parcet (ICMAT-CSIC) stepped down from the Board here, we take the opportunity of expressing our gratitude for all the work they have done for the ICMAT. Together with the executive team and the manager of the CFTMAT who acts as a secretary, these new personnel representatives will make up the ICMAT Board until the end of 2024. Some of the tasks of the Board will consist of drawing up a new action plan at the institute; notifying the annual report of activities; drafting the budget of the institute and reporting on the assignment of personnel from the UAM; the UC3M and the UCM, as well as submitting proposals to the Steering Committee for modifications to the Internal Regulations and Procedures.

Javier Aramayona joined the ICMAT as a Senior Scientist in the summer of 2020, while in the autumn CSIC exams were held for two posts, one for that of Senior Scientist and the other for Research Professor, which were successfully completed by Nuno Freitas and David Ríos, respectively. Researcher Nuria E. Campillo from the CSIC Margarita Salas Centre for Biological Research joined the ICMAT on a temporary basis for a one-year stay.

A new member of the management team was Teresa Ruiz (IC-MAT-UAM), charged with administrative tasks, and also Teresa López, who was hired for the management of the CSIC Extraordinary Support for the Severo Ochoa project. There was also a replacement at the Europe and Transfer Office, which saw the arrival of Monica Castresana, while at the end of the year Marc Cornadó joined the institute on a "Garantía Juvenil" contract to provide support for the management of ICMAT projects.

In addition, 19 post-doctoral and 20 pre-doctoral researchers joined the institute (both through the CSIC and the universities) in 2020. Seven JAE-INTRO SOMdM grants were also awarded to master students, seven further JAE-INTRO research introduction grants to university students, and 25 grants for the Severo Ochoa introduction to research.



#### 3.1. Research groups

At present, the ICMAT is structured around three main research groups:

- GROUP A: <u>Algebra and geometry</u>
- GROUP B: Mathematical analysis and differential equations
- GROUP C: <u>Applied mathematics</u>

#### GROUP A: Algebra and geometry

The group conducts research in a broad variety of topics, in the areas of abstract algebra (group theory, commutative algebra), algebraic geometry (arithmetic geometry, number theory, moduli spaces of bundles), differential geometry (geometric analysis, geometric mechanics, dynamical systems and the geometry of PDEs) and topology (topological fluid dynamics, symplectic and contact topology, low-dimensional topology).

As such, our research is naturally interdisciplinary, fostering an important level of cross-fertilization between the different areas. In addition, a number of the themes we study find their motivation in ideas stemming from physics, such as special metrics, gauge theories and their algebro-geometric counterparts.

The main research lines may be grouped into the following four general directions:

- Algebraic geometry and mathematical physics: The research of this line is devoted to the study of moduli spaces of vector bundles and related objects, and their interplay with various algebraic and geometric structures, involving techniques from algebraic geometry, differential geometry, topology, Lie theory, geometric analysis and theoretical physics.
- Differential geometry, symplectic geometry and geometric mechanics: The research of this line centres on differential and contact topology, differential and riemannian geometry, geometric mechanics with applications to control theory, dynamical systems and the geometry of PDEs.
- **Group theory:** This line includes several areas of group theory with applications to other fields, such as ring theory, topology, dynamics, and logic. Connecting threads of this line are the approximation of infinite groups by finite structures, and the study of groups through their actions on non-positively curved spaces.
- Arithmetic geometry: The research in this line is devoted to problems at the core of arithmetic geometry, like the equivariant Tamagawa number conjecture or the development of Arakelov geometry, as well as its interplay with related fields like complex and non-Archimedean analysis, algebraic geometry and even theoretical physics.

The following researchers are part of this group:

#### Faculty

- Luis Álvarez
- Yago Antolín
- Javier Aramayona
- Ana Bravo
- José Ignacio Burgos
- Manuel de León
- José Francisco Fernando
- Oscar Segundo García-Prada
- Tomás Luis Gómez
- Luis Guijarro
- Andrei Jaikin
- Ignacio Luengo
- David Martín

- Daniel Peralta
- Francisco Presas
- Piergiulio Tempesta
- Orlando Villamayor

#### Members

- Giovanni Bazzoni
- Federico Cantero
- Leonardo Colombo
- Mario García
- Daniel Macías
- Carolina Vallejo

#### Doctoral students

- Alexandre Anahory
- Julio Aroca
- Guillermo Barajas
- Miguel Ángel Berbel
- Jan Boschheidgen
- Andoni de Arriba
- Celia del Buey
- José Luis Carmona Jiménez
- Bilsono Castro López
- Dahyana Eugen Farias
- Eduardo Fernández
- Manuela Gamonal Fernández
- Raúl González
- Jacob Goodman
- Manuel Lainz
- Xabier Legaspi
- Diego López
- Hang Lu
- Javier Martínez Aguinaga
- Enrique Martínez Cardenal
- Manuel Mellado
- Samuel Ranz
- Daniel Reyes Nozaleda
- Álvaro Rodríguez
- Álvaro Romaniega
- Guillermo Sánchez Arellano
- Roberto Téllez
- Didac V. Aris

#### Associated members

- María Barbero
- Juan Carlos Marrero
- Eva Miranda
- Edith Padrón
- Ana José Reguera
- Cristina Sardón

#### Master students

- Jesús Aguado López
- Verónica Arroyo Rodríguez
- Alejandro Fernández Jiménez
- Jorge Hidalgo
- Asier López Gordón
- Eduardo de Lorenzo
- Alejandro Mahillo Cazorla
- Ismael Morales López
- Rodrigo de Pool Alcántara
- Daniel Isaac Puignau Chacón
- Wei Zhou



In 2020, this group organised the following seminars weekly:

- Group theory Seminar
- Number theory Seminar
- Geometry Seminar
- Geometric mechanics and control Seminar
- Commutative algebra, algebraic and arithmetic geometry Seminar

#### **GROUP B: Mathematical analysis and differential equations**

Mathematical analysis and partial differential equations are very active, deeply interrelated fields of research with a preponderant position within the mathematical sciences. This line deals with fundamental problems in the fields of harmonic analysis, partial differential equations, geometric group theory, functional analysis, geometric measure theory, operator algebra, differential geometry and probability, and has been awarded with a total of seven ERC grants.

The group is formed by two sublines:

- Mathematical analysis: This subline focuses on classical problems around the Kakeya conjecture and Bochner-Riesz multipliers, the Schrödinger and wave equations, elliptic PDE in rough domains and connections with geometric measure theory, harmonic analysis and geometric group theory for nonamenable groups, classical and abstract Calderón-Zyg-mund theory and problems around the invariant subspace problem. Other fields such as operator theory, geometry of Banach spaces, complex analysis, quantum probability and analytic number theory are also well represented.
- **Differential equations and applications:** This subline studies differential equations arising in fluid mechanics, spectral theory, mathematical physics and mathematical biology. This is an interdisciplinary subject, with significant applications to engineering, biology and physics.

The following researchers are part of this group:

#### Faculty

- José María Arrieta
- Daniel Azagra
- Matteo Bonforte
- Florentino Borondo
- Ángel Castro
- Fernando Chamizo
- Diego Córdoba
- Alberto Enciso
- Daniel Faraco
- Eva Gallardo
- María del Mar González
- Manuel Mañas
- José María Martell
- Jesús Munárriz
- Rafael Orive
- Javier Parcet
- Fernando Quirós
- Aníbal Rodríguez

Moreover, it organised a study group on Euler systems and the "<u>Groups in Madrid"</u> workshop (November 28-29, 2019).

The following CSIC research groups are involved in Group A:

- <u>GROUP 4: Algebraic geometry and mathematical physics</u>
- GROUP 5: Differential geometry and geometric mechanics
- <u>GROUP 8: Group theory</u>
- GROUP 9: Number theory
- Keith Mckenzie Rogers
- Alberto Ruiz
- Pedro Tradacete
- Dmitry Yakubovich

#### Members

- Davide Barbieri
- Pablo Candela
- Mingming Cao
- José Manuel Conde
- Elena di Lorio
- Nastasia Grubic
- Matthew Blair Hernández
- Teresa Elvira Luque
- María Medina de la Torre
- Javier Montés Maldonado
- Ana Primo
- Javier Ramos
- Daniel Seco
- Fan Zheng

#### **Doctoral students**

- Antonio Ismael Cano
- Víctor Cañulef
- Laia Domingo Colomer
- Alejandro Garriz Molina
- Miguel García
- Diego González
- Francisco Javier González
- Irene Gonzálvez
- M. Mar Grande Toledano
- Peio Ibarrondo
- Glenier Lázaro Bello
- Luis Martínez
- Francisco José Mengual
- Manuel Miranda
- Miguel Monsalve
- Jesús Ocáriz
- Elena Salguero
- Omar Sánchez
- Jaime Santos
- Eduardo Tablate Vila

#### Associated members:

• Antonio Córdoba

#### Master students:

- Sandro Barisi Marín
- Joaquín Domínguez de Tena
- Alba Dolores García Ruiz
- David de Hevia Rodríguez
- Pablo Hidalgo
- José Manuel Navarro
- David Rello
- Eduardo Tablate

#### **GROUP C: Applied mathematics**

This research group works to develop the mathematical foundations and models needed to deal with the main new societal challenges, with a focus on data science, machine learning and quantum technologies. It is divided in the following research lines:

- Mathematics of quantum information theory: Quantum technologies are nowadays one of the most promising technologies for the near future. They exploit quantum effects to develop new techniques in fields like cryptography, metrology, material science, pharmacology and many others, which have the potential to go far beyond the current (classical) state of the art. The group "Mathematics and quantum information" at ICMAT works in a wide variety of mathematical problems which are motivated by quantum technologies. Some of the topics considered in this line are: condensed matter and many body systems, quantum control, foundational aspects of quantum mechanics and the theory of operator algebras.
- Machine learning and data science: Machine learning and data science are disciplines that are at the core of many current significant societal developments. Embedded in the disciplines of statistics, probability, optimization and algebra, with strong support from computer science developments, this line emphasizes methodological developments focusing on providing efficient bayesian approaches to the treatment of large scale inference and prediction problems and methods to deal with the presence of adversaries ready to perturb the data and structure in a problem though adversarial risk analysis and adversarial machine learning. Moreover, it also emphasizes dealing with complex applied problems mainly in the areas of security and cybersecurity, with the aid of its DataLab.
- **Mathematical modelling and simulation:** This covers a wide spectrum ranging from the multidisciplinary mathematical approach to the problems, with emphasis in numerical computation, to the promotion of applications by means of collaborations with other departments such as engineering, biology, physics and earth sciences all around the world. Research include topics such as microfluidics modelling and technological applications, geophysical fluid dynamics, etc.

The following researchers are part of this group:

#### Faculty

- Marco Antonio Fontelos
- Alberto Ibort
- Fernando Lledó
- Carlos Palazuelos
- David Pérez
- Carlos Rascón
- David Ríos
- Ignacio Villanueva

In 2020, this group organised the following seminars weekly:

- Analysis and applications Seminar
- PDEs and fluid mechanics Seminar
- Number theory Seminar
- Online Analysis and PDEs Seminar

It also participated in the organisation of the study group on Euler systems, previously mentioned.

The following CSIC research groups are involved in Group B:

- GROUP 1: Mathematical analysis
- <u>GROUP 2: Differential equations and applications</u>
- GROUP 9: Number theory

#### Members

- Jared Aurentz
- Carlos Calvo Tapia
- Jezabel Curbelo
- Fabio di Cosmo
- John S. Fabila Carrasco
- David Gordo
- Jose Antonio Jiménez
- Víctor Manuel Jiménez Morales
- Alex Kosgodagan
- Juan Manuel Pérez
- Alberto Torres

#### **Doctoral students**

- Patricia Contreras
- John Stewart Fabila
- Bruno Flores
- Victor Adolfo Gallego
- Guillermo García
- José Garre
- Si Liu
- Luis Diego Martínez
- Adrián Martínez
- Roi Naveiro
- Alberto Redondo
- Simón Rodríguez
- Alberto Ruiz de Alarcón

#### Associated members

Carlos Escudero

#### Master students

- Renzo Bruera
- Esperanza Garijo

In 2020, this group organised the following seminars regularly:

- Applied mathematics Seminar
- DataLab Seminar
- Q-Math Seminar

The following CSIC research groups are involved in Group C:

- <u>GROUP 3: Statistics, probability and operations research</u>
  <u>(SPOR)</u>
- <u>GROUP 6: Mathematics of quantum information:</u>
  <u>foundations and applications</u>
- <u>GROUP 7: Mathematical modelling and simulation</u>



#### 3.2. Executive team and Board



Ana María Mancho

Javier Parcet

Daniel Peralta

Miguel Anchuelo

José María Arrieta

José Manuel Conde

#### **ICMAT Committees**

- Scientific Committee
  - Chairmen: Alberto Enciso, José María Martell.
  - Members: Diego Córdoba, Oscar García-Prada, Andrei Jaikin, David Pérez, David Ríos
  - Support Staff: Mónica Castresana
- Committee of Internal Institutional Relations
  - Chairmen: Fernando Quirós
  - Members: Luis Álvarez-Cónsul, Eva Gallardo, Fernando Lledó
  - Support Staff: Esther Fuentes/Teresa López
- Committee of External Institutional Relations
  - Members: José María Arrieta, Daniel Peralta, José María Martell
  - Support Staff: Mónica Castresana
- Mathematical Culture Unit
  - Chairmen: David Martín, José María Martell
  - Coordinator: Ágata Timón
  - Members: Javier Aramayona, Alberto Enciso, Daniel Peralta, Fernando Quirós
  - Support Staff: Laura Moreno Iraola

- Equality Committee
  - Chair: Ana Bravo
  - Coordinator: Ágata Timón
  - Members: Javier Aramayona, Eva Gallardo, David Martín
  - External Members: Marina Logares (UCM), Marta Macho-Stadler (EHU), Catalina Martínez (IPP)
  - Support Staff: Laura Moreno Iraola
- Committee of Internal Regulations
  - Chair: Tomás Gómez
  - Members: Luis Guijarro, Ignacio Villanueva, Alberto Ibort
  - Support Staff: Esther Fuentes
- Postgraduate Committee
  - Chairmen: Ángel Castro, Pedro Tradacete
  - Members: José Francisco Fernando, Ana Primo, Daniel Seco
  - Support Staff: Esther Ruiz
- Library Committee
  - Members: José Manuel Conde, Mario García
  - Support Staff: Teresa Ruiz
- ICT Committee
  - Members: Davide Barbieri, Ignacio Luengo, Daniel Macías
  - Support Staff: Eduardo de Córdoba, Alfonso Núñez





#### 3.3. ICMAT External Scientific Advisory Committee



From left to right and top to bottom, Martin R. Bridson (University of Oxford), Luis Caffarelli (Texas State University), Peter Constantin (Princeton University), Frances Kirwan (University of Oxford), Jill Pipher (Brown University), Antonio Ros (Universidad de Granada), Claire Voisin (College de France) y Shing-Tung Yau (Harvard University).

The ICMAT External Scientific Advisory Committee, approved by the Centre's Board of Directors at the end of 2019, is composed of eight prestigious international mathematicians:

Martin R. Bridson (Isle of Man, 1964) is Whitehead Professor of Pure Mathematics at Oxford, and the current President of the Clay Mathematics Institute. Bridson is internationally renowned for his contributions to group theory and low-dimensional topology, where his results about geometric and algorithmic properties of groups have been deeply influential. Together with Haefliger, he authored the monograph "Metric Spaces of Non-Positive Curvature" which, with nearly 2000 citations, has become a keystone of the field of geometric group theory. Bridson obtained his PhD in 1991 at Cornell, and subsequently held positions at Princeton, Geneva, and Imperial, before joining Oxford in 2007. He has been a recipient of the LMS Whitehead Prize (1999), the Wolfson Research Merit Award of the Royal Society (2012), and the Steele Prize of the American Mathematical Society (2020). He was an Invited Lecturer at the 2006 International Congress of Mathematicians, and is a Fellow of the Royal Society since 2016.

