ICMAT

INSTITUTO DE CIENCIAS MATEMÁTICAS

Annual Report 2022

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MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

AGENCIA ESTATAL DE INVESTIGACIÓN

CSIC Consejo Superior de Investigaciones Científicas

UAM Universidad Autónoma de Madrid

Universidad Complutense Madrid

uc3m Universidad Carlos III de Madrid

Excelencia Severo Ochoa

Image: Íñigo de Amescua/ICMAT

ICMAT Annual Report 2022

The Institute of Mathematical Sciences is a joint research centre of the Consejo Superior de Investigaciones Científicas (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). ICMAT is a leading international research centre in mathematics, recognized by the Spanish accreditation of excellence Severo Ochoa.

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Javier Aramayona, ICMAT director

Image: Íñigo de Amescua/ICMAT

1. INTRODUCTION

2022, A Year of Renewed Hope

2022 marked the start of a long-sought return to normality after the COVID-19 global pandemic, notably through the gradual restoration of face-to-face activities. The Institute made a huge collective effort to recover its prior scientific momentum, capitalizing on its third consecutive Severo Ochoa award, obtained immediately before the pandemic struck. In particular, a large number of seminars, conferences, workshops, graduate schools, etc., were organized in 2022, which helped mitigate the negative scientific effects brought by the pandemic.
This return to normality, together with the outstanding level of scientific output that ICMAT continues to offer, allows us to look to the future with renewed hope, and to be certain that the brightest times still lie ahead.

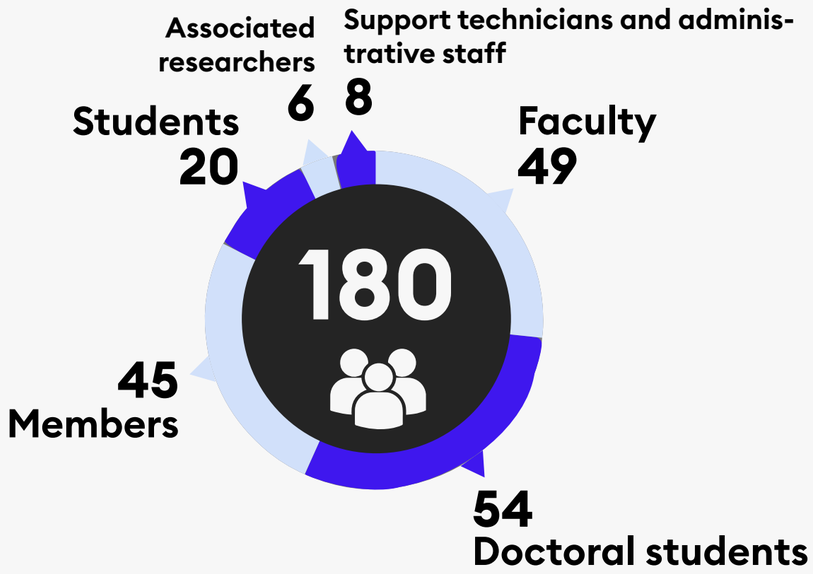
Javier Aramayona, ICMAT director

2. ICMAT IN FIGURES

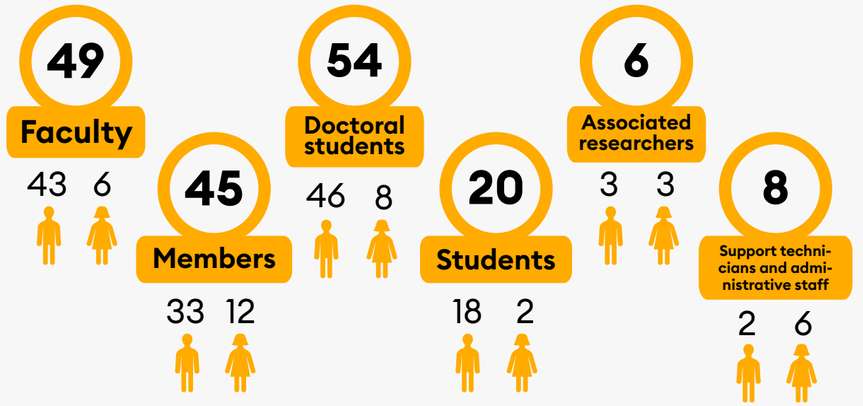
Scientific activities

18 Workshops	**56** Courses	**21** Colloquia
5 Joint Mathematics Colloquium	**12** Joint Mathematics Junior Colloquium	**4** Special Colloquium
1 Distinguished Lectures	**174** Seminars	**3** Thesis