Luis Caffarelli (Argentina, 1948) is Sid W. Richardson Foundation Regents Chair in Mathematics No. 1 Professor of Mathematics at the University of Texas at Austin. Caffarelli is a well-recognized expert in partial differential equations and free boundary problems, where he has had a countless number of breakthrough achievements. Caffarelli received his Ph.D. from the Universidad de Buenos Aires (Argentina) and after that, he was a postdoc at the University of Minnesota where he eventually became Professor. He has also held professorial positions at the Courant Institute of Mathematical Sciences, the University of Chicago, and the Institute for Advanced Study in Princeton. Caffarelli has been recognized with several prestigious awards, including the Bôcher Memorial Prize (1984), from the American Mathematical Society for "his deep and fundamental work in nonlinear partial differential equations, in particular his work on free boundary problems, vortex theory and regularity theory;" the Rolf Schock Prize (2005) from the Royal Swedish Academy of Sciences, the Wolf Prize in Mathematics (2012) from the Wolf Foundation, and the Shaw Prize in Mathematics (2018) from the Shaw Prize Foundation for "his groundbreaking work on partial differential equations, including creating a theory of regularity for nonlinear equations such as the Monge-Ampère equation, and free-boundary problems such as the obstacle problem, work that has influenced a whole generation of researchers in the field." Caffarelli has also been awarded Doctor Honoris Causa from the École Normale Supérieure (Paris, France), the University of Notre Dame (USA), the Universidad Autónoma de Madrid (Spain), and several universities in Argentina such as the Universidad de La Plata or the Universidad de Buenos Aires. Caffarelli gave a plenary lecture at the 2002 International Congress of Mathematicians and was an invited speaker at the 1983 edition.

**Peter Constantin** (Romania, 1951) is the John von Neumann Professor of Mathematics and Applied and Computational Mathematics and serves as director of the Programme in Applied and Computational Mathematics at Princeton University since 2012. He has also been a Louis Block Professor and Louis Block Distinguished Service Professor at the University of Chicago (2005-2011). He is an ISI Highly Cited Researcher and a Fellow of the American Academy of Arts and Sciences. Furthermore, he has been invited to give talks at the International Congress of Mathematical Physics (Paris 1994), the International Congress of Industrial and Applied Mathematics (Edinburgh 1999).

**Frances Kirwan** (UK, 1959) is a professor at the Mathematical Institute of Oxford University (United Kingdom). She was the President of the London Mathematical Society from 2003 to 2005. Her work on algebraic geometry and symplectic geometry has earned her numerous awards, including the Whitehead Prize (1989) and the Whitehead Senior Prize (2013) from the London Mathematical Society, as well as an OBE in 2014. Furthermore, she is a Fellow of the Royal Society, since 2001, has held an EPSRC Senior Research Fellowship from 2005 to 2010, is a Fellow of the American Mathematical Society since 2012, and is a member of the European Academy. Jill Pipher (USA, 1955) is Vice President for Research at Brown University and Elisha Benjamin Andrews Professor of Mathematics. She is currently the president of the American Mathematical Society, was the president of the Association of Women in Mathematics (AWM, 2011-2013) and is a founding director of the Institute for Computational and Experimental Research in Mathematics, an NSF mathematical institute in Providence, USA. Pipher obtained her Ph.D. in Mathematics from the University of California at Los Angeles in 1985. After that, she was L. E. Dickson Instructor at the University of Chicago. Pipher has obtained breakthrough results in harmonic analysis and partial differential equations. She has also worked in cryptography; she co-founded NTRU Cryptosystems, Inc., and holds four patents related to encryption algorithms. Pipher is an inaugural fellow of the American Mathematical Society (2012) and was selected as a fellow of the Association for Women in Mathematics in the inaugural class in 2017. In 2019 she was named a SIAM Fellow "for her profound contributions in analysis and partial differential equations, groundbreaking work in public key cryptography, and outstanding scientific leadership." Pipher was an invited speaker at the 2014 International Congress of Mathematicians.

**Antonio Ros** (France, 1957) is Professor at the Department of Geometry and Topology in the Universidad de Granada (Spain). He is a member of the School of Geometrical Analysis in Granada, whose quality and scientific impact is internationally recognized. His research interests concern differential geometry, analysis and focus in the theory of minimal surfaces and isoperimetric problems. Among his results, one can highlight the celebrated proof of the double bubble conjecture (joint with Hutchings, Morgan and Ritoré) and more recently, together with Meeks and Pérez, he has completed the classification of properly embedded minimal planar domains in euclidean 3-space. Both results were published in Annals of Mathematics. Antonio Ros was an invited speaker at the 2006 International Congress of Mathematicians.

#### 3.4. Support technicians

Thanks to funding from the Severo Ochoa project, the ICMAT is able to count on its technical support team, which enables the Institute to develop its own internationalization, knowledge transfer, outreach and gender programmes, among others. The research support offices have adapted to working conditions forced by the COVID-19 outbreak and has been in constant communication with the researchers, so that their ongoing projects and applications are minimally impacted by the pandemic.

The vast majority of the activities that the ICMAT organises, as well as the daily work of the Institute need administrative support. The main task of the **Administrative Office** consists in providing technical support to CFTMAT management and administration as well as to the research staff and also visitors who come to the Institute to attend different events. Among these tasks, it is worth mentioning the management and processing of billing arising from the activities conducted at the centre; the processing of expenses and settlements concerning the researchers themselves as well as visitors; the active participation in the organization of schools and conferences held at the Institute; support for the Severo Ochoa project regarding the justification of the assistance for and expenses incurred by the centre's research personnel for any procedure or activity that may be required.

Throughout 2020, the **ICT Office** provided support for researcher personnel in the creation of websites for events, content updates, corporative mail and the development of intranet applications, as well as the management of purchases of ICT material. Likewise, it has taken charge of the renovation of the Wi-Fi infrastructures of the centre as well as the planning of the new network infrastructures that will be implemented throughout the year 2021. Furthermore, more than twenty ICMAT members worked with the cluster, which consists of more than 1,200 computing processors and six GPU, making use of 60 % of the computing capacity. In addition, ICT Office provided development support in the implementations of online applications offered by different research groups at the ICMAT. Claire Voisin (France, 1962) holds the chair of Algebraic Geometry at the Collège de France. She obtained her Ph.D. from the Université Paris-Sud XI-Orsay. She has worked as a CNRS researcher at the Institut de Mathématiques de Jussieu and the Ecole Polytechnique before joining her current institution in 2016. Voisin has been awarded the European Mathematical Society Prize (1992), the Clay Research Award (2008) for "her disproof of the Kodaira conjecture," the Ruth Lyttle Satter Prize in Mathematics (2007) "for her deep contributions to algebraic geometry, and in particular for her recent solutions of two long-standing open problems: the Kodaira problem and Green's conjecture." She has also received the Shaw Prize in Mathematics (2017) from the Shaw Prize Foundation and received the Gold medal of the French National Centre for Scientific Research (2016), the highest scientific research award in France. Voisin was an invited speaker at the 1994 and 2010 editions of the International Congress of Mathematicians.

**Shing-Tung Yau** (China, 1949) is the William Caspar Graustein Professor of Mathematics at Harvard Univeristy. He got his Ph.D. from the University of California-Berkeley and after that, he was a member of the Institute for Advanced Study at Princeton, Stony Brook University, Stanford University, and Univeristy of Califiornia-San Diego. Yau was awarded the Fields Medal in 1982 "for making contributions in differential equations, also to the Calabi conjecture in algebraic geometry, to the positive mass conjecture of general relativity theory, and to real and complex Monge-Ampère equations." Yau has also obtained the Wolf Prize in Mathematics (2010) for "his work in geometric analysis and mathematical physics," the United States National Medal of Science (1997), and the Humboldt Research Award (1991) from the Alexander von Humboldt Foundation in Germany. Yau was also a plenary speaker at the 1978 International Congress of Mathematicians.

In 2020, the **ICMAT Communication and Outreach activities** moved completely online. Many of our activities –latest news, press articles, outreach videos, social networks, etc.- were already on this format, and were thus maintained without difficulty. In fact, 50 news items were published throughout the year, together with 47 articles in *Café y Teoremas* and 20 entries on the blog. However, it was necessary to adapt many other activities (workshops, conferences, etc.) to the online format (via Zoom, YouTube, and other platforms and social media).

We organized talks and debates via online platforms, more informal get-togethers on social networks, and also online workshops with students and general public. On one hand, this new situation enabled us to extend our sphere of influence, involve people from different parts of Spain and Latin America in our activities, and have at our disposal material available for viewing at all times. But, on the other hand, the lockdown provoked the cancelation of several outreach activities –in 2020 only ten outreach activities were organized–, and the reduction of direct interaction with the public on those remaining online.

During the same period, the third ICMAT Severo Ochoa project started. The **Severo Ochoa office** provided technical and administrative support for all the activity financed through the SO project and the preparation of the documentation required for the corresponding justification of the second ICMAT Severo Ochoa project finished at the end of 2019. This office also provided support to the direction of the Institute.

The **European Office** has assisted ICMAT researchers in their applications to international calls issued by public and private entities. In addition to the projects already under way, in 2020 ICMAT researchers have received funding for the implementation of three projects from the H2020 programme: one Consolidator Grant of the European Research Council (ERC) and two Marie Curie International Fellowships.

In addition to these offices, Marta Sanz González (ICMAT-CSIC) was also appointed in an administrative role for the David Ríos AXA Project.

## 4. Scientific results

In 2020, the scientific production of ICMAT researchers has exceeded 161 publications. According to the Journal of Citations Reports Web of Science, 29 publications appear in D1 (first decile) and 72 in Q1 (first quartile) if one uses the Article Influence Score, and with the Impact Factor, 18 are in D1 and 62 are in Q1. Similarly, SCImago Journal Rank returns a total of 57 items in D1 and 106 in Q1, and Elsevier CiteScore gives 35 D1 and 79 Q1.

Here are scientific reviews of 15 of these articles:

#### "Recognition of being fibered for compact 3-manifolds"

Authors: Andrei Jaikin-Zapirain (ICMAT-UAM)

Source: Geometry & Topology

Date of publication: 25 March 2020

#### <u>Link</u>

#### **Review:**

Much attention has been paid recently to those properties of 3-manifolds which can be deduced from the finite quotients of their fundamental groups; or, from another viewpoint, from the structure of their lattice of finite-sheeted coverings. Having assembled these finite quotients into the profinite completion of the fundamental group, this amounts to the study of "profinite invariants" of the 3-manifold. A profinite invariant may be defined as some property P of a group G such that, whenever H is a group with property P and  $\hat{G} \cong \hat{H}$ , then G also has property P. One may restrict attention to a particular class of groups (for example fundamental groups of compact orientable 3-manifolds) and require both G and H to be from that class.

A compact orientable 3-manifold M is fibered if M admits the structure of a surface bundle over  $S^1$ . Work of Stallings, together with the resolution of the Poincaré Conjecture, shows that M is fibered if the fundamental group  $\pi_1(M)$  of M is isomorphic to a semidirect product  $Z \rtimes N$  with N finitely generated. Thus, the fundamental group of a compact orientable 3-manifold detects whether the 3-manifold is fibered. We may ask whether to be fibered is also a profinite property. It is confirmed in this paper.

<u>Theorem</u>: Let M and N be two compact orientable 3-manifolds such that  $\pi_1(M) \cong \pi_1(N)$ . Then M fibers over the circle if and only if N does.

The proof uses in an essential way results of I. Agol, P. Przytycki and D. Wise on separability of 3-manifold groups which has had significant implications on our understanding of the profinite completion of the fundamental groups of compact 3-manifolds.

"Harmonic measure and quantitative connectivity: geometric characterization of the L -solvability of the Dirichlet problem"

Authors: Jonas Azzam, Steve Hofmann, José María Martell (ICMAT-CSIC), Mihalis Mourgoglou and Xavier Tolsa

Source: Inventiones Mathematicae

Date of publication: 2020

#### <u>Link</u>

#### **Review:**

The celebrated 1924 <u>Wiener criterion</u> provided the necessary and sufficient conditions on the geometry of the domain responsible

for the continuity of harmonic functions at the boundary. That is, the conditions needed to solve the Dirichlet problem for Laplace's equation with continuous boundary data, and with continuity of the solutions up to the boundary. In this recent work, J. Azzam, S. Hofmann, J.M. Martell, M. Mourgoglou, and X. Tolsa address the analogous issue in the case of singular data. To be more precise, they provide a purely geometric characterization of the open sets for which  $L^{\rho}$  solvability holds, for some  $\rho < \infty$ , and with non-tangential convergence to the data almost everyhere, thus allowing for singular boundary data.

Solvability of the  $L^p$  Dirichlet problem is fundamentally tied to quantitative absolute continuity of harmonic measure with respect to surface measure on the boundary: indeed, it is equivalent to the so-called "weak- $A_{\infty}$ " property of the harmonic measure. It is through this connection to quantitative absolute continuity of harmonic measure that the authors obtain the geometric characterization of the  $L^p$  solvability.

The study of the relationship between the geometry of a domain, and the absolute continuity properties of its harmonic measure, has a long history. The classical result of F. and M. Riesz, Lavrentiev's quantitative extension, and <u>Bishop and Jones'</u> local version dealt with the complex plane. Higher dimensional results are due to <u>Dahlberg</u> in Lipschitz domains and, in the setting of Chord-arc domains by <u>David and Jerison</u>, and independently by <u>Semmes</u>. In all these results, the domains under consideration satisfy two main geometric conditions. The first one is related to the regularity of its boundary expressed via its rectifiability or its uniform rectifiability. The second one concerns the topology of the domain and involves some strong connectivity.

The work of <u>S. Hofmann, P. Le, J.M. Martell, and K. Nyström</u> established that the "weak- $A_{\infty}$ " property of the harmonic measure implies that the boundary of the domain is uniformly rectifiable. On the other hand, in light of the example of <u>Bishop and Jones</u>, and on account of the aforementioned connection to solvability of the Dirichlet problem, it has been an important open problem to determine the minimal connectivity assumption, which, in conjunction with uniform rectifiability of the boundary, yields quantitative absolute continuity of harmonic measure with respect to surface measure.

In the present work, the authors consider a connectivity condition called the *weak local John condition*, and which solves this problem. This condition says, roughly speaking, that from each point in the domain there is local non-tangential access (via a "carrot-path") to an ample portion of a surface ball at a scale on the order of its distance to the boundary. Thus, the authors obtain a geometric characterization of the domains for which one has quantitative absolute continuity of harmonic measure; equivalently, for which one has solvability of the Dirichlet problem with singular ( $L^p$ ) data. In fact, they provide two geometric characterizations of such domains, one in terms of uniform rectifiability combined with the weak local John condition, the other in terms of approximation of the boundary in a *big pieces* sense, by bound-

#### "Improved Hölder regularity for strongly elliptic PDEs"

Authors: Kari Astala, Albert Clop, Daniel Faraco (ICMAT-UAM), Jarmo Jaaskelainen and Aleksis Koski

Source: Journal de Mathematiques Pures et Appliquees

#### Date of publication: August 2020

#### **Link**

#### **Review:**

Hilbert XIX problem can be interpreted as trying to mathematically prove or disprove whether nature uses beauty as a selection mechanism. At least in solid mechanics, the principle of minimum total potential energy interprets this question as asking whether the minimizers of integral functionals are smooth if the lagrangian is smooth. This is the starting point of the theory of elliptic regularity. For convex scalar functionals the answer is yes. The solution to the HIlbert problem was obtained independently in the 1960 by Nash in Princeton and by Enrio De Giorgi in a small village in the south of Italy. The research on elliptic regularity has been enormous since then modifying the properties of the lagrangian in multiple ways. A branch of the theory has been to make quantitative versions of De Giorgi-Nash theory.

That is to say make precise the more convex and regular is the lagrangian the more regular is the minima. Recall, that the starting point of the Calculus of Variations as stablished by Euler and Lagrange in mid eighteen century is that extremal of variational problems satisfy the corresponding Euler Lagrange equation. Convexity of the functional translates into ellipticity of the equation and regularity of the lagrangian into regularity of the Euler Lagrange equation. Perhaps the easiest setting is the case of an autonomous functional (which is a natural assumption for the author). The classical theory yields the non linearity is C<sup>1</sup> the minimizers are C<sup>[1,\alpha]</sup> for every  $0 < \alpha < 1$ .

The reviewed article is part of a programme of understanding elliptic equations with complex analytic methods, particularly the theory of quasiconformal mappings. To the surprise of many we prove a striking new result in the autonomous case. If the nonlinear function in the Euler Lagrange equation is only Lipchitz, it follows that the regularity of the solution depend on the ellipticity constants. Being pessimistic one would then expect after linearization, that the solution behaves as the solution of a linear elliptic equation with measurable coefficients. Indeed, this was the strategy known back to Hilbert's times. However, we prove that if the original equation is autonomous there is an automatic improve of the integrability. In summary we obtain two coefficients  $1/K < \alpha(K) < \beta(K) < 1$  such that  $u \in C^{[1, \alpha(K)]}$  but not in  $C^{[1,\beta(K)]}$ .

The proof reduces the second order equation to a nonlinear elliptic system (autonomous) using the, by now, popular method of Bers and Niremberg. This formalism allows to detect an improvement for a Poincare inequality which is the ingredient that remain oblivious to approaches based on real variable methods. It remains as a beautiful challenge for the energetic reader to decide wether  $\alpha(K) = \beta(K)$  or not.

#### "Global Smooth Solutions for the Inviscid SQG Equation"

**Authors**: Ángel Castro (ICMAT-CSIC), Diego Córdoba (ICMAT-CSIC) and Javier Gómez-Serrano Source: American Mathematical Society

Date of publication: July 2020

#### Link

#### **Review:**

The Surface Quasi-Geostrophic (SQG) equation was originally derived for modelling the movement of large masses of air in the atmosphere and, in particular, for frontogenesis, the formation of sharp fronts between masses of hot and cold air. This is an equation that reduces the dynamics of fluids from three to two dimensions, by eliminating altitude and working on a plane –in this case, the surface of the Earth, taken over a small region so that its curvature can be disregarded. The equation is given in terms of temperature and is an evolution equation. Given some initial conditions of temperature for an initial time, the solution of the equation yields as a result the temperature over subsequent time. Once the temperature is known, the movement of the fluid can be determined. In this paper the study is conducted on all the plane R<sup>2</sup>, although studies exist in which bounded regions are also considered.

Despite the use that the SQG equation may have in other sciences, this is not the characteristic that has prompted the interest of the authors of this present study. Peter Constantin, Andrew Majda Esteban Tabak pointed out that the structure of the equation is similar to that of the Euler equation for an incompressible fluid. Indeed, in both the Euler 3D equation for the formulation of vorticity and the equation for the gradient of the temperature on the SQG equation, a transport term appears, with a velocity given by an operator of degree -1 in derivatives and also a quadratic term that involves singular integrals. However, the Euler equation considers the evolution of a vector of three components in 3 dimensions and an SQG the evolution of a scalar in two dimensions, the latter therefore being easier to manage. In turn, the Euler equation is a limit case of the Navier-Stokes equation, in which the viscosity of the fluid is taken to be zero. The burning issue in fluid mechanics is to determine whether the Navier-Stokes solutions are globally regular or if on the other hand they develop singularities in finite time. This question remains unresolved in both the Navier-Stokes equations and the Euler equation. Constantin, Majda and Tabak studied the SQG equation with the aim of gaining a greater understanding of the Euler equation, and the authors of this paper have followed in their footsteps. The search for singularities in the SQG equation could provide a better understanding of the mechanisms governing the behaviour of the Euler equation.

Until the publication of the paper, it was known that the SQG equation remained smooth for a short time interval, regardless of the initial conditions, but the only known examples in which the solutions remained smooth over all time were the trivial stationary solutions, when the temperature is given by any radial function.

In this paper, the authors show that families of initial conditions exist such that the solution is smooth over all time, without the development of any singularity. Such solutions consist of a global rotation with constant angular velocity of the temperature. To achieve the proof, the problem is reduced analytically to check an open condition that is then rigorously demonstrated by means of computer-assisted proofs using interval arithmetic.

The analytical part is based on the application of the Crandall-Rabinowitz theorem, which involves the study of the spectrum of the operator given by the linearization of the SQG equation. It is this study that requires the obtention of certain bounds of the eigenvalues of the linear operator, which, module small errors that can be estimated with pen and paper, are given by enormous but explicit expressions, and it is the obtention of these



bounds for which the computer is employed. The philosophy of interval arithmetic is as follows: a computer is unable to yield rigorously the result of any operation because only a finite amount of numbers is available in its register. Nevertheless, this register of numbers can be used to work with a finite number of intervals covering a large part of the real number line, and it is with these intervals that rigorous estimates of complex operations can be obtained. For example, if we wish to add *A* plus *B*, it may be said that *A* is in interval *I* and *B* is in interval *J*; the sum of *I* plus *J* produces the interval *K*, and then it may be rigorously stated that the result of *A* plus *B* is within *K*. If the interval *K* is sufficiently small, whatever this may mean in your problem, you have won.

#### "Undecidability of the Spectral Gap in One Dimension"

**Authors**: Johannes Bausch, Toby S Cubitt, Angelo Lucia and David Pérez-García (ICMAT-UCM)

Source: Physical Review X

Date of publication: August 2020

<u>Link</u>

#### **Review:**

One of the main steps in the scientific method for experimental sciences is the need to make predictions for a given hypothetical explanation of a phenomenon, so that such predictions can be tested again in experiments. At the level of quantum systems, this is the problem of, starting from a description of the microscopic interactions of a system, derive the measurable global properties of lowest energy state in the ideal scenario when the number of elementary constituents of the system grows to infinity.

In this article, the authors show that this problem is impossible to solve, even in the simplest possible case of a one-dimensional system. Impossible here means that there exists no algorithm, or mathematical reasoning, no matter how complex, that can solve it.

This result is especially unexpected since there was a general consensus in condensed matter physics that one-dimensional systems were "easy". And indeed, there were several evidences in this direction. For instance, for a given fixed number of particles and assuming a control on the energy gap between the lowest and second-lowest energy levels of the system, it was shown recently that there are even efficient algorithms that solve the problem. It is also known since the 60s that temperature cannot create phase transitions in 1D systems (as opposed to the 2D case) and it is also well known that some of the most exotic quantum properties of nature, like topological order (whose discovery was awarded with the Nobel prize on 2016), cannot exist in one-dimensional systems.

The result proven in this paper builds on the techniques developed in 2015 by the authors to show the analogue result for 2D systems. On top of that, the authors introduce a new extra key ingredient, also quite unexpected. This is the existence of quantum interactions that, despite having a local nature (that is, particles interact only with their nearest neighbors) create in 1D patterns with arbitrary long periods. This is a new, purely quantum, property, since it is well known that this property cannot hold for classical systems in 1D. Indeed, that it holds for classical systems in 2D was a breakthrough results in the context of tiling problems in the 60s.

The result proven in this paper, despite being a no-go result, has a beautiful positive side. It implies the existence of 1D quantum systems that display a new quantum effect named "size-driven transition": the system behaves as an insulator for all system sizes below a critical threshold and, from this threshold on, the system switches dramatically its behavior to become a superconductor. Moreover, this critical threshold can be uncomputably large.

#### "Parabolic Higgs bundles and representations of the fundamental group of a punctured surface into a real group"

**Authors:** Olivier Biquard, Oscar Garcia-Prada (ICMAT-CSIC) and Ignasi Mundet i Riera

Source: Advances in Mathematics

Date of publication: 7 October 2020

#### <u>Link</u>

#### Review:

The relation between representations of the fundamental group of a compact Riemann surface X into a compact Lie group and holomorphic bundles on X goes back to the celebrated theorem of Narasimhan and Seshadri (1965), which implies that the moduli space of irreducible representations of  $\pi_1(X)$  in the unitary group U(n) and the moduli space of rank n and zero degree stable holomorphic vector bundles on X are homeomorphic. This generalises the classical case of representations in U(1), the unit circle, and their relation with the Jacobian of X. The theorem was generalised by Ramanathan (1975) to representations into any compact Lie group. The gauge-theoretic point of view of Atiyah and Bott (1982), and the new proof of the Narasimhan–Seshadri theorem given by Donaldson (1983) following this approach, brought new insight and new analytic tools into the problem.

The case of representations into a non-compact reductive Lie group G required the introduction of new holomorphic objects on the Riemann surface X called G-Higgs bundles, introduced by Hitchin in 1987. His work, together with work of Donaldson (1987), Simpson (1988) and Corlette (1988), established a homeomorphism between the moduli space of G-Higgs bundles and the moduli space of representations of  $\pi_1(X)$  in G, what is usually referred as non-abelian Hodge correspondence. There is another direction in which the Narasimhan-Seshadri theorem has been generalised. This is by allowing punctures in the Riemann surface. Here one is interested in studying representations of the fundamental group of the punctured surface with fixed holonomy around the punctures. These representations now relate to the parabolic vector bundles introduced by Seshadri (1977). The correspondence in this case for G = U(n) was carried out by Mehta and Seshadri (1980). A differential geometric proof modelled on that of Donaldson was given for the parabolic case by Biquard (1991).

In the paper under review, the authors combine the non-compactness in the group and in the surface to study representations of the fundamental group of a punctured surface into a non-compact reductive Lie group G (real or complex). After appropriately defining the notion of parabolic G-Higgs bundle, in the main result of the paper they prove a non-abelian Hodge correspondence in this situation, establishing a homeomorphism between the moduli space of parabolic G-Higgs bundles with the fixed relevant data at the punctures and the moduli space of representations of the fundamental group of the puntured surface with fixed conjugacy classes in G at the punctures. This generalizes the case of GL(n, C) studied by Simpson (1990). This correspondence opens the door to the use of analytic and algebraic geometric techniques for the study of the topology of character varieties for surfaces with punctures.

#### "Virtual classes of parabolic SL(C)-character varieties"

Authors: Ángel González-Prieto (ICMAT-UCM)

Source: Advances in Mathematics

Date of publication: 15 July 2020

#### **Review:**

The parabolic character variety, parametrizing representations of the fundamental group of a Riemann surface onto an algebraic group *G*, plays a prominent role in moduli space theory, particularly in non-abelian Hodge correspondence. However, despite their importance, very few is known about the geometry and topology of these character varieties, even in the simplest cases. The paper under review deals with the computation of the virtual class of parabolic character varieties for  $G = SL_2(\mathbf{C})$ . This virtual class in the Grothendieck ring of complex algebraic varieties is a very subtle invariant with a natural geometric interpretation in terms of cut-and-paste operations. This work represents the first attempt of computing the virtual class of the character variety, instead of the *E*-polynomial as treated in the literature, and deals with the parabolic case in its greatest generality.

For conducting this analysis, the paper under review proposes to use a Topological Quantum Field Theory (TQFT), an algebraic tool of geometry nature imported from theoretical physics. Roughly speaking, the idea is to chop the punctured surface into simple pieces, in such a way that each piece contains only one relevant part of the data: it is either a hole of the surface (a twice drilled torus), a tube with a puncture, the initial cap of the surface or its ending cap. The TQFT allows us to isolate the information of each simple piece and gives us a rule for combining them to assemble more complicated geometries.

Beyond the calculation itself, the paper under review also shows a very remarkable emerging phenomenon of interference between the parabolic punctures. When a puncture is added to the surface through the TQFT, its algebraic information regarding the virtual class of the character variety interacts with the information of all the previously added punctures. As a result of this interaction, the data of two punctures may mutually annihilate, create new elements or perturb the existing ones. The type of interaction that takes places in each situation strongly depends on the arithmetic of the eigenvalues of the conjugacy class attached to the punctured. At the geometric side, these interferences are the algebraic counterpart of the singularities arising in the character variety for non-generic parabolic data, which lead to drastic geometric changes.

## "Beltrami fields with hyperbolic periodic orbits enclosed by knotted invariant tori"

**Authors:** Alberto Enciso (ICMAT-CSIC), Alejandro Luque and Daniel Peralta-Salas (ICMAT-CSIC)

**Source:** Advances in Mathematics

Date of publication: 28 October 2020

#### <u>Link</u>

#### Review:

TBeltrami flows are a particular class of stationary solutions of the Euler equations of hydrodynamics. Their relevance was unveiled by V.I. Arnold in 1965 through his celebrated structure theorem for inviscid fluids in equilibrium, which roughly asserts that a stationary solution of the Euler equations is either integrable or a Beltrami field.

Motivated by Hénon's numerical simulations, Arnold suggested that there should exist Beltrami fields whose dynamics has an arbitrarily complicated topology and the same complexity as the motions in celestial mechanics. In the light of the modern theory of Hamiltonian systems, it is natural to interpret this suggestion as the existence of invariant tori of complicated topology enclosing many homoclinic connections that intersect transversally. The interest of this problem is not merely academic. Invariant tori of Beltrami fields play a key role in fluid mechanics, where they are known as vortex tubes. The study of knotted vortex tubes, which goes back to Lord Kelvin in the XIX century, is an important topic in the Lagrangian theory of turbulence and has been extensively pursued in the last decades.

In the paper under consideration, the authors show that there are Beltrami fields with invariant tori of arbitrary topology that enclose regions with any prescribed number of hyperbolic periodic orbits. According to Katok's celebrated theorem, the existence of hyperbolic orbits is a necessary condition for having positive topological entropy (a key feature of chaos). This result goes one step further in order to establish the aforementioned Arnold's vision of Beltrami fields. The method of proof builds on previous constructions of Enciso and Peralta-Salas (2015), and combines dynamical systems techniques –KAM theory and Melnikov analysis) with fine estimates for elliptic PDEs–.

#### "Invariant subspaces for Bishop operators and beyond"

**Authors:** Fernando Chamizo (ICMAT-UAM), Eva A. Gallardo-Gutiérrez (ICMAT-UCM), Miguel Monsalve-López and Adrián Ubis

**Source:** Advances in Mathematics

Date of publication: 2 December 2020

#### <u>Link</u>

#### **Review:**

The *Invariant Subspace Problem* is one of the most celebrated open questions in Operator Theory: Does every bounded linear operator on a complex, infinite dimensional separable Hilbert space have a nontrivial closed invariant subspace? Around 1950, Errett Bishop proposed as possible operators lacking closed invariant subspaces the operators acting on the Lebesgue space  $L^2[0,1)$  defined by  $T_a f(t) = t f(\{t+\alpha\})$  where  $\alpha$  is an irrational and  $\{x\}$  denotes the fractional part of x. Clearly, if  $\alpha$  is rational, then the orbit of any function is finite and hence  $T_a$  has nontrivial closed invariant subspaces.

On the other hand, if  $\alpha$  is an irrational, a complicate mixing arises which suggests, somehow, the absence of nontrivial closed invariant subspaces. Nevertheless, Alexander M. Davie proved in 1974 that such subspaces do exist if  $\alpha$  is not a Liouville number, a number with very good rational approximations. An important theorem due to Aharon Atzmon generalizes Davie's argument and allows concluding the existence of non-trivial closed invariant subspaces if the iterates of T and its adjoint acting on some function have a moderate growth.

In the paper under review, some Diophantine approximation techniques involving continued fractions are employed to show that there are non-trivial closed invariant subspaces for the most of the Liouville numbers. This theorem improves considerably previous results. In fact, it is also proved that in a slightly bigger set, Atzmon's theorem could not be applied, finding the threshold for the application of such a technique. Therefore, new significant advances should involve new approaches. The results extend to the  $L^{\rho}$  spaces for  $1 \le \rho < \infty$ , which are obviously separable Banach spaces.

From the functional analytical point of view, it is shown that Bishop's operators are quasitriangular, a property assuring that there exists a sequence of almost invariant finite dimensional subspaces. On the other hand, they do not satisfy Dunford property (C) what implies that a construction of non-trivial closed invariant subspaces using resolvents is unavailable. Loosely speaking, the situation is worse than the mere nonexistence of eigenfunctions.



#### "Splash Singularities for a General Oldroyd Model with Finite Weissenberg Number"

Authors: Elena Di Iorio (ICMAT-CSIC), Pierangelo Marcati and Stefano Spirito

Source: Archive for Rational Mechanics and Analysis

Date of publication: 22 October 2019

#### <u>Link</u>

#### **Review:**

The Oldroyd model, introduced by J. G. Oldroyd in 1950, describes the complex behavior of viscoelastic fluids. The study of viscoelastic materials started in the XIX century, when mathematical physicists such as Kelvin and Maxwell started investigating and making experiments with models made of springs and dashspots. They proposed models represented by first order linear differential equations. Later, when human-made polymers were engineered, the need of more accurate and complex mathematical models arose since the existing ones were not suitable to describe all the viscoelastic materials. For this reason, the Oldroyd model has been introduced. It is a frame-invariant model, due to the presence of the Oldroyd derivative instead of the material derivative and it is characterized by the presence of both elastic and viscous forces, whose ratio is called *Weissenberg number* (We).