Personnel



Distribution by gender



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3. PERSONNEL

3.1. Research groups

At present, ICMAT is structured around three main research groups:
· GROUP A: Algebra and geometry
· GROUP B: Mathematical analysis and differential equations
· GROUP C: Applied mathematics

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 Cónsul
• Yago Antolin Pichel
• Javier Aramayona Delgado
• Nuno Barroso de Freitas
• Ana Bravo
• José Ignacio Burgos Gil
• José Francisco Fernando Galván
• Oscar García Prada
• Tomás Gómez de Quiroga
• Luis Guijarro Santamaría
• Andrei Jaikin Zapirain
• Manuel de León Rodríguez
• Ignacio Luengo Velasco
• David Martín de Diego
• Daniel Peralta Salas
• Francisco Presas Mata
• Piergiulio Tempesta

Members
• Alexandre Anahory de Sena Antunez Simoes
• Mathieu Ballandras
• Benjamin Bode
• Caterina Campagnolo
• Federico Cantero Morán
• Eva Elduque Laburta
• Eduardo Fernández Fuertes
• Dominik Francoeur
• Mario García Fernández
• Héctor García de Marina Peinado
• Alejandra Garrido Angulo
• José Ángel González Prieto
• Luis Hernández Corbato
• King Leung Lee
• Daniel Macías Castillo
• Leo Margolis
• Alan McLeay
• Beatriz Molina Samper

- Alberto Navarro Garmendia
- Beatriz Pascual Escudero
- Arpan Saha
- Amna Shaddad
- Carolina Vallejo Rodríguez

Doctoral students
- Jesús Aguado López
- Guillermo Barajas Ayuso
- Jan Boschheidgen
- Javier Casado Álvarez
- Bilson Castro López
- Iván Chércoles Cuesta
- Andoni de Arriba de la Hera
- Rodrigo Alonso de Pool Alcántara
- Celia del Buey de Andrés
- Sergio Domingo Zubiaga
- Dahyana Eugenia Farias Uncovich
- Guillermo Gallego Sánchez
- Manuela Gamonal Fernánez
- Raúl González Molina
- Jacob Goodman
- Manuel Lainz Valcázar
- Xabier Legaspi Juanatey
- Asier López Gordon
- Francisco Javier Martínez Aguinaga
- Enrique Martínez Cardenal
- Daniel Martínez Marqués
- Manuel Mellado Cuerno
- Henrique A. Mendes da Silva e Souza
- Javier Peñafiel Tomás
- Samuel Ranz Castañeda
- Daniel Reyes Nozaleda
- Álvaro Rodríguez Abella
- Álvaro Romaniega Sancho
- Guillermo Sánchez Arellano
- Pablo Sánchez Peralta
- Roberto Téllez Domínguez
- Didac Violan Aris
- Wei Zhou

Associated members
- Juan Carlos Marrero
- Edith Padrón
- Orlando Villamayor

Master students
- Alberto Angurel Andrés
- Sergio Domingo Zubiaga
- Miguel González González
- Javier Peñafiel Tomás
- Sergio Romero Alba
- Diego Ruiz Cases
- Pablo Sánchez Peralta

In 2022, this group organised the following activities:
- Group theory Seminar
- Number theory Seminar
- Geometry Seminar
- Geometry, mechanics and control Seminar
- Commutative algebra, algebraic and arithmetic geometry Seminar
- Study Group on Euler Systems
- Research Group on Moduli Spaces
- Reading Seminar on Vertex Algebras
- Geonuma Website
- Groups in Madrid

The following CSIC research groups are involved in Group A:
- GROUP 4: Algebraic geometry and mathematical physics
- GROUP 5: Differential geometry and geometric mechanics
- GROUP 8: Group theory
- GROUP 9: Number theory

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-Zygmund 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 Algarra
- Matteo Bonforte
- Florentino Borondo Rodríguez
- Ángel Castro Martínez
- Fernando Chamizo
- Diego Córdoba Gazolaz
- Alberto Enciso Carrasco
- Daniel Faraco Hurtado
- Eva Gallardo Gutiérrez
- María del Mar González Nogueras
- Manuel Mañas Baena
- José María Martell Berrocal
- Carlos Mora Corral
- Jesús Munarriz Aldaz
- Rafael Orive Illera
- Javier Parcet Hernández
- Ana Primo Ramos
- Fernando Quirós Gracián
- Anibal Rodríguez Bernal
- Keith Rogers
- Alberto Ruiz González
- Pedro Tradacete Pérez
- Dmitry Yakubovich