The paper addresses to the study of a 2D incompressible, free-boundary Oldroyd model, with finite We. The authors focus on the existence of singularities for the domain, in particular on the splash singularity, given by a configuration where the domain self-intersects in one point. The equations describing this model are the conservation of mass and the conservation of momentum but they are not sufficient to provide complete description of the flow and a constitutive equation involving the elastic stress tensor is required, which is the Oldroyd equation. These equations establish the final system together with the initial data and the free-boundary conditions, given by the balance of the force fields at the interface.

The proof is based on a conformal-lagrangian change of variables in order to fix the moving domain and the use a fixed point argument to prove the local existence for the system. As a consequence of the estimates, the researchers get that the local existence time T can be estimated from above by We 1+We . Finally, they prove stability estimates, with respect to a suitable one parameter family of perturbated solutions, and they are able to show the existence of a splash singularity.

#### "The fractional porous medium equation on the hyperbolic space"

**Authors:** Elvise Berchio, Matteo Bonforte (ICMAT-UAM), Debdip Ganguly and Gabriele Grillo

**Source:** Calculus of Variations and Partial Differential Equations

Date of publication: 15 September 2020

#### <u>Link</u>

#### **Review:**

In this article, the authors consider a nonlinear degenerate parabolic equation of porous medium type, i.e. with a convex nonlinearity, whose diffusion is driven by the (spectral) fractional Laplacian on the hyperbolic space, which is the s-power (in the spectral sense) of the standard Laplace-Beltrami operator on that space. This equation is used in classical Porous Medium Equation (PME) models of slow diffusion processes, which are realistic models for density-driven diffusions. Nowadays, the PME has many applications, that stem from physics to engineering, and more recently biology and even finance.

In a previous paper of 2008, two of the authors showed that the negative curvature of the ambient-space somehow accelerates the diffusion processes. Later, Vázquez showed in 2014 that solutions to the PME on the hyperbolic space have faster speed (but still

finite) of propagation, precisely they accelerate by a logarithmic factor. In this case, the diffusion is made even faster as a side effect due to the fractional operators, and the speed of propagation becomes infinite. Roughly speaking, the particles processes underlying the fractional or non-local operators allow the particles to jump; hence, the diffusion becomes really fast, since the particles have a nontrivial probability of jumping at infinity. Fractional derivatives (which are integro-differential operators) are often called nonlocal derivatives or operators, because in order to compute the nonlocal derivative of a function at some point, it is necessary to know the value of the function at all points.

In this new article, the fractional porous medium equation has been introduced for the first time on non-compact, geometrically non-trivial examples. This is the simplest nontrivial examples in which the different geometric quantities, like negative curvature, exponential growth of the volume of balls, etc. enter into play in a significant way and provide important differences with respect to the Euclidean case.

In fact, the researchers provide the existence and uniqueness of solutions for this equation in an appropriate weak sense, for data belonging either to the usual Lp spaces or to larger (weighted) spaces, determined either in terms of a ground state of the Laplace-Beltrami operator on the Hyperbolic space, or of the (fractional) Green's function. These quantities are strictly connected with the operator and somehow provide a natural environment, larger than the usual one. For example, slowly (polynomially) decreasing data can be included in this theory, instead of the fast (exponentially) decreasing ones. However, one must keep in mind that the hyperbolic measure grows exponentially, hence integrable function must decrease exponentially fast.

"Uniqueness of entire ground states for the fractional plasma problem"

Authors: Hardy Chan, María Del Mar González (ICMAT-UAM), Yanghong Huang, Edoardo Mainini and Bruno Volzone

**Source:** Calculus of Variations and Partial Differential Equations

Date of publication: 26 October 2020

#### Link

#### Review:

The equation in dimension two has an interpretation in Plasma Physics since the spatial domain represents the cross section of a Totamak machine –a toroidal shell containing a plasma ring surrounded by vacuum–. The region inhabited by the plasma is exactly the set  $\{u>C\}$ , with u modeling the flux function.

In this work we consider its factional version, in which the diffusion given by the Laplacian –which is a local operator–, is replaced by a non-local diffusion defined from an integro-differential operator. We prove uniqueness of ground states, which are entire, radially symmetric and decreasing solutions in the radial variable. The main difficulty comes from the non-locality of the equation since, contrary to the local case, it cannot be reduced to the study of an ODE. Instead, we use a monotonicity argument for PDEs.

#### "Noncommutative strong maximals and almost uniform convergence in several directions"

**Authors:** José M. Conde-Alonso (ICMAT-UAM), Adrián M. González-Pérez and Javier Parcet (ICMAT-CSIC)

Source: Forum of Mathematics, Sigma

Date of publication: 20 November 2020

#### <u>Link</u>

#### Review:

A general form of the fundamental theorem of calculus in one dimension is the following: given an integrable function *f*, Leb-

esgue's differentiation theorem states that the integral averages of f over balls (or cubes) of shrinking radii around a given point x converge to the value f(x) at almost every point x. This *almost everywhere convergence* to original data is also known to hold in other scenarios, when replacing Euclidean balls by other averaging processes. The standard strategy to establish this almost everywhere convergence leads to prove a maximal inequality. This is nothing but a quantitative estimate for the maximal operator Massociated with the corresponding averaging process. Indeed, the underlying maximal inequality behind Lebesgue's differentiation is the celebrated Hardy-Littlewood maximal theorem, which is almost one hundred years old. It states that M maps the space of integrable functions into the space of weakly integrable functions, and it yields the best possible convergence result.

The same problem of convergence can be studied when the integral averages are taken with respect to rectangles -in two dimensions- with sides parallel to the axes instead of cubes. In this case, a new, significant difficulty appears, that comes from the fact that the rectangles may not have bounded eccentricity, and therefore the geometric arguments that apply in the case of cubes can no longer be used. The first convergence result in this context is due to Jessen-Marcinkiewicz-Zygmund. They established the convergence of integral averages for functions in LlogL, a proper subclass of the integrable functions. This can be shown to be optimal. In this case, the strategy using maximal inequalities leads to studying the strong maximal operator. And the relevant maximal inequality was independently established by De Guzmán and Córdoba-Fefferman in the seventies. In higher dimensions -when replacing rectangles by parallellepipeds-, analogous results are also true, with appropriate modifications of the relevant classes of functions involved.

In this paper, José M. Conde-Alonso, Adrián M. González-Pérez and Javier Parcet considered generalizations of the two lines of results concerning the geometry of rectangles. The setting is now the theory of von Neumann algebras and noncommutative measure/Lp theory. The geometric notion of rectangle can naturally be replaced by a product structure on the von Neumann algebra under consideration.

The primary goal in the paper is to investigate noncommutative strong maximals, almost uniform convergence in several directions to initial data and applications in noncommutative harmonic analysis. The main results of the paper are a noncommutative form of Jessen-Marcinkiewicz-Zygmund theorem about almost everywhere convergence of integral averages, and a noncommutative form of De Guzmán/Córdoba-Fefferman maximal inequality.

The products to which the main results can apply may be tensor products of quantum martingale filtrations, ergodic means or subordinated Markov semigroups, but also free products and other noncommuting compositions.

## "Protecting from Malware Obfuscation Attacks through Adversarial Risk Analysis"

Authors: Alberto Redondo and David Ríos Insua (ICMAT-CSIC)

Source: Risk Analysis

Date of publication: 21 July 2020

#### Link

#### **Review:**

The digital era is bringing along new global threats among which cybersecurity related ones emerge as truly worrisome. The operation of critical cyber infrastructures relies on components which could be cyber attacked, both incidentally and intentionally, suffering major performance degradation. A key concern is malware (an acronym for malicious software) which, according to ENISA, is among the top threats in the cybersecurity landscape. Indeed, malware in its many forms –including *trojans, worms*, viruses, spyware or adware– affect millions of hosts each year) Moreover, the negative impacts of such threats may include not only purely financial costs, but also deaths and injuries when dealing with cyber-physical systems, going through stolen personal identifiable information or business secrets in enterprise systems.

Detection systems are important components in cybersecurity risk management frameworks. Anti-malware tools based on scanning file signatures used to recognize most malware until relatively recently. However, these tools are much less effective nowadays due to the continuous changes introduced in malware. In particular, a prominent attacking strategy through malware is obfuscation, which designates a group of procedures that make a malware binary more difficult to be detected through anti-malware tools, with current obfuscation techniques having become really sophisticated. A few approaches have been used to detect obfuscation attacks, however they tend to ignore the fact that adaptive adversaries are behind such attacks.

The paper under review proposes a global methodology to protect from obfuscation attacks based on Adversarial Risk Analysis (ARA). First, a general hybrid framework for malware detection is presented serving as an initial benchmark. The authors then illustrate the problems entailed by metamorphic malware which render standard detection methods less effective. Next, the proposed ARA model to detect obfuscation attacks is presented. Its effectiveness and advantages are illustrated over several examples.

#### "Transport pathways across the West African Monsoon as revealed by Lagrangian Coherent Structures"

**Authors:** Coumba Niang, Ana Maria Mancho (ICMAT-CSIC), Víctor José García-Garrido, Elsa Mohino, Belén Rodriguez-Fonseca and Jezabel Curbelo

**Source:** Scientific Reports

Date of publication: 27 July 2020

#### <u>Link</u>

#### **Review:**

The West African Monsoon (WAM) system is the main source of rainfall in the agriculturally based region of the Sahel. Understanding transport across the WAM is of crucial importance due to the strong impact of humidity and dust pathways on local cloud formation. In general, predicting rainfall in tropical Africa is exceedingly difficult; our standard weather models rarely provide accurate forecasts even a day out. That's partly due to a lack of observations in the region and partly because those models were developed in more temperate regions like the United States and Europe, which have different climate and atmospheric dynamics.

In this article, an interdisciplinary team used daily averages of nearly 40 years of horizontal and vertical wind velocity observations from the European Centre for Medium-Range Weather Forecasts' ERA-Interim meteorological analysis data set to identify the mean velocity fields during the month of August—the peak month of the monsoon. Climatologists have long used these mean climatological velocity fields to paint a broad picture of transport within the monsoon. Here the team applied a tool from dynamical systems theory called Lagrangian descriptors to gain deeper insights into the source and mixture of moisture and dust through the atmospheric features of the monsoon, including the African Easterly Jet and the Tropical Easterly Jet. Their method provides a geometrical partition in a 3D flow, which identifies mixing regions in the atmosphere for moisture-bearing particles originated on the ocean surface and dust-bearing ones coming from the land surface.

The new method could inform drought assessments because it can identify where humidity and dust mix and these conditions favor the formation of clouds. How these essential components for cloud formation are mixed up and in what proportion has not been previously described. For this reason the tool opens new possibilities that could improve cloud parameterization or could provide more accurate drought indices. However further work is needed in this direction to achieve these goals.



## 5. Awards and distinctions

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

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

(More information: Severo Ochoa section, page 27)



#### The ICMAT awarded two Marie Curie grants

In 2020, the ICMAT was successful in obtaining two of the Marie Curie grants for projects in two fields of mathematics: algebraic geometry and Hamiltonian dynamics. First, Amna Shaddad, a graduate from Imperial College London who completed her doctorate at the University of Manchester. She will undertake a project concerning Hamiltonian dynamics with applications to problems in engineering; in particular, the movement of vehicles and robotics, under the supervision of Manuel de León (ICMAT-CSIC). In the case of researcher Alberto Navarro Garmendia, a graduate from the Complutense University of Madrid who completed his PhD at the same university, he will study problems in the theory of motives, a relatively modern concept consisting in the study of the shape of objects by means of algebraic and arithmetic geometry. He will do it under the supervision of José Ignacio Burgos Gil (ICMAT-CSIC) and Frédéric Déglise (ENS Lyon).



The purpose of the Marie Curie grants is to promote the mobility of men and women researchers throughout Europe. Funding for projects of this nature are awarded jointly to the receiving institution and to the researcher.

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

The Royal Spanish Mathematical Society (RSME) and the BBVA Foundation awarded the José Luis Rubio de Francia Prize for 2019 to María Ángeles García Ferrero, a postdoctoral researcher at the University of Heidelberg Institute of Applied Mathematics (Germany). García Ferrero completed her doctorate at the ICMAT under the supervision of Alberto Enciso (ICMAT-CSIC) in the field of partial differential equations; specifically, on the heat equation.

This researcher, who had already in 2019 been awarded in 2019 one of the RSME-FBBVA Vicent Caselles Prizes, is only the second woman to have won the José Luis Rubio de Francia Prize since 2004.



María Ángeles García Ferrero

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

Diego Alonso Orán, a postdoctoral researcher at the Institute for Applied Mathematics, University of Bonn, with an Alexander von Humboldt grant, is one of the six Vicent Caselles prize-winners 2020 announced by the Royal Spanish Mathematical Society (RSME) and the BBVA Foundation. Before taking up his post at this prestigious European university, Alonso was a postdoctoral researcher at the ICMAT, where he completed his thesis under the supervision of Antonio Córdoba (ICMAT-UAM).



Diego Alonso Orán

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

Every year, the Spanish Society of Applied Mathematics (SeMA) awards its Antonio Valle Prize to young researchers in recognition of their work in the field of applied mathematics. This year, and for the first time in the 22 years of its history, two researchers were awarded the prize ex-aequo: Jezabel Curbelo Hernández and Rafael Granero Belinchón. Both researchers completed their doctoral theses at the ICMAT: Curbelo –at the moment of the price, assistant lecturer doctor at the Autonomous University of Madrid and a member of the ICMAT– in 2014 under the supervision of Ana María Mancho (CSIC-ICMAT), and Granero –assistant professor at the University of Cantabria – in 2013 under the supervision of Diego Córdoba (CSIC-ICMAT) and Rafael Orive-Illera (UAM-ICMAT).





Jezabel Curbelo Hernández

Rafael Granero Belinchón

## Manuel de León (ICMAT-CSIC), Corresponding Academic of the Royal Galician Academy of Sciences

Manuel de León, a CSIC Research Professor at the ICMAT, and former director of the ICMAT, has joined the Royal Galician Academy of Sciences as Corresponding Academic. An expert in differential geometry and its applications to mechanics and mathematical physics, De León has also been a permanent member of the Royal Academy of Exact, Physical and Natural Sciences since 2017. He likewise belongs to the Royal Canary Islands Academy of Sciences and is a Medallist of the Spanish Royal Mathematical Society ([RSME] as well as being a founder and president of the Spanish Mathematical Committee (CE-MAT). He has furthermore been the first Spanish member of the Executive Committee of the International Mathematical Union (IMU) and was the president of the 2006 International Congress of Mathematicians (ICM) in Madrid.



Manuel de León

## Daniel Peralta gave two MINT Distinguished Lectures at the University of Tel Aviv

On January 20th and 22nd, 2020, Daniel Peralta-Salas, a CSIC senior scientist at the ICMAT, gave two <u>MINT Distinguished Lec-</u><u>tures</u> at the University of Tel Aviv. In the first session, this researcher presented his results on topological structures in elliptic partial differential equations, and in the second he lectured on different aspects of stationary Euler equations in fluid dynamics.

The MINT Distinguished Lectures are organized by the Mathematical Institute Tel Aviv (MINT) and have attracted to this city in Israel outstanding mathematicians such as Kari Astala (one of the directors of the ICMAT Laboratories and the ERC Advanced Grant), Carlos Kenig (currently president of the International Mathematical Union) and James Maynard (Oxford University, a European Mathematical Society prize-winner).



Daniel Peralta

## Altenea Biotech, the company headed by Núria Campillo, a visiting researcher at the ICMAT, is awarded the 2020 Madrid Impacta Prize

The biotechnology company Altenea Biotech, a *spin-off* of the Spanish National Scientific Research Council (CSIC) and the National Scientific and Technical Research Council of Argentina, is devoted to the design and implementation of these models and has received the 2020 <u>Madrid Impacta</u> award, conferred by Madrid City Hall in recognition of "the best business solutions to problems arising from COVID-19". The company is headed by Núria Campillo, a researcher with the Margarita Salas Centre for Biological Research (CSIC) and a visiting researcher at the ICMAT during the present 2020-2021 course.



Best paper for the American Statistical Association

The Transportation Statistics Interest Group of the American Statistical Association (ASA) select two winners as best paper: 'Forecasting aviation safety occurrences', by Bruno Flores Barrio y David Ríos Insua.



## 6. Funding and research projects

#### Non-competitive public funding

Evolution of the total ICMAT funding since its creation, according to the four institutions of which it is composed (CSIC, UAM, UCM and UC3M), is shown in the following table:

2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
832k €	810k €	792k €	792k €	792k €	370k €	400k €	365k €	372k €	304k €

#### **Competitive funding**

#### **National Plan**

Code	Project		€	Start-final date
EUR2020-112265	"El interfaz entre la geometría compleja Kahler y no-Kahler"	Mario García-Fernández	60 000 €	01/12/2020 - 30/11/2022
EIN2020-112197	"Análisis y Geometría de la Ecuación de Hamilton-Jacobi"	Manuel de León Rodríguez	10 000 €	01/11/2020 - 31/10/2022
EIN2020-112235	"Ayuda Europa Investigación para la preparación de una propuesta ERC SYNERGY GRANT"	Ana María Mancho	15 000 €	01/11/2020 - 31/10/2022
EIN2020-112392	"Hacia el motivo de los Espacios de Moduli de Fibrados de Higgs"	Oscar García Prada	10 000 €	01/11/2020 - 31/10/2022
EIN2019-103354	"The interface between Kähler and non-Kähler geometry"	Mario García-Fernández	10 000 €	01/06/2019 - 31/05/2020
EIN2019-103037	"New applications o geometric integration in engineering"	David Martín de Diego	15 500 €	01/06/2019 – 31/12/2021
EUR2019-103821	"Estructuras Topológicas en EDP"	Daniel Peralta	75 000 €	01/10/2019 - 30/9/2021. Extended: until 31/12/2021
ERC2018-092824	"Evolución singular de flujos incompresibles"	Ángel Castro	75 000 €	01/12/2018 - 31/05/2020
EQC2018-005104-P	"adquisición de equipamiento científico-tecnológico"	Ana M. Mancho	102 493,09 €	01/01/2018 - 30/06/2020
PID2019-106715GB-C21	"GESDYSYHYS"	David Martín de Diego and Daniel Peralta	78 287 €	01/06/2020 - 31/05/2023
PID2019-107914GB-100	"Fronteras del analisis armonico"	Javier Parcet and José Mª Martell	74 173 €	01/06/2020 - 31/05/2023
PID2019-108936GB-C21	"Simetrías e invariancia homotópica en aritmética y geometría: fundamento"	Francisco Presas and Daniel Macías	111 320 €	01/06/2020 - 31/05/2023
PID2019-103860GB-100	"Aspectos lineales y no lineales en ecuaciones en derivadas parciales. Dinamica asintotica y perturbaciones"	José María Arrieta Algarra and Aníbal Rodríguez Bernal	55 600 €	01/01/2020 - 31/12/2022
PID2019-105979GB-100	"Operadores y Geometría en Análisis Matemático"	Eva Gallardo	74 103 €	01/01/2020 - 31/12/2022
PID2019-109339GA-C32	"Non-Kähler geometry and mirror symmetry" (*Project coordinated with PID2019-109339GB-C31, PR: Oscar García-Prada)	Mario García-Fernández	31 823 €	01/01/2020 - 31/12/2022
PID2019-109339GB-C31	"Espacios de Moduli y Teoría de Gauge"	Oscar García Prada	37 147,00 €	01/01/2020 - 31/12/2022
PGC2018-097286-B-100	"Análisis Funcional No Lineal y Geométrico"	Daniel Azagra Rueda	90 508 €	01/01/2019 - 31/12/2022
PGC2018-101179-B-I00	"Propiedades de grupos de automorfismos y estructuras relacionadas"	Javier Aramayona	13 068 €	01/01/2019 - 31/12/2021
CEX2019-000904-S	"Apoyo a Centros de Excelencia Severo Ochoa"	Diego Córdoba Gazolaz	4 000 000 €	01/01/2020 - 31/12/2023
BEWATS	"Sistema de Monitorización de Basuras en Costas"	Ana M. Mancho	ICMAT Budget: 32 880 € Total Budget: 98 580 €	01/09/2019 - 30/04/2021
RED2018-102810-T	"Red Temática de Geometría y Física"	Oscar García Prada	16 000 €	01/01/2020 - 31/12/2021

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Code	Project	PR	€	Start-final date
RTC-2017-6593-7	"SecRating: Plataforma para el cálculo de ratings de ciberseguridad y gestión del ciber riesgo de proveedores"	David Ríos	262 452 €	01/01/2018 - 31/12/2019 Extended until 31/12/2020
MTM2017-85934-C3-1-P	"Análisis y geometría con aplicaciones a problemas inversos"	Keith Rogers	13 915 €	01/01/2018 - 31/12/2021
MTM2017-85934-C3-2-P	"Cálculo de variaciones y geometría con aplicaciones a mecánica de medios continuos y problemas inversos"	Luis Guijarro and Daniel Faraco	69 454 €	01/01/2018 - 31/12/2021
MTM2017-89423-P	"Singularities in free surfaceflows"	Marco Antonio Fontelos	28 677 €	01/01/2018 -31/12/2020
MTM2017-89976-P	"Formación de singularidades en fluidos incompresibles"	Diego Córdoba	51 425 €	01/01/2018 - 31/12/2020
MTM2017-86875-C3-1-R	"Avances en gestión de riesgos para la seguridad"	David Ríos	32 186 €	01/01/2018 - 31/12/2020
MTM2017-82690-P	"Invariantes asintóticos de grupos"	Andrei Jaikin	36 300 €	01/01/2018 - 31/12/2020
MTM2017-83496-P	"Aritmética y análisis armónico"	Antonio Córdoba and Fernando Chamizo	23 353 €	01/01/2018 - 31/12/2020
MTM2017-88385-P	"Métodos matemáticos en información cuántica"	Ignacio Villanueva and Carlos Palazuelos	35 332 €	01/01/2018 - 31/12/2020
MTM2017-84098-P	"Fundamentos matemáticos de las tecnologías de la información cuántica: convexidad, muestreo y algebras de operadores"	Alberto Ibort	58 564 €	01/01/2018 - 31/12/2020
MTM2017-82105-P	"Estructuras Algebraicas, Analíticas y o-Minimales STRNAO"	José Francisco Fernando	51 425 €	01/01/2018 - 31/12/2021
MTM2016-76072-P	"Análisis geométrico y numérico de sistemas dinámicos y aplicaciones a la física matemática"	David Martin de Diego and Daniel Peralta	65 219 €	30/12/2016 - 29/06/2020
MTM2017-85757-P	"Ecuaciones no lineales y no locales. Difusión y geometría"	Matteo Bonforte	19 602 €	01/01/2018 - 31/12/2020
MTM2016-79400-P	"Simetrías en geometría aritmética, algebraica y simpléctica"	José Ignacio Burgos Gil and Francisco Presas	75 141 €	30/12/2016 - 29/06/2020
MTM2017-87596-P	"Problemas no lineales de difusión"	Fernando Quirós Gracián	40 535 €	01/01/2018 - 30/09/2021
PID2019- 110712GB-100	"Ecuaciones con perturbaciones de potencias de Laplaciano"	Fernando Soria de Diego and Ana Primo Ramos	55 660 €	01/06/2020 - 31/05/2023

#### CSIC Calls

Code	Project	PR	€	Start-final date
CSIC-I-LINK. LINKA20079	"The interplay between geometry, mechanics and control in multi-agent systems"	David Martín de Diego	24 000 €	01/01/2019 - 31/12/2021
2019AEP064	"Análisis geométrico y numérico de sistemas dinámi- cos y aplicaciones a la física matemática"	David Martin y Daniel Peralta	10 649,72 €	01/01/2020 - 31/12/2020
2019AEP151	"Simetrías en geometría aritmética, algebraica y sim- plectica"	Fran Presas	15 275,35 €	01/01/2020 - 31/12/2020
C00PA20398	"Existencia global de soluciones para la ecuación de IPM"	Ángel Castro	24 000€	01/01/2020 - 31/12/2021
20205CEX001	Ayudas Extraordinarias Menciones Excelencia Severo Ochoa	Diego Córdoba Gazolaz	562 500 €	05/02/2020 - 31/03/2021

#### Regional programmes

Code	Project	PR	€	Start-final date
SI1/PJI/2019-00514	Desigualdades de martingalas no conmutativas.	José Manuel Conde Alonso	20 700 €	01/01/2020 - 31/12/2022
S2018/TCS-4342	Quantum Information Technologies Madrid+ (QUITEMAD+-CM).	David Martín de Diego	project: 1 050 060 € ICMAT: 200 000 €	01/01/2019 - 31/12/2022
IND2018/TIC-9901.	Grant from the Madrid Government for Industrial Doctorate. Researcher: Bruno Flores	David Ríos	64 000 €	26/02/2019 - 25/02/2022
PEJD-2018-POST/TIC- 9375	Grant from the Madrid Government for hiring postdoc. Grant for the incorporation of visiting re- searchers. Postdoc Researcher: David Gordo	David Ríos	35 000 €	16/03/2019 - 15/03/2020



#### International Funding

Internationally, the European Union is the main source of funding for the ICMAT.

#### ERC and Marie Skłodowska-Curie projects

Code	Reference	Project	PR	EU Funding	Start-final date
GEOFLUIDS	633152	"Geometric problems in PDEs with applications to fluid mechanics"	Alberto Enciso	1 256 375 €	01/03/2015 - 29/02/2020
GAPS	648913	"Spectral gaps in interacting quantum systems"	David Pérez- García	1 462 750 €	01/09/2015 - 31/08/2020
TraX	734557	"Stability and Transitions in Physical Processes"	Florentino Borondo	Total: 526 500 € ICMAT: 63 000 €	01/03/2017 - 28/02/2021
RESTRICTIONAPP	841228	"A multilinear approach to the res- triction problem with applications to geometric measure theory, the Schrö- dinger equation and inverse problems"	Javier Ramos and Keith Rogers	172 932,48 €	01/08/2019 - 02/10/2021
NONFLU	788250	"Non-local dynamics in incompressible fluids"	Diego Córdoba	1 779 369 €	01/09/2018 - 31/08/2023
QUAMAP	834728	"Quasiconformal Methods in Analysis and Applications"	Kari Astala. ICMAT members: Daniel Faraco and Keith Rogers	Total: 2 280 350 € ICMAT: 771 850 €	01/09/2019 - 31/08/2024
ROBOTTOPES	846722	"The momentum polytopes of nonholonomic systems"	Amna Shaddad and Manuel de León	160 932 €	16/09/2020 - 15/09/2022
GHAIA	777822	"Geometric and Harmonic Analysis with Interdisciplinary Applications"	Davide Barbieri	1 930 500 €	01/01/2017 - 31/10/2021 Extended (without a final date)
H2020-MSCA- IF-2018	839749	"Novel techniques for quantitative behaviour of convection-diffusion equations"	Jørgen Endal and Matteo Bonforte	160 932 €	01/09/2019 - 31/08/2022

#### H2020 Industrial Leadership Pillar

Code	Reference	Project	PR	EU Funding	Start-final date
IMPRESSIVE	821922	"Integrated Marine Pollution Risk assessment and Emergency management Support Service In ports and coastal enVironmEnts"	Ana María Mancho	176 315 €	01/12/2018 – 31/05/2021

#### H2020 Societal Challenges Pillar

Code	Reference	Project	PR	EU Funding	Start-final date
Trustonomy	815003	"Building Acceptance and Trust in Autonomous Mobility"	David Ríos	Project budget: 3 920 000 € ICMAT budget: 206 500 €	01/05/2019 – 30/04/2022

#### Other projects

#### National Science Foundation (NSF)

Code	Project	PR	Budget	Start-final date
DMS-1901290	"Operator Algebras, Groups, and	David Kerr (Texas A&M)	36 000 \$	21/12/2018 - 29/02/2020
	Applications to Quantum Information"	and Fernando Lledó		

#### Private funding

Title	Reference	Project	PR	€	Start-final date
Axa Permanent Chair	01AXACT01	"Análisis de Riesgo Adversario"	David Ríos	1 100 000 € (147 000 €per year)	01/09/2014 - 31/08/2022
Beca Iberoamérica Santander Investigación 2018	Co4Drones.	"Planificación de trayectorias interpoladoras y localización de agentes mediante sensores de distancia en el diseño de controles para la formación de múltiple rotorcrafts (drones)"	Leonardo Colombo	4790 €	01/01/2019 - 31/12/2020
BBVA Foundation- Becas Leonardo		"Garantías de Seguridad con Controles Basados en Datos para Sistemas Cooperativos".	Leonardo Colombo	39 987 €	30/10/2020 - 30/04/2022
La Caixa Foundation INPhINIT			Didac Violan and Francisco Presas	122 592 €	01/10/2020 - 30/09-2022
La Caixa Foundation INPhINIT			Laia Domingo y Florentino Borondo	122 592 €	15/10/2020 - 14/10/2022
La Caixa Foundation INPhINIT			Hang Lu Su	122 592 €	10/01/2018 - 09/04/2021
La Caixa Foundation INPhINIT			Didac Aris	122 592 €	01/10/2020 - 30/09/2023
La Caixa Foundation INPhINIT			Guillermo Barajas	122 592 €	01/10/2019 - 30/09/2022
La Caixa Foundation INPhINIT			Si Liu	122 592 €	01/10/2017 - 20/12/2020
La Caixa Foundation INPhINIT			Laia Domingo and Florentino Borondo	122 592 €	15/10/2020 - 14/10/2022
La Caixa Foundation Junior Leader			Jared Lee Aurent	305 100 €	01/09/2018 - 13/02/2021
La Caixa Foundation INPhINIT Incoming		"Dynamical and Numerical Aspects of Multi-agent Control Systems with Applications to Robotics"	Jacob Goodman	122 592 €	28/01/2020 - 27/01/2023
La Caixa Foundation Junior Leader		"Decentralized Strategies for Cooperative Robotic Swarms"	Leonardo Colombo	305 100 €	01/05/2019 - 31/08/2022
BBVA Foundation, Funding Call for Researchers on Big Data 2019	AMALFY	"Adversarial Machine Learning: Methods, Computations and Applications to Malware, Fake News and Autonomous Vehicles."	David Ríos	100 000 €	30/04/2020 - 30/04/2022



## 7. Severo Ochoa Programme

In December 2020, and for the third consecutive year, the ICMAT was distinguished with the Severo Ochoa seal of excellence by the Spanish Ministry of Science and Innovation.

This accreditation is endowed with four million euros for the development of a programme to strengthen institutional capacity over a four-year period as well as to provide 14 pre-doctoral contracts. This will enable different scientific programmes to be set in motion, which will help the ICMAT to maintain its status as one of the leading international centres in mathematical research.

The ICMAT first obtained the Severo Ochoa seal of excellence in 2011 – when the first call for the programme was issued – and then again in 2015, so the successful submission in 2019 means that the institute has obtained this distinction for the third consecutive time. All of these calls are made on a competitive basis, and in 2019 a total of 55 submissions were made for the Severo Ochoa and María de Maeztu Centres and Units of Excellence and were, in a statement issued by the Ministry, "independently evaluated by an international scientific committee composed of prestigious researchers renowned for their impact".

In addition to the ICMAT, the following institutions received the Severo Ochoa seal of excellence in the latest call: the National Centre for Cancer Research (CNIO), the Institute of Photonic Sciences (ICFO), the Institute for Biomedical Research (IRB), el Barcelona Graduate School of Economics (BGSE), the Canary Islands Institute of Astrophysics (IAC), the Centre for Research in Agricultural Genomics (CRAG), the Barcelona Institute of Materials Science (ICMAB), the Catalan Institute of Chemical Research, and finally the Institute of Marine Sciences (ICM), which joins the programme for the first time.

Six María de Maeztu units of excellence are also added to the list: the IMDEA Energy Foundation, the University of Córdoba Department of Agriculture, and the Catalan Institute of Human Paleoecology and Social Evolution Private Foundation – these three also appearing for the first time – the University of Valencia Institute of Molecular Science (ICMOL), the Autonomous University of Barce-Iona Institute of Environmental Technology and Science (ITCA), and the University of Barcelona Institute of Cosmic Sciences (ICC).

The purpose of the Severo Ochoa Centres of Excellence and the María de Maeztu Units of Excellence awards is to provide funding and accreditation for research centres and units in any field of science that demonstrate impact and scientific leadership at an international level and collaborate actively with their social environment and business sectors.

As on previous occasions, much of the funding this year is devoted to the hiring of personnel: experts in management and pre-doctoral researchers who have contributed to the development of the ICMAT programme of excellence. Likewise, this funding has also covered temporary transfers of contracted research personnel as well as seven collaboration grants for master students in mathematical research. They have received funding for their enrolment as well as an additional quantity per month for training purposes. Funding has also been provided for students in the final year of their degree courses for introduction to research, with the aim of enabling them to attend the JAE School (conducted this year online) as well as undertaking research stays with members of the ICMAT.