Members
- Siddhant Govardhan Agrawal
- Davide Barbieri
- Glenier Lázaro Bello Burguet
- Pablo Candela Pokorna
- Mingming Cao
- Hon to Hardy Chan
- José Manuel Conde Alonso
- Antonio Jesús Fernández Sánchez
- Claudia García López
- Björn Gebhard
- Wadim Gerner
- Adrián González Pérez
- Nastasia Grubić
- Matthew Blair Hernández
- Elena Di Iorio
- Salvador López Martínez
- Teresa Elvira Luque Martínez
- María Medina de la Torre
- Javier Montes Maldonado
- Neel Janak Patel
- Javier Ramos Maravall
- Guillermo Rey Ley
- Tomás Sanz Perela
- Daniel Seco Forsnacke
- Fan Zheng

Doctoral students
- Antonio Ismael Cano Mármol
- Víctor Cañulef Aguilar
- David de Hevia Rodríguez
- Laia Domingo Colomer
- Joaquín Domínguez de Tena
- Alba Dolores García Ruiz
- Enrique García Sánchez
- Francisco Javier González Doña
- Pablo Hidalgo Palencia
- Peio Ibarrondo Murguialday
- Miguel Martínez González
- Luis Martínez Zoroa
- Jorge Pérez García
- Jorge Ruiz Cases
- Elena Salguero Quirós
- Omar Sánchez Antonio
- Eduardo Tablate Vila

Associated members
- Antonio Córdoba Barba
- Alberto Ruiz

Master students
- Antonio Álvarez López
- Fernando Ballesta Yagüe
- Miguel Francisco Barea Fernández
- Jorge Santiago Ibáñez Marcos
- Andrés Laín Sanclemente
- José Antonio Lucas Manchón
- David Muñoz Lahoz

In 2022, this group organised the following activities:
- Analysis and Applications Seminar
- PDE's and Fluid Mechanics Seminar
- Number theory Seminar
- Machine Learning Seminar
- Study Group on Euler Systems

The following CSIC research groups are involved in Group B:
- GROUP 1: Mathematical Analysis
- GROUP 2: Differential Equations and Applications
- GROUP 9: Number Theory

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 ex-

ploit 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: condense 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
• Nuria Campillo Martín
• Marco Antonio Fontelos López
• Alberto Ibort Latre
• Fernando Lledó Macau
• Ana María Mancho Sánchez
• Carlos Palazuelos Cabezón
• David Pérez García
• Carlos Rascón Díaz
• David Ríos Insua
• Ignacio Villanueva Díez

Members
• Makrina Agaoglou
• Jorge Castillejos
• Fabio di Cosmo
• Daniel García Rasines
• César Byron Guevara Maldonado
• Tamara X. J. Kohler
• Angelo Lucia
• Roi Naveiro Flores
• Juan Manuel Pérez Pardo
• Alejandro Pozas-Kerstjens

Doctoral students
• José Manuel Camacho Rodríguez
• Laura Castilla Castellano
• Bruno Flores Barrio
• Guillermo García Sánchez
• Pablo Páez Velasco
• José Ramón Pareja Monturiol
• Simón Rodríguez Santana
• Alberto Ruiz de Alarcón Torregrosa
• Pablo Varas Pardo

Master students
• Kristina Kit

In 2022, this group organised the following activities:
• Applied mathematics Seminar
• DataLab Seminar
• Q-Math Seminar
• Machine Learning Seminar
• Modelling in Microfluidics and Technological Applications
• Geophysical Fluid Dynamics
• Stochastic and Analytical Methods in Applied Mathematics

The following CSIC research groups are involved in Group C:
• GROUP 3: Statistics, Probability and Operations Research (SPOR)
• GROUP 6: Mathematics of Quantum Information: Foundations and Applications
• GROUP 7: Mathematical Modelling and Simulation

3.2. Executive team and board

ICMAT Executive team

- Director: José María Martell [until July 2022]
- Fernando Quirós [from July 2022 until November 2022]
- Javier Aramayona [from November 2022]