Funding has also been made available to cover the costs of different ICMAT seminars and colloquies (most of which have been held online). Costs arising from the outreach and communication activities conducted at the centre have also been met, in addition to those of the gender plan, material assets (mainly computer equipment) and fungible assets, training costs of centre members and costs of representation.

## 8. Scientific activities

For obvious reasons, the scientific activity has decrease during 2020. Several programmes have been canceled, and most of the activity after March 2020 have taken place online.

#### • Geometric Integration and Computational Mechanics

15 – 19 June

Organizing committee: Elena Celledoni (NTNU, Trondheim, Norway), Melvin Leok (University of California, San Diego, EEUU) and David Martin de Diego (ICMAT).

Web

#### Virtual Workshop on Financial Mathematics and Stochastic Analysis

22 – 23 June

Organizing committee: Mauricio Elizalde (UAM) and Carlos Escudero (UNED and ICMAT).

<u>Web</u>



#### JAE School

7 – 9 September

Organizing committee:

Web: Daniel Seco (ICMAT-UC3M) and Luis Hernández Corbato (ICMAT-UCM).

#### <u>Web</u>

#### • Online Workshop on Nonlocal PDEs and Applications

10 - 11 December

Organizing committee: Xavier Cabré (ICREA and Universitat Politècnica de Catalunya), José A. Cañizo (Universidad de Granada), Fernando Quirós (ICMAT-UAM).

#### <u>Web</u>

#### • Harmonic Analysis and PDEs Meeting

11 December

Organizing committee: Keith Rogers (ICMAT-CSIC).

<u>Web</u>

#### **COLLOQUIA**

The programmes of joint colloquia with the UAM and Special Colloquium organized by the ICMAT were cancelled in 2020 due to the pandemic. Nevertheless, the joint colloquia with the UCM continued (the first one took place on January and the second one was held online) and one colloquium with the UAM was celebrated in February, before the pandemic.

#### ICMAT-UCM Colloquium

Coordinators: Piergiulio Tempesta (ICMAT-UCM) and David Martín de Diego (ICMAT-CSIC).

 "Gluing Methods for Vortex Dynamics in Euler Flows" Manuel Del Pino (University of Bath, UK)
 29. January 2020

29 January 2020

"Integrable PDEs and Pentagram Maps"
 Boris Khesin (University of Toronto, Canada)
 16 December 2020



#### SEMINARS

Seminars are held every week at the ICMAT on different areas of research. After march, many of the seminars are organized via Zoom.

- Analysis and applications seminar. Coordinators: José Conde (ICMAT - UAM).
- Analysis and applications seminar. Coordinators: José Conde (ICMAT UAM).
- Analysis and PDE's seminar. Coordinators: Ángel Castro (IC-MAT-CSIC), Francisco Gancedo (US-IMUS), Rafael Granero (UC) and Fernando Quirós (ICMAT-UAM).
- Applied Mathematics. Coordinator: Florentino Borondo (IC-MAT-UAM).
- Communtative Algebra-Algebraic and Aritmetic Geometry seminar UAM-ICMAT. Coordinator: Ana Bravo (ICMAT-UAM).
- DataLab Seminar. Coordinator: Roi Naveiro (ICMAT-CSIC).
- Geometry seminar. Coordinator: Mario García Fernández (ICMAT UAM).
- Geometric mechanics and control seminar. Coordinator: Leonardo Colombo (ICMAT UAM).
- Group theory seminar. Coordinator: Yago Antolín (ICMAT–UCM).
- Junior Seminar. Coordinators: A. Llinares (ICMAT-UAM) and Luis Diego Martínez Magán (ICMAT-CSIC).
- Machine Learning seminar. Coordinators: Matteo Bonforte (ICMAT-UAM), Davide Barbieri (ICMAT-UAM) & Mar González (ICMAT-UAM).
- Number theory seminar. Coordinators: Enrique González Jiménez (UAM) and Daniel Macías (ICMAT-UAM).
- PDEs and fluid mechanics seminar. Coordinators: Ángel Castro (ICMAT-CSIC) and Diego Córdoba (ICMAT-CSIC).
- Q-Math seminar. Coordinator: Juan Manuel Pérez Pardo (ICMAT-UC3M).

A total of 96 seminars were held in 2020, distributed in the following fields:

- a. Analysis and applications: 18
- b. Analysis and PDEs: 6
- c. Applied Mathematics: 3
- d. Commutative algebra, algebraic and arithmetic geometry: 1
- e. DataLab: 5
- f. Geometry: 16
- g. Geometric mechanics and control: 10
- h. Group theory: 11
- i. Junior: 6
- j. Machine Learning: 5
- k. Number theory: 11
- I. PDEs and fluid mechanics: 2
- m. Others: 2



## 9. Theses

11 researchers completed their PhD theses at the ICMAT in 2020. The titles, authors and supervisors of which are listed below:

 <u>Contributions to supply chain cyber risk management analytics</u>, Alberto Redondo

Advisor: David Ríos Insua (ICMAT-CSIC)

Date: 18 December 2020

 Minimal surfaces and splitting results on riemannian manifolds. Duality and approximation in variable Lebesgue spaces, Jesús Ocáriz

Advisor: Antonio Córdoba Barba (ICMAT-UAM)

Date: 17 December 2020

<u>Affective decision making for social robotic agents</u>, Si Liu

Advisor: David Ríos Insua (ICMAT-CSIC)

Date: 16 December 2020

• <u>Symmetries of curved metric measure spaces</u>, Jaime Santos Rodríguez

Advisor: Luis Guijarro Santamaría (ICMAT-UAM)

Date: 4 December 2020

• <u>Bishop operators: invariant subspaces and spectral theory</u>, Miguel Monsalve López

Advisor: Eva Gallardo Gutiérrez (ICMAT-UCM)

Date: 26 November 2020

<u>Contributions to the security of machine learning</u>, Roi Naveiro Flores

Advisors: David Ríos Insua (ICMAT-CSIC) and David Gómez-Ullate (Cadiz University)

Date: 5 November 2020

• <u>Topics in additive combinatorics and higher order Fourier</u> <u>analysis</u>, Diego González Sánchez

Advisor: Pablo Candela (ICMAT-UAM)

Date: 25 September 2020

 <u>Morse-Sard type theorems in Rn and in Banach spaces</u>, Miguel García Bravo

Advisor: Daniel Azagra Rueda (ICMAT-UCM)

Date: 4 September 2020

 <u>Teoría de números clásica en tres contextos diferentes</u>, José Granados Palomo

Advisor: Fernando Chamizo Lorente (ICMAT-UCM)

Date: 17 July 2020

• The discrete magnetic Laplacian: geometric and spectral preorders with applications, Jhon Stewart Fabila Carrasco

Advisor: Fernando Lledó (UC3M-ICMAT)

Date: 18 June 2020

 <u>Models of linear operators satisfying operator inequalities</u>, Glenier Lázaro Bello Burguet

Advisor: Dmitry Yakubovich Lazarev (ICMAT-UAM) Date: 5 June 2020



Miguel García Bravo in his thesis defense

## 10.Institutional Networks

#### Strategic Network of mathematics (REM)



In 2019 the State Research Agency renewed its support in the category of strategic networks for the <u>Red Estratégica de Matemáti-</u> cas (REM) with funding of 50,000€for the 2019-2021 period.

The REM is a project funded by the State Research Agency, which consists of:

- CRM/BGSMATH (Centre de Recerca Matemàtica/ Barcelona Graduate School in Mathematics)
- BCAM (Basque Centre for Applied Mathematics)
- ICMAT (Instituto de Ciencias Matemáticas)
- REDIUM (Red de Institutos Universitarios de Matemáticas)
- Math-in (Red Española Matemática-Industria)
- Centros Públicos de Educación Superior

Coordinator: Luis Vega (BCAM).

The REM conducted much work to restructuring the *Comité Español de Matemáticas* (CEMAT – Spanish Mathematical Committee) throughout 2020. This restructuring enabled to CEMAT to launch the "Mathematical Action against the Coronavirus" initiative, which is also backed by the REM.

An international workshop on the role of mathematics in the challenge posed by data science is soon to be organized, with a multi-purpose objective: (i) to highlight the usefulness of mathematics in data science; (ii) to stress the usefulness of data science in mathematics; (iii) to raise the visibility of the capacity of the Spanish mathematical community in the field of data science, and (iv) to encourage the involvement of young researchers in this area.

Furthermore, one of the two ESGI Schools planned for 2020 was also organized. The organization of the other, which was postponed until 2021, has now been confirmed and will be held online.

In addition, a course of study on the "Analysis of the evolution of the avenues of research in mathematics and the influence of the TFG-TFM on the employment opportunities for students of mathematics" is currently being drawn up and is expected to be completed by the end of the second year of funding.

In particular, in 2020, the DiMa Outreach School, associated with the "March – the month of mathematics" scheme, successfully presented a submission to the FECyT. This submission was largely supported by the REM, which has also pledged a financial contribution to the co-funding of the scheme. Entities and associations such as the FESPM, the SEIEM, the RSME, the CEMAT EESTALMAT have also provided backing to all the foregoing, as well as for a report devoted to the situation of master studies directly related to Mathematics and Statistics at the different universities involved.

#### **SOMM**a



SOMM Alliance presentation

Since October, 2017, the ICMAT has formed part of an alliance between the Severo Ochoa centres and the María de Maeztu Units, known as SOMMa. SOMMa gathers over 50 top Spanish research institutions with over 8500 researchers, was launched officially on October the 18th, 2017, with the support of then Secretary of State of Research of the Ministry of Economy, Carmen Vela, as an initiative to visibilize the Spanish science with the Severo Ochoa and María de Maeztu mentions of excellence of the Spanish State Plan for R+D+I.

The Severo Ochoa and María de Maeztu mentions are the highest institutional recognition to scientific research in Spain. Their awardees, selected by an international evaluation committee, cover practically all areas of knowledge, from physics and mathematics to environmental sciences and biomedicine, as well as humanities. A reflection of the excellence of SOMMa centres and units is the fact that they are also those institutions that occupy the first positions in international scientific rankings.

Throughout 2020, the Alliance conducted the following strategic activities:

- December 2020 <u>Change in the presidency of SOMMa</u>. The new president of SOMMa is Maria A. Blasco, director of the Spanish National Cancer Research Centre (CNIO), and until now first vice president of SOMMa. The new president has expressed her will to "carry on working for the recognition of Spanish science as one of the political and economic priorities of this country". Blasco is accompanied by SOMMa vice presidents M<sup>a</sup> José Sanz, director of the Basque Centre for Climate Change (BC3), and Antonio Molina, director of the Centre for Plant Biotechnology and Genomics (CBGP-UPM-INIA).
- November 2020 <u>Leading scientific associations and innovative</u> companies demand to place R&D at the heart of our country's <u>strategy</u>. SOMMa, ASEICA and AseBio, entities that together



account for almost ten thousand researchers across the public and private sector, dozens of research centres and nearly 300 leading Spanish companies in the biotechnology sector, have joined their voices to urge the political class to transform the country. More than 40 organisations supporting stronger support for science and innovation have signed a document that calls for Spain to reach and exceed 2.5% investment in R&D by 2027 and radically change its current economic model.

- July 2020 <u>ERC Advanced Webinar</u>. On 3 July 2020, the SOM-Ma community held a webinar in connection to one of the most notorious European research funding schemes: the ERC Advanced Grants. The event is aimed at helping SOMMa members to secure funds for research projects from especially competitive funding programmes such as this one. Over 80 researchers and research support staff from 34 SOMMa members attended. The participants represented a wide range of disciplines, ranging from economics to engineering, supercomputing, math, materials science, life and health sciences, agronomics, astroand particle physics, chemistry and environmental sciences.
- June 2020 <u>Constitution of the new SOMM alliance Executive Board</u>. The SOMM alliance designated a new Executive Board for internal coordination across the strategic axes of action. Four new delegates and a new executive director design and execute in coordination with the presidency the strategies for communication, visibility, I+D+i, global impact and intitutional relations.

- May 2020. <u>Article in defense of mathematics published in El</u> <u>País</u>.
- January 2020 <u>Pedro Duque made firm commitment to the</u> <u>Severo Ochoa programme of excellence</u>. The Minister of Science and Innovation Pedro Duque met with Luis Serrano, then president of the Severo Ochoa/Maria de Maeztu alliance (SOMMa) and director of the Centre for Genomic Regulation (CRG). The minister expressed his firm commitment to the continuity of the Severo Ochoa/Maria de Maeztu programme.

#### Red de Divulgación Matemática (DiMa)

The Red de Divulgación Matemática (DiMa – Mathematical Outreach Network) is a platform consisting of disseminators of mathematics in Spain and enjoys the support of institutions (universities and research centres) and mathematical societies, among which is the ICMAT. The DiMa is a cooperative space for the sharing of experiences, materials, learning and reflection on mathematical outreach.

In 2020, the network has received funding from the Spanish Foundation for Science and Technology (FECYT) to organize a programme of outreach activities in different cities of Spain, during march 2020. "Marzo, mes de las matemáticas" will celebrate the Internacional Day of Mathematics with public talks, exhibitions, workshops, educational materials, etc., all produced by members of the DiMa.



DiMa presentation

## 11. Transfer activities

#### AXA-ICMAT Permanent Chair in Adversarial Risk Analysis

The AXA Chair in Adversarial Risk Analysis, funded by the AXA Foundation and directed by David Ríos Insua, continued its activity throughout the year.

Ríos studies problems in which an individual or an organization may tackle threats presenting intelligent or adaptive behaviours. Specifically, he deals with problems such as the protection of critical infrastructures against terrorist attacks; the preparation of bids in an auction against other potential buyers, and the protection of computer systems against cyberattacks.

Unlike the standard risk analysis, adversarial risk analysis takes into account the intention of attackers, their objectives and their capacity to modify their strategy for achieving them.

Moreover, in 2020 the group of David Ríos organized the following transfer projects:

- Contract: Xeerpa Marketing Solutions, S.L. "Recomendador de contenidos basado en el perfil digital de un usuario". 75 000 € 01/02/2020 - 31/01/2022.
- Grants for scientific research groups, Fundación BBVA: "AMALFI: Adversarial Machine Learning: Methods, Computations and Applications to Malware, Fake News and Autonomous Vehicles". 100 000 € 30/04/2020 - 30/04/2022.

The following activities were organised as well:

• NON-HOMOGENEOUS POISSON MODELS TO FORECAST AVIATION SAFETY OCCURRENCES AND THEIR SEVERITY

#### Speaker: Bruno Flores Barrio

Date: Monday, 21 September 2020 - 11:30

Place: Online

 CÓMO SER UN FÁRMACO Y NO MORIR EN EL INTENTO ('Machine learning' para el desarrollo de fármacos)

#### Speaker: Nuria E. Campillo

Date: Thursday, 15 October 2020 - 10:00

Place: ICMAT. Aula Azul and online

SECURITY ASPECTS OF MACHINE LEARNING

#### Speaker: Roi Naveiro Flores

Date: Thursday, 29 October 2020 - 10:30

Date: ICMAT. Aula Azul and online

MACHINE LEARNING AND DECISION SUPPORT ISSUES IN AUTOMATED DRIVING SYSTEMS

#### Speaker: David Ríos Insua

Date: Monday, 23 November 2020 - 13:00

Place: Online

SUPPLY CHAIN CYBER RISK MANAGEMENT ANALYTICS

Speaker: Alberto Redondo

Date: Wednesday, 9 December 2020 - 11:00

Place: Online

#### International consortiums

In 2020, the ICMAT participated in two international consortiums:

• Integrated Marine Pollution Risk Assessment and Emergency Management Support Service In ports and coastal enVironmEnts (IMPRESSIVE)

Duration: 01/12/2018 - 31/05/2021

Participant: Ana María Mancho (ICMAT)

The aim of the IMPRESSIVE project is to develop a global platform for the real-time management of accidental marine pollution in and around ports of the European Union. The monitoring and advanced modelling of these areas is of great importance, since the traffic and refuelling of vessels involves a high risk of contamination due to spillage and effluents. Mathematics is vital for modelling the movement of ocean currents and the prediction on the effect of pollutants should they reach the coast.

The project is devising a protocol for action, which will be tested and validated in the Puerto de la Luz (Gran Canaria), the Port of Taranto (Italy) and the Port of Rafina (Greece).