José María Martell. Image courtesy of Martell

Fernando Quirós. Image: UAM

Javier Aramayona. Image: Íñigo de Amescua

- Deputy director: Eva Gallardo [until July 2022]

Heads of Department

- Fundamental Mathematics: Javier Aramayona [until July 2022]

- Applied Mathematics: Fernando Quirós [until July 2022]

ICMAT Board

- José María Arrieta Algara (Faculty representative)

José María Arrieta. Image courtesy of Arrieta

- José Manuel Conde Alonso (Faculty representative)

José María Arrieta. Image courtesy of Arrieta

- Daniel Peralta Salas (Faculty representative)

Daniel Peralta Salas. Image : ICMAT

- Gabriel Catalán (secretary)

Gabriel Catalán. Image : ICMAT

ICMAT Committees

Scientific Committee
Chairs Alberto Enciso, José María Martell.
Members: Diego Córdoba, Oscar García-Prada, Andrei Jaikin, David Pérez, David Ríos
Committee of Internal Institutional Relations
Chair: Fernando Quirós
Members: Luis Álvarez-Cónsul, Eva Gallardo, Fernando Lledó

Committee of External Institutional Relations
Members: José María Arrieta, Daniel Peralta, José María Martell

Mathematical Culture Unit
Chairs: David Martín, Javier Aramayona
Coordinator: Ágata Timón
Members: José María Martell, Alberto Enciso, Daniel Peralta, Fernando Quirós

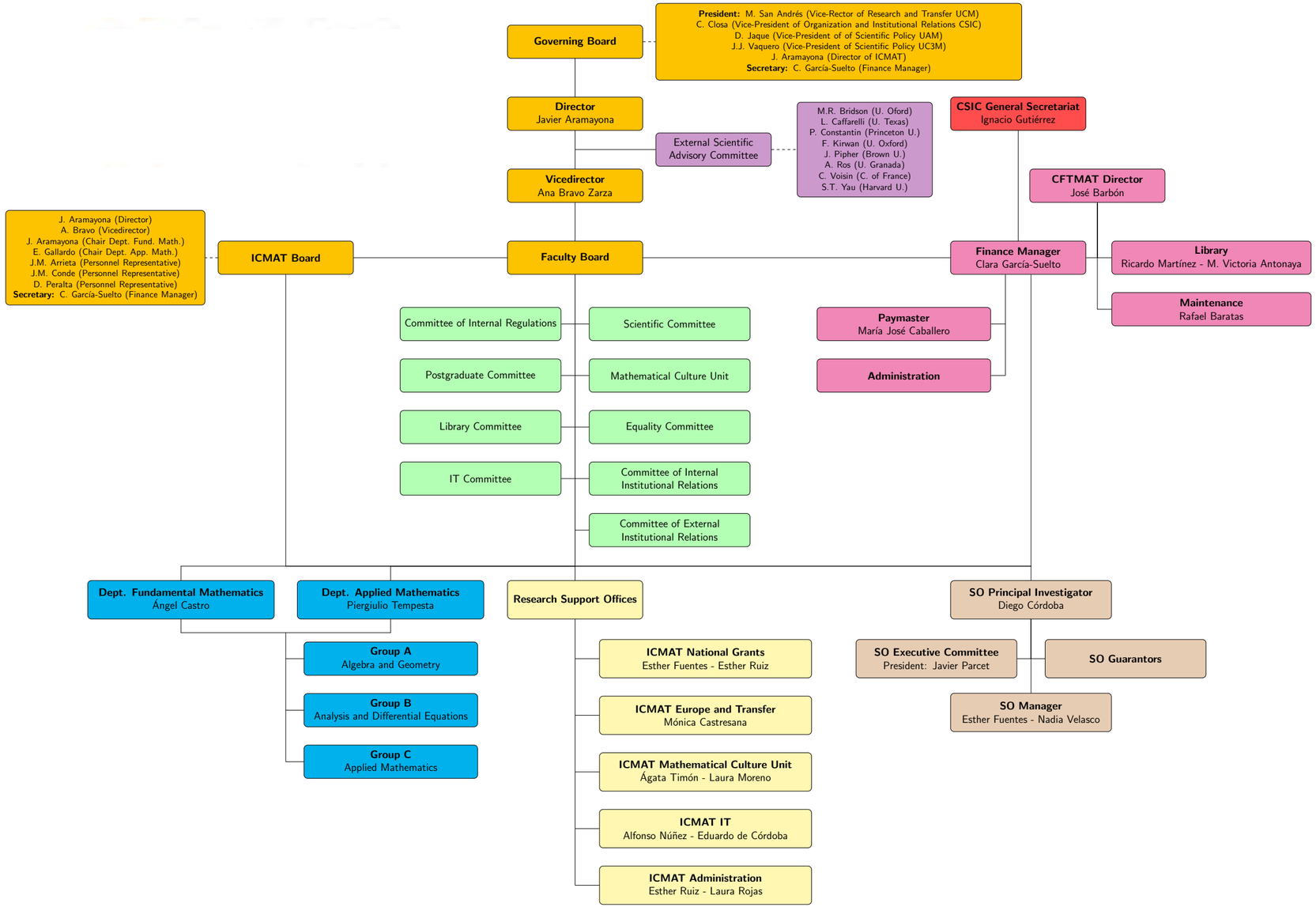
Equality Committee
Chair: Ana Bravo
Coordinator: Ágata Timón
Members: Javier Aramayona, Eva Gallardo, David Martín, Laura Moreno Iraola
External Members: Marta Macho-Stadler (EHU)