#### <u>Web</u>

## • Building Acceptance and Trust in Autonomous Mobility (TRUSTONOMY)

Duration: 01/05/2019 - 30/04/2022

Participant: David Ríos Insua (ICMAT)

In addition to the scientific and technological challenges arising from self-driving vehicles in complex and unpredictable surroundings, scientists also have to tackle other issues, such as analyzing the risks involved in these types of vehicles, designing communication between machine and human being, studying the impact on the economy and on certain sectors of industry. All of these questions are dealt with in the Trustonomy project.

As its title indicates, the main aim of the project is to create acceptance and trust in autonomous mobility. David Ríos is in charge of producing risk analysis models capable of responding to and predicting the specific hazards arising from this emerging form of travel and mobility. This scheme has received 3.9 million euros from the European Union H2020 programme.

#### <u>Web</u>

#### Quantum computing

The Mathematics and Quantum Information group, led by David Pérez García (ICMAT-UCM), is one of the participants in the CSIC Quantum Technologies Platform. One of the advantages enjoyed by its members is that they are able to use IBM superconducting quantum computers (according to terms in the contract signed between the CSIC and IBM).

#### DataLab

The ICMAT DataLab group, headed by David Ríos Insua, participates in the AIHub, the platform that designs the strategic plan of CSIC activities in the field of Artificial Intelligence (AI).



## 12.Communication and outreach activities

Throughout 2020, even during the lockdown, the ICMAT continued its intense outreach and communication activity through the Communication and Outreach Office, formed by Laura Moreno Iraola and Ágata Timón G Longoria, with advice and support from Daniel Peralta, Alberto Enciso, Javier Aramayona, David Martín de Diego and José María Martell. Regular organization of activities continued with the publication of press releases, the ICMAT Newsletter, the "Café y Teoremas" section in El País, and events, such as the Science Week and Matemáticas en la Residencia. A full list of the activities is as follows:

#### **ICMAT Newsletter**

The ICMAT publishes a news bulletin which reports on what happens in a centre of mathematical excellence. This newsletter presents subjects of interest regarding current mathematical research, as well as the scientific activities of the centre and personal profiles of notable figures in the scientific community. The authors of these articles are researchers from the Institute itself or other mathematicians who collaborate with the ICMAT, as well as a team of professional journalists in the field of mathematical communication and outreach.

Two issues of the ICMAT newsletter were published in 2020:

#### Newsletter #19





#### EDITORIAL

#### The surprising usefulness of knowledge generated merely by intellectual curiosity

years ago, Abraham Flexner published a timeless cissiv per's Magazine, the title of which, The Usefulness of Use-novdedge, we have paraphrased for the headline in this in all the second states and the second states and the energy, a borther and states who have an associate an enormous with the sale of their chain of department stores in New just letters the Wall Street crash, and the Bamberger sib-wrete thinking about investing part of the proceeds in a new of Medicine in Newark.

y or Measurement in revears. wer, Revere proposed a much more ambitious project to the argenrs: to create in the USA an institute develop and only only to persuade them is invest for million collars tal the value at me) in what came to be known as the Institute for Advanced (ISA). Utimately, icane to be built in Princeton rather than wark, together with a large university consisting of an out-min intellectual community, Brannes and other facilities.

In Nevers, together with a large university consisting of an out-standing intellectual community, learnes and other facilities. The LKS was efficially created on May 20°, 1930, with Flexem-randum he presented to the Beard of Instees, Flexemer wrote as Bellows. The Institute should be small and placit (ar. Insteald). It and its phenomena as a laboratory, without heiring disturbed by the immediate concentro of oursent events. L. It is professors should enjoy full intellectual freedom and be completely releved of all and stamparts of the Beard of an our second state of the immediate concension billions and burners. L. This professors should enjoy full intellectual freedom and be completely releved of all and stamporary members, ranging from young doctrars. The temporary members, ranging from young doctrars. The IMS currently consists of four schools. Mathematics, Natural Sciences, Theoretical Physics being those that instally existed. The most dista-tion of the IMS science when a linear science when the internation framework with to the IAS took splace when 1 pinet is an Assisten-tar took of the IAS took splace when 1 pinet is an Assisten-ter took of the IAS took splace when 1 pinet is an Assisten-ter took of the IAS took splace when 1 pinet is an Assisten-ter took of the IAS took splace when 1 pinet is an Assisten-ter took of the IAS took splace when 1 pinet is an Assisten-ter took of the IAS took splace when 1 pinet is an Assistent become

nur uotet, terman wegi and John von Neuman, annog others, My first visis to the K3 took place when I jeined it as an Assistant Perfessor at Princeton University in 1974. I subsequently became as a visiting professor on several occasions. The Institute remains in my memory as a majcia place where I was able to collaborate with the most creative mathematicitans of the moment and con-verse with mytical Bigurus in my mathematical training such as Arne Bertring, Atlee Selberg and André Weil. Jako gotto meet, al-though not to taki, Kuru Gödel themself in person, whose impact on my mathematical career has been of great importance. I was albo able to get to know at first hand the unital convolution

also able to get to know at first hand the utopia conceived romoted by Flexner. The centre was truly a paradise for in-

## tellectuals, a space of freedom in which scientists could pursue their ideas undisturbed by the madding crowd. After the time they spent there, they were not obliged to give an account of them-selves to anyone. Their work did not necessarily have to be fo-cused on the solving of great problems or changing the world although in many cases their achievements there did in fact d estimates the solution of the strength of the solution of the Project by ven Neumann is perhaps the greatest example of the atomishin usefulness of thought intellectual to the solutions of thought intellectual of the institute, Flexner expressed his reflectio published in Harper's Magazine, in which he enormous usefulness that research motivate utimately have. In what follows, we give some tracts from the essay, translated into Spanish.

Antonio Córdoba, ICMAT director between 2016 and 2019, UAM Professor Emeritus

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#### Newsletter #20

EDITORIAL





May 12: Celebration of Women in Mathemat Profile: Alexandre Anabori (ICMAT).

Scientific review: Fourier series in BMO with theoretical implications

Tell me about your thesis: Ángela Capel [Te University of Munich and Munich Center for Q Science and Technology]

More Science

Throughout history, humankind has been the victim of severe epidemics, such as the black plaque in the mid-14th century; smallpac in the mid-18th century, or the ill-named Spanish flu some one hundred years ago, among others. Thanks to the enormous programs made in the contemporary real, not cely have we been able to live longer and better lives, but we have blieved ourselves to be safe from attacks of many kinds, from natural disasters and, of course, pandemics. Nevertheless, uits suddniy, systems in the vourd. And when the number of infected cases and deaths grows alarmingly, the best messure advanced health systems in the vourd. And when the number of infected cases and deaths grows alarmingly, the best messure to adopt has been confinement; this, to ulpiolable our world and put trends that once seemed unquestionable into reverse. and put trends that once seemed unquestionable into reverse. The effects of this discuss have proved to be overwheelming, and here, at the ICMAT, we wish to express our soluarity and send our support in the most direct way to the families affected. It is also an opportune moment to give our thanks to all those who have been engaged on the farefrand of this problem, and especially, to applaud the determination and dedication of our health workers.

especially, to applaud the determination and dedication of our health workers. Despite the devastating impact that COVID-19 has had on our of the most frequently heard messages has been that *this particles* and the most frequently heard messages has been that *this particles* and the advantage of the most frequently heard messages has been that *this particles* and the advantage of the most frequently heard messages has been that *this particles* and the advantage of the maximum of the advantage of the advantage of the most frequently heard messages has been that *this particles* and treatments are being sought that will help us to return to normally, and the due to understand and response to latvare found in all these endeavours by means of models, predictions and by this discipline is crucial, aliance they serve as an argument to highlight the significance of mathematics before the powers that be Nevertheless. If all we do is emphasize this importance, we run the risk do society at large regarding the discipline as a fashicable held of study that is only useful in the short term. It is virial that we origoned in that the mathematics chards: bad works participations and complex system of ideas, concepts, theories and devigenments that mathematics chards the part to preveasing the discipline is a fashicable field of study that is only useful to distinguish clarky. We must also bereas the term that the mathematics chards the terms the preveasing in the short term. It is virial that we find the terms that the mathematics chards the terms that the mathematics chards the preveasing the short term. The virial that we find the terms that the mathematics chards the preveasing the short term the terms and the preveasing the short term the term terms and the preveasing the short term that the mathematics chards the preveasing the short term terms and the preveasing the short term terms that the mathematics that we current the preveasing the short term. For the short term terms the term terms that the mathematics that

#### **Press releases**

The ICMAT regularly sends press releases to a broad range of journalists specializing in science and education, with the aim of keeping the general public informed about the activities of the Institute. In 2020, nine press releases were prepared and issued, covering a wide variety of topics: from reports on new scientific results to information about events, the award of grants and prizes, etc. All these press releases are available on the ICMAT website.

#### "Café y Teoremas," El País

'Café y Teoremas' is a weekly publication coordinated by the IC-MAT and published in the section entitled Materia of the El País daily newspaper. This space is devoted to mathematics and the context in which mathematics is set, where researchers, members and collaborators of the centre give an account of the latest developments in the discipline, as well as sharing the points of confluence between mathematics and other social and cultural expressions. They also highlight those to whom we owe these developments and how they transformed them from coffee into theorems. 47 articles appeared in 2020. The full list of articles is as follows:



- <u>La física matemática que probó que el futuro del universo</u> <u>está bien definido</u>, Alberto Soria. 3 January.
- Primer avance en décadas en un problema aparentemente imposible, Pablo Candela. 9 January.
- <u>Matemáticas, turbulencia y auroras boreales</u>, Ágata Timón, Daniel Faraco. 15 January.
- <u>Matemáticas para igualar la oferta y la demanda en agricul-</u> <u>tura</u>, Javier Borondo. 31 January.
- <u>Matemáticas para predecir la propagación del coronavirus</u>, Miguel A. Herrero. 7 February.
- <u>Adiós a Louis Nirenberg, maestro de ecuaciones diferencia-</u> <u>les</u>, Antonio Córdoba. 14 February.
- <u>Matemáticas para afrontar los retos de los coches autóno-</u> <u>mos</u>, Alex Kosgodagan, David Ríos. 18 February.
- <u>Un documental recupera la figura de la matemática del siglo</u> <u>XVIII María Andresa Casamayor</u>, Mirella R. Abrisqueta, Julio Bernués, Pedro J. Miana. 20 February.
- <u>Bertrand Russell y los fundamentos de las matemáticas,</u> Antonio Córdoba. 28 February.
- <u>Cómo garantizar la seguridad de robots y vehículos autóno-</u> <u>mos</u>, Thomas Beckers, Sandra Hirche, Leonardo Colombo. 4 March.
- <u>17 maneras de decorar su pared: los grupos de papel pinta-</u> <u>do</u>, Julio Aroca. 10 March.
- En las estructuras muy grandes siempre aparecen patrones, Juanjo Rue. 19 March.
- <u>El premio Abel reconoce a dos pioneros de la interacción</u> <u>entre probabilidad y álgebra</u>, Yago Antolín, Talia Fernós. 24 March.
- <u>Métodos infinitos para resolver problemas de carácter finito</u>, Elías Baro González, Amador Martín Pizarro, Daniel Palacín Cruz. 1 April.
- La importancia de interpretar bien los datos y modelos de la <u>COVID-19</u>, José María Martell. 6 March.
- <u>Matemáticas para salir de la cuarentena del coronavirus</u>, Clara Burgos Simón, Juan Carlos Cortés López, Elena López Navarro, David Martínez Rodríguez, Pablo Martínez Rodríguez, Raúl S. Julián, Rafael Jacinto Villanueva Micó. 15 April.
- <u>Adiós a un matemático surrealista y mágico</u>, David Martín de Diego. 22 April.
- <u>Disfrutar de las matemáticas en 'streaming'</u>, Javier Aramayona, David Martín, Ágata Timón. 27 April.
- <u>El camino más corto entre dos puntos no siempre es recto,</u> Javier Aramayona. 5 May .

- ¿Por qué necesitamos un día de las mujeres matemáticas?, Laura Moreno Iraola. 12 May.
- <u>Ida Rhodes, el poder de la mujer-máquina</u>, María Isabel González Vasco. 19 May.
- <u>Una estudiante de doctorado resuelve un problema abierto</u> <u>desde hace décadas</u>, Marithania Silvero. 29 May.
- <u>Muere Ann Mitchell, cazadora de patrones criptográficos en la lucha contra los nazis</u>, María Isabel González Vasco, Ágata A. Timón. 3 June.
- ¿Todo número entero es la suma de, como mucho, nueve cubos?, Enrique González Jiménez. 12 June.
- <u>El matemático que soñaba con ordenadores en 1830</u>, José Merodio. 17 June.
- <u>Las herramientas matemáticas que han revolucionado la</u> <u>tecnología digital</u>, Davide Barbieri, Eugenio Hernández. 1 July.
- <u>El matemático que afirma que Pi no es un número</u>, Fernando Chamizo. 2 July.
- <u>La medida de todas las cosas</u>, Pedro Tradacete, Ignacio Villanueva. 14 July.
- <u>Las matemáticas del cubo de Rubik</u>, Javier Aramayona, Hugo Parlier, Ágata Timón. 20 July.
- <u>La física que nunca perdió su humanidad</u>, María Ángeles García Ferrero, Juan García Ferrero. 27 July.
- <u>Matemáticas para que los robots nos ayuden a vestirnos,</u> Ágata Timón. 4 August.
- <u>¿Entiendes realmente la cartografía de la Tierra?</u>, Boris Khesin. 12 August.
- <u>Las matemáticas que producen y detectan las 'fake news'</u>, Víctor Gallego, Alberto Redondo, Ágata Timón. 19 August.
- <u>Algunos problemas con los datos de la pandemia de la covid,</u> Ricardo Cao Abad, Ágata Timón. 2 September.
- <u>Grandes retos en las ecuaciones de los fluidos</u>, Ángel Castro, Diego Córdoba. 7 September.
- <u>El objeto que fascina a matemáticos y criptógrafos</u>, Iván Blanco-Chacón. 15 September.
- <u>Las simetrías de las ecuaciones del universo</u>, Álvaro Rodríguez Abella. 21 September.
- <u>La serie que cambió el mundo</u>, Javier Ramos Maravall. 1 October.
- <u>Los tamaños del infinito</u>, Juan Gerardo Alcázar Arribas. 8 October.
- <u>Un Nobel de Física muy matemático</u>, José M. Martín Senovilla. 16 October.
- <u>Modelos matemáticos para el diseño de fármacos</u>, Wendy Cornell. 20 October.
- <u>Un puente matemático entre los billares, los gases y el algo-</u> <u>ritmo de Google</u>, Pierre-Antoine Guihéneuf. 28 October.
- <u>Cómo usar matemáticas para desarrollar un páncreas artificial</u>, María Ángeles García-Ferrero. 13 November.
- <u>Ajedrez y matemáticas para optimizar las medidas de con-</u> <u>finamiento</u>, Luis Seco. 16 November.
- <u>Subastas: teoría y práctica</u>, David Ríos. 9 December.
- <u>Por qué muchos datos empiezan por 1</u>, Javier Aramayona, Ágata Timón. 16 December.



#### News

The ICMAT regularly publishes <u>news</u> on its website about the scientific and outreach activity conducted at the centre. In 2020, 50 news items were published.

#### Blog

The <u>ICMAT Blog</u> provides a platform on the website for the dayto-day activity at the centre, as well as for sharing information regarding mathematics and the mathematical community. In 2020, 20 articles appeared on this blog.

#### Social networks

The ICMAT maintains active profiles on the main social networks. The number of followers as of December 2020, is shown below:

- Facebook: 30 408 followers, 29 305 likes
- Twitter: : 27 750 followers
- Instagram: 3190 followers
- YouTube: 2072 subscribers; 55 700 views

An average of three different contents are usually posted every day on Facebook and Twitter, dealing with current mathematical issues about both the ICMAT occasionally and in general, and exclusively about the ICMAT on Instagram. Videos made by the ICMAT are uploaded onto YouTube.

#### **OUTREACH ACTIVITIES**

#### 11 February, International Day of Women and Girls in Science

The ICMAT has joined in celebrating <u>11 February, International</u> <u>Day of Women and Girls in Science</u> with different activities:

#### Workshop: "Women mathematicians"

On 11 February, Ana Bravo, UAM lecturer, chair of the ICMAT Equality Committee and member of the Institute, gave a workshop for secondary school students, during which the work of women mathematicians, especially in arithmetics and geometry, was presented.