Committee of Internal Regulations
Chair: Tomás Gómez
Members: Luis Guijarro, Ignacio Villanueva, Alberto Ibort

Postgraduate Committee
Chairs: Ángel Castro, Pedro Tradacete
Members: José Francisco Fernando, Ana Primo, Daniel Seco

Library Committee
Members: José Manuel Conde, Mario García

ICT Committee
Members: Davide Barbieri, Ignacio Luengo, Daniel Macías


Governing Board
President: M. San Andrés (Vice-Rector of Research and Transfer UCM)
C. Closa (Vice-President of Organization and Institutional Relations CSIC)
D. Jaque (Vice-President of of Scientific Policy UAM)
J.J. Vaquero (Vice-President of Scientific Policy UC3M)
J. Aramayona (Director of ICMAT)
Secretary: C. García-Suelto (Finance Manager)
Director
Javier Aramayona
External Scientific Advisory Committee
M.R. Bridson (U. Oford)
L. Caffarelli (U. Texas)
P. Constantin (Princeton U.)
F. Kirwan (U. Oxford)
J. Pipher (Brown U.)
A. Ros (U. Granada)
C. Voisin (C. of France)
S.T. Yau (Harvard U.)
CSIC General Secretariat
Ignacio Gutiérrez
Vicedirector
Ana Bravo Zarza
CFTMAT Director
José Barbón
J. Aramayona (Director)
A. Bravo (Vicedirector)
J. Aramayona (Chair Dept. Fund. Math.)
E. Gallardo (Chair Dept. App. Math.)
J.M. Arrieta (Personnel Representative)
J.M. Conde (Personnel Representative)
D. Peralta (Personnel Representative)
Secretary: C. García-Suelto (Finance Manager)
ICMAT Board
Faculty Board
Finance Manager
Clara García-Suelto
Library
Ricardo Martínez - M. Victoria Antonaya
Maintenance
Rafael Baratas
Committee of Internal Regulations
Scientific Committee
Paymaster
María José Caballero
Postgraduate Committee
Mathematical Culture Unit
Administration
Library Committee
Equality Committee
IT Committee
Committee of Internal Institutional Relations
Committee of External Institutional Relations
Dept. Fundamental Mathematics
Ángel Castro
Dept. Applied Mathematics
Piergiulio Tempesta
Research Support Offices
SO Principal Investigator
Diego Córdoba
Group A
Algebra and Geometry
Group B
Analysis and Differential Equations
Group C
Applied Mathematics
ICMAT National Grants
Esther Fuentes - Esther Ruiz
ICMAT Europe and Transfer
Mónica Castresana
ICMAT Mathematical Culture Unit
Ágata Timón - Laura Moreno
ICMAT IT
Alfonso Núñez - Eduardo de Córdoba
ICMAT Administration
Esther Ruiz - Laura Rojas
SO Executive Committee
President: Javier Parcet
SO Guarantors
SO Manager
Esther Fuentes - Nadia Velasco

3.3. ICMAT External Scientific Advisory Committee

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 Mathematicians (Zurich 1994) and 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.

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 University. 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.

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).

3.4. Managing and Administrative Personnel

Thanks to the Severo Ochoa funding, ICMAT has an excellent managing and administrative team, which enables the Institute to develop its own internationalization, knowledge transfer, outreach and gender programmes, among others.

Administrative Office:
- Esther Ruiz
- Teresa Ruiz

ICT Office
- Eduardo de Córdoba
- Alfonso Núñez

Mahematical Culture Unit
- Laura Moreno Iraola
- Ágata Timón G. Longoria

Severo Ochoa Office
- Esther Fuentes

Project Management Office
- Mónica Castresana (International projects)
- Marc Cornadó (National projects)
- Esther Ruiz (National projects)

AXA Office
- Marta Sanz González

4. SCIENTIFIC RESULTS

Some of the standout papers published by ICMAT researchers in 2022 are as follows

"Spectral determination of semi-regular polygons"

Authors: Alberto Enciso (ICMAT-CSIC), Javier Gómez-Serrano (Brown University)
Source: Journal of Differential Geometry, vol. 122(3), pp. 399-419

Link

Review: Let us say that an n-sided polygon is semi-regular if it is circumscriptible, and its angles are all equal but possibly one which is then larger than the rest. Regular polygons, in particular, are semi-regular. The main result of the paper is that, in the class of convex polygons, semi-regular polygons are uniquely determined by just three geometric quantities: the area, the perimeter, and a third quantity depending only on the interior angles of the polygon that appears in the heat trace asymptotics of a polygon. As a consequence of this, we show that semi-regular polygons are spectrally determined, meaning that if Ω is a convex piecewise smooth planar domain, possibly with straight corners, whose Dirichlet or Neumann spectrum coincides with that of an n-sided semi-regular polygon P, then Ω is congruent to P.

"Fourier multipliers in SLn (R)"

Authors: Javier Parcet (ICMAT), Éric Ricard (Université de Caen Normandie), Mikael de la Salle (CNRS Lyon)
Source: Duke Mathematical Journal, vol. 171, pp. 1235-1297

Link

Review: "Vicent Lafforgue and Mikael de la Salle proved in 2011 that there are no Lp approximations by any net of Fourier multipliers over SL(n,R) for p>a(n) and some a(n)>2 which converges to 2 as n increases to infinity. Thus providing the first known topological group for which Fourier Lp summability fails with p finite. This unprecedented pathology leads to a strong form of nonamenability which is potentially useful to distinguish the group von Neumann algebras of PSL(n,Z) for different n>2, the most iconic form of Connes' rigidity conjecture.
In this article, the authors establish precise regularity conditions for Lp boundedness of Fourier multipliers over SL(n,R). The main result is inspired by Hörmander-Mikhlin criterion from classical harmonic analysis, although it is substantially and necessarily different. Locally, sharp growth rates of Lie derivatives around the singularity are given. The asymptotics also match Mikhlin formula for a exponentially growing metric with respect to the word length. Additional decay comes imposed by this growth and Mikhlin condition for high order terms. Lafforgue/de la Salle's rigidity theorem fits here.
A second result gives a new and much stronger rigidity theorem for radial multipliers in SL(n,R). More precisely, additional regularity and Mikhlin type conditions are proved to be necessary up to an order |1/2 - 1/p| (n-1) for large enough n in terms of p. This rigidity increases with the rank, which leads to radial generating functions satisfying HM sufficient conditions in a given rank n and failing the rigidity conditions for ranks m >> n. This gives a vague indication that Connes' rigidity conjecture could be solved using harmonic analysis tools.

"Canonical metrics on holomorphic Courant algebroids"

Authors: Mario García-Fernández (ICMAT-UAM), Roberto Rubio (Weizmann Institute of Science, UAB), Carlos Shahbazi (Universität Hamburg, UNED), Carl Tipler (Université de Bretagne Occidentale)
Source: Proceedings of the London Mathematical Society, vol. 125, issue 3, pp. 700-758

Link

Review: The Calabi Conjecture, made by Eugenio Calabi in 1954, asserts that given a smooth volume form μ on a compact Kähler manifold X there exists a Riemannian metric g on X which is compatible with the complex structure (that is, a Kähler metric) and has prescribed volume form Vol_g = μ. From the work of E. Calabi and Shing-Tung Yau, we know that such a metric exists and is unique upon fixing a natural topological quantity: a positive element in the degree-two de Rham cohomology group H^2(X,R). In the particular case of a Calabi-Yau manifold, Yau's theorem implies that X admits a metric with holonomy contained in SU(n), and that these metrics are parametrized by the Kähler cone of X. The initial step of the proof is to fix the