Workshop "Women mathematicians," given by Ana Bravo.

## Escape Road: "In search of Nobel and non-Nobel women scientists" $\ensuremath{\mathsf{N}}$

This activity consisted of a treasure hunt held from February 3rd to February 14th at the Campus de Cantoblanco, devoted to women scientist Nobel prize-winners and also to winners of a Fields Medal, which is regarded as equivalent to a Nobel Prize in mathematics, as well as other women scientists whose great discoveries were not recognized with either of these prizes.

The event was organized by the gender and equality committees belonging to the following CSIC centres: the Madrid Institute of Material Sciences, the Institute of Ceramics and Glass, the Institute of Catalysis and Petrochemistry, the National Centre for Biotechnology, the Severo Ochoa Centre of Molecular Biology, the Institute of Mathematical Sciences, the Institute of Theoretical Physics, The Institute for Research in Food Sciences, the Institute of Micro and Nanotechnology and the National Centre for Microelectronics.

#### "European Researchers' Night"

The ICMAT celebrated the <u>European Researchers' Night 2020</u> by means of an online joint activity with MediaLab Prado (Madrid) and CSIC centres at the Campus de Cantoblanco, which was held on 27 November. The Institute directed the "Gigantic numbers: a small window into infinity" workshop in which Javier Aramayona, ICMAT-CSIC researcher, explained how, in everyday games, such as cards or the famous Rubik's cube, one may encounter gigantic numbers, whose magnitude is hard to grasp for the human mind. In this activity, the speaker and his audience thought about some of these numbers, which offer an interesting viewpoint about the distinction between finiteness and infinity. This activity was possible with the support of the ICMAT Unit of Scientific Culture.

There were also activities aimed at schools during the morning and early afternoon, which were also open to the public in the afternoon sessions.

The ICMAT also participated in the Escape Road: "A la búsqueda de las científicas Nobel y no Nobel," an online route consisting of interactive panels and challenges representing the life and work of women Nobel Prize winners in the different branches of science, as well as women winners of Fields Medals (equivalent in mathematics to the Nobel Prize), together with those overlooked for these awards.



Javier Aramayona in his talk.

#### "Science in Action"

Science in Action is a competition based on innovative ideas for bringing science closer to the general public. Those selected in the first phase show their proposals live in a grand final that becomes a great celebration of science. Together with other scientific institutions, the ICMAT is participating in the organization of this dissemination activity. The competition took place on 2-4 October online.

#### "Mathematics at the Residencia"

Mathematics at the Residencia consists of a series of talks by internationally renowned speakers on the public understanding of mathematics. It is organized by the ICMAT in collaboration with the CSIC Vice-presidency of Organization and Scientific Culture and the Residencia de Estudiantes of Madrid.

In 2020, the following talk was organised online:-

#### "Fin de siglo XIX en Palermo: la Ciencia entre Il Gattopardo y el estilo Liberty"

Speaker: Guillermo Curbera (Universidad de Sevilla)

#### Date: 12 November

More information

#### CICLO

Matemáticas en la Residencia

#### Fin de siglo XIX en Palermo: la Ciencia entre Il Gattopardo y el estilo Liberty MATICO

En el cambio del siglo XIX al XX en Palermo convivía una tensa situación social y política con los excesos de una nobleza decadente, tal como retrata la novela "Il Gattopardo" (Giuseppe Tomasi di Lampedusa, 1958). En ese contexto aparece de forma inusitada una actividad matemática de primer orden internacional, liderada por el ioven matemático Giovanni Battista Guccia, pariente del personaie histórico que está detrás de Gattopardo. Esta actividad científica llevó a crear en 1914 la mayor sociedad matemática del mundo: Il Circolo Matematico di Palermo.



#### "Science Week"

The Science and Technology Week is one of the leading events in social communication of science and technology held in Spain. The ICMAT has participated in this scheme since 2009 by programming conferences and dissemination workshops addressed to all types of audiences. The main objective of these activities has been to improve the social perception of mathematics by revealing its surprising, unexpected and amusing features as well as those most closely related to society in general.

In 2020, the Institute organised two online activities for secondary school students held on 4 and 5 November:

- Conference: "¡Eh! ¿Dónde está todo el mundo?", Alberto • Ibort (ICMAT-UC3M)
- Conference: "Matemáticas y robótica", David Martín de Diego (ICMAT-CSIC)



Alberto Ibort and David Martín de Diego

#### The "Miradas Matemáticas" collection

Miradas Matemáticas consists of a series of books launched in 2017 and combining mathematical outreach and didactics, designed to bring research closer to secondary school and baccalaureate teachers. The books in the collection are produced by the ICMAT, the Spanish Federation of Mathematics Teachers (FESPM) and the publisher Los Libros de la Catarata.

#### The following volumes were published in 2020:

- <u>Cálculo infinitesimal. El lenguaje matemático de la naturaleza,</u> Antonio J. Durán (Universidad de Sevilla). February 2020
- Jugando con las matemáticas. Los juegos como recurso de enseñanza y aprendizaje matemático, José Muñoz Santoja, Juan Antonio Hans Martín, Antonio Fernández-Aliseda Redondo (Grupo Alquerque). June 2020
- La geometría de las ciudades, José María Sorando Muzás • (Universidad de Zaragoza). August 2020
- Cónicas. Historia de su independencia del cono, Agustín Carrillo de Albornoz Torres (FESPM) y Manuel de León (IC-MAT-CSIC). October 2020





#### **Graphic communication**

The Mathematical Culture Unit is responsible for preparing posters for the different activities that take place at the centre in order to assist and facilitate their publicity and diffusion.



## 13.Equality actions

The number of women researchers engaged in the field of mathematics is still far below that of men, and the further that researchers progress in their professional careers the more this gap increases. The ICMAT is committed to offering equal opportunities for all and believes that mathematical talent is distributed equally regardless of gender, race or geographical location. In particular, the current situation entails the loss of great minds for science and constitutes a state of affairs that can and must be remedied. To that end, in 2016 an action plan was launched by the ICMAT Board and the Severo Ochoa programme, executed through the centre's Gender Committee (now, Equality Committee), which demonstrates the institutional commitment of the ICMAT to equality in general.

In 2020, the Equality Committee consisted of the following members: Ana Bravo (ICMAT-UAM, chairperson); Javier Aramayona (ICMAT-UAM); Eva Gallardo (ICMAT-UCM); Marina Logares (UCM) Marta Macho Stadler (UPV/EHU); David Martín de Diego (ICMAT-CSIC); Catalina Martínez (IPP-CSIC); Laura Moreno Iraola (ICMAT-CSIC) and Ágata A. Timón (ICMAT-CSIC). With the collaboration of other ICMAT members and of other institutions, this Committee devised, executed and evaluated the actions of the ICMAT Strategic Gender Plan.

The Equality Committee organized or collaborated with the following activities in 2020:

#### "Science by Women" programme. Fundación Mujeres por África (FMxA)



For six consecutive years, the ICMAT has participated in the <u>Science by Women programme</u> belonging to the Fundación Mujeres por África (Women for Africa Foundation, FMxA), the aim of which is to promote the access of African women to science and technology; to support them in their research careers; to highlight their achievements; to promote their leadership in the international scientific community, and to help them strengthen the capacities of their research groups in their different countries of origin. Thanks to this project, the ICMAT welcomes women from African countries who are selected to come to the centre to collaborate with ICMAT researchers in accordance with their fields of research.

In 2019, (5<sup>th</sup> edition), Sara Abdelsalam (Egypt) was selected. She would have worked with Ángel Castro and his group, but she couldn't because of the COVID-19 health crisis. In 2020, (6<sup>th</sup> edition), Fagueye Ndiaye (Senegal) was elected to join the ICMAT for six months. She will work with Daniel Faraco and his group from May 2021.

## February 11th commemoration, International Day of Women and Girls in Science

More information in page 35 of this report.

#### #STEMatEsElla



The ICMAT Severo Ochoa project, the Higher Institute for Internet Development (ISDI) and the University of Oviedo Chair of Analytical Intelligence sponsor the third edition of the #steMatEsElla programme, inaugurated at the start of the 2020/2021 course. It is run by the Asociación Española de Ejecutiv@s y Consejer@s (Spanish Association of Executives and Councellors - EJE&CON) and the Real Sociedad Matemática Española (Royal Spanish Mathematical Society - RSME), with the collaboration of the IC-MAT and the Basque Centre for Applied Mathematics (BCAM).

#steMatEsElla is a scheme for promoting the professional scientific and business careers of women degree students and female master and PhD students of mathematics and related disciplines (grouped under the acronym CTIM). This is the only programme in Spain to combine mentoring, coaching, webinars and visibility of reference points, while also working on soft skills. The aim is to put women students in contact with STEM professionals, both in the academic sphere (female researchers and teachers belonging into the RSME and the ICMAT) and in the business sector (EJE&CON executives and counsellors). This is achieved by means of regular tutorial sessions that will be held during the 2020-2021 academic year, and which will be organized by the Ernst & Young company in its capacity as collaborator in this scheme. The new edition has started on 2020.

Other action of this programme is the <u>#STEMatEsElla Dialogues</u>, based on the "Diálogos de género y ciencia" activity, organized by the ICMAT from 2016 to 2019. The aim of these dialogues is to bring leading exponents of STEM subjects into closer contact with students in the field in order to provide role models and to stimulate the exchange of thoughts and opinions in a relaxed and familiar environment. In 2020, the series of talks was inaugurated by Nuria Oliver (Data-Pop Alliance, ELLIS, Vodafone Institute and Generalitat Valenciana), one of the foremost specialists in artificial intelligence and data science in Spain. Her talk, "Data, data, data", was celebrated on 7 October online.

#### May 12, Celebrating Women in Mathematics

For the second year running, the Day of Women in Mathematics was held on 12 May, the birthday of the Iranian mathematician



Maryam Mirzakhani, the only woman to win a Fields Medal and who sadly died in 2017. Throughout that month, and with the slogan Celebrating Women in Mathematics, a series of activities were organized all over the world - many of which, given the circumstances, were virtual events - with the aim of highlighting the work of women mathematicians, profiling outstanding figures and helping in the struggle to close the gender gap that exists in the discipline. This second edition enjoyed a considerable follow-up, with more than 80 events registered on the website set up for the celebration and thousands of views of the documentary Secrets of the Surface. The Mathematical Vision of Maryam Mirzakhani in 124 different countries, according to the organizers of the May 12 initiative. The idea for this celebration came from the Women's Committee of the Iranian Mathematical Society and was approved at the World Meeting for Women in Mathematics (WM)<sup>2</sup>, one of the satellite congresses that was held at the last International Congress of Mathematicians (ICM), held in Río de Janeiro (Brazil) in 2018.

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



#### "She Does Maths", ICMAT Newsletter

This is a permanent section of the ICMAT Newsletter in which a portrait of a women mathematician (preferably at her place of work) is given, together with a brief description of her research work. This content is also available on the blog <u>Mujeres con Ciencia</u>. On the basis of this section of the Newsletter, posters in A3 are prepared that are later attached to the doors of the science faculties and mathematics departments of the three Madrid universities of which the Institute forms part: UAM, UCM and UC3M. In 2020, Isabel Fernández (Universidad de Sevilla) and Evelyne Miot (Institut Fourier, CNRS, and Grenoble-Alpes University, France) were the protagonists of this section.

ICMAT Newsletter #19 First semester 2020



SHE DOES MATHS

abel Fernández came to the ICMAT to give one of the plenary talks at the MAT conference

Differendia geometry, geometric analysis, variational problem studio that area, actiones of constant emises curvature. Laura Mennes Iranta, Isabel Fernindez University of S-eU Johnson Jind a profilection for geometry is owhen she finance university of Canada Geometry Department, where she studio considered here the studies of the studies of the studies constant of the dispersion for choice School of Computing Dispersion, where the combines teaching with research wo here facility of the dispersion for choice School of Computing Dispersion, where the combines teaching with research wo the facility of persisting that the dispersion for choice and the dispersion for choices in the study of Laurizes that minimize area linear benefacility of the relative to the constance.

Minimal surfaces are those with zero mean curvature. They arise to the search for which sets that, among all those having the sense point of view, they correspond to seab bubbles, geometric elements that you which was introduced by the physical Joseph Plateau. Fernilates has conducted research into these surfaces in the why fail within the lided a geometry, thorhoughs from their areas of mathematics are used to study them, such as partial differential qualition, measure theory and algebraic geometry.

Pennande a currently studying more generals type of surfaces. He accides Weingelman surfaces, which are "Those in which a relation exist belowsen their mean curve and their Gauss curve', shreegbars for a sub constraint of the surface study of Bevilla institute of Marthematics (IMOG) and member of the Board of the Hogy Sogned Behamistics (IMOG) and member of the Board of the Hogy Sogned Behamistics (IMOG) and member of the Board of the Hogy Sogned Behamistics (IMOG) and the Hogy Sogned Behamistics to have been invited to deliver a talk at the International Corgons of Mathematicalism (IMM), the foremain international technic Holemania and the Benstein problem in Hesisheler societ", or written fyrabio Mara, her find and collaborator, was published in genumal "Threatione of the Amminican Mathematical Gooty" in the grown Threations of the Amminican Mathematical Gooty" in

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SHE DOES MATHS: Evelyne Miet

#### Research fields: Differential equations, fluid mechani equations, Vlasov-Poisson equations. Laura Moreno Iracia

Since 301, Evelow Mich has been a permanent researcher at the Institut Fourier which beings to the Centrer National de la Reherrhe Scientingu (2008) and the Université d'enolisie Agres. In Marchin big aux, the was rehefield to genic the Canada and Summun Fiscale, organized by the researcher David Prantis, buch pandrising prevention for the main strainty. This would have been her first visit to the Centre, and and was aspecting to make how of the risk to working alongiad an area the patch panent of the panel provides and the visit, we are add to table to her visit visit.

Until the was 14 years of U. Mick was convinced that she would tauly mick time. However, a tasketing of mathematics persuade here to change her mind. The set us the task of mading a deter time statey, Ler Mickeine au Finninger by Dents Gaueg, In white the action introduces the hostory of mathematics in a fact anding way. If impressed me as anywhich hall i ended up studyin order to go deeper into the subject, and little by little becam Unity immersed in the discipling.

This researcher is a specialist in partial differential equations balonging to the field of fluid rections: - 2-dimensional and subscription to the field of fluid rections: - 2-dimensional and on -Photon regulations - and subscription of the source scherdinger equations in particular, she studies solutions to these equations when insignation appears which generally correspond to vote parties of Kamatos that are defined by the Subscription equations in paramas, determined by Subscriptions of the source equations and um fluids, buenched by Schrödinger equations source equations - to charge points in gatarnas, determined by subscriptions of the source equations.

Met hair made important contributions to the leads methodes above. Binc has obtained results on the factor equation in 2-disingularities, in the case of 3-dimensional floats, in collabors, multively and the second second second second second second multively and the second second second second second second methy may be setting the second second second second second thereby managed between the system proposed by Rupert Klein, Andrew J. Majda and Kumaran Bamostarin in 1958, and hereby managed the setability results of sectiones and uniqueness under the conjecture of symmetry in the configuration of the Klaments.

But if Miot had to choose the results of which she is mos proud, she would probably opt for those obtained with Banic and Faou on the problem of finite-time collapse of vortex fit aments before income a vortex recommendion. As Midt bereat



remarks: "Like these results because they have provided a partial rights verification of a phenomenon that has in fact also been observed in numerical experiments and in physics thanks to analytical tools. This research work was published in the prastigous New York University Courant Institute of Mathematical Sciences journal Communications on Pure and Activity Anthronomics.

In addition to har research work, Midl's also deputy cirector Mattrice. The algorithm is a documentary centre bathoging to the CMRS and the University of Grenole that provides Af-Phrelia Meth, a courd providing access to maintenniate anientars as well as home directories and databases of Finchin Institutions, maning others, and Catacima, a platform by which nea may access French mathematical contracts, journemais. Furthermen, 2018 the region launched Magnetin, an open access publication platform of which Midl's one of the collaboration.

d as the herself explains. The best experience 'unknews' has been herself explains, the best experience 'unknews' has been that is held in the Apis for high block block buddens with learning difficulties. We combine math leasons with mountain bible sessions and high "basis both president bible reading the submit a bible with other mathematicans or takes with thy young high school or PhD students, in which her species and high species and herding the species and high the species and herding the species





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