Kähler class, whereby the problem is reduced to a PDE for a smooth function on X, namely, the complex Monge-Ampère equation, amenable to the application of analytical techniques.
Following recent advances in Kähler geometry there has been a renewed interest on extending Yau's theorem to the case of compact complex manifolds which do not admit any compatible Kähler metric. As a natural generalization of the Calabi problem, and motivated by string theory, Shing-Tung Yau has proposed to study the Hull-Strominger system, which couples a Hermitian-Yang-Mills connection on a bundle with a (balanced) hermitian metric on a Calabi-Yau manifold, possibly of non-Kähler type. The construction of compact solutions for these equations was pioneered by Jixiang Fu, Jun Li and Shing-Tung Yau, and has been an active topic of research in complex geometry over the last fifteen years.
In contrast to the existence problem for the Hull-Strominger system, the uniqueness problem for these equations has never been systematically addressed in the literature. Even for compact complex surfaces, where the existence of solutions is well understood thanks to the work of the physicists Andrew Strominger, the uniqueness problem is still open.
The work by Mario García-Fernández (ICMAT-UAM), Roberto Rubio (Weizmann Institute of Science, UAB), Carlos Shahbazi (Universität Hamburg, UNED) and Carl Tipler (Université de Bretagne Occidentale) presents a first systematic approach to the uniqueness question for the Hull-Strominger system via variational techniques. To do this, the authors combine the Aeppli cohomology of the complex manifold with some unexplored geometric structures, known as holomorphic Courant algebroids. The paper puts forward the idea that the existence and uniqueness problem for the Hull-Strominger system should be better understood as the problem of finding 'the best metric' in a holomorphic Courant algebroid Q, given by the absolute minima of a natural functional for metrics on a fixed 'Aeppli class'. This novel approach to the Hull-Strominger system is gauge-theoretical in nature and brings up new tools–such as the dilaton functional–that may help to elucidate an analogue of the Donaldson-Uhlembeck-Yau Theorem in the realm of (higher) categorified gauge theory.

"On the symplectic type of isomorphisms of the p-torsion of elliptic curves"

Authors: Alain Kraus (Institut de Mathématiques de Jussieu), Nuno Freitas (ICMAT)
Source: Memoirs of the American Mathematical Society, nº 1361, vol. 277

Link

Review: Let p≥3 be a prime. Let E/Q and E'/Q /Q be elliptic curves with isomorphic p-torsion modules E[p] and E'[p]. Assume further that either (i) every G_Q-modules isomorphism ϕ:E[p]→E′[p] admits a multiple $\lambda\cdot\phi$ with $\lambda\in\mathbb{F}^{\times}_{p}$ preserving the Weil pairing; or (ii) no G_Q-isomorphism ϕ:E[p]→E′[p] preserves the Weil pairing. This paper considers the problem of deciding if we are in case (i) or (ii).
Our approach is to consider the problem locally at a prime l≠p. Firstly, we determine the primes l for which the local curves E/Ql and E′/Ql contain enough information to decide between (i) or (ii). Secondly, we establish a collection of criteria, in terms of the standard invariants associated to minimal Weierstrass models of E/Ql and $\mathrm{E}'/\mathbb{Q}_{\ell}$, to decide between (i) and (ii). We show that our results give a complete solution to the problem by local methods away from p.
We apply our methods to show the non-existence of rational points on certain hyperelliptic curves of the form y^2=x^p−l and y^2=x^p−2l where l is a prime; we also give incremental results on the Fermat equation x^2+y^3=z^p. As a different application, we discuss variants of a question raised by Mazur concerning the existence of symplectic isomorphisms between the p-torsion of two non-isogenous elliptic curves defined over Q.

"The Hanna Neumann conjecture for surface groups"

Authors: Yago Antolín (ICMAT-UCM), Andrei Jaikin-Zapirain (ICMAT-UAM)
Source: Compositio Mathematica, vol. 158, issue 9, pp. 1850-1877

Link

Review: The Hanna Neumann conjecture is a statement about the rank of the intersection of two finitely generated subgroups of a free group. The subject of the conjecture was originally motivated by a 1954 theorem of Albert Howson who proved that the intersection of any two finitely generated subgroups of a free group is always finitely generated. In a 1957 paper Hanna Neumann improved Howson's bound by showing that if H and K are subgroups of a free group F of finite ranks n ≥ 1 and m ≥ 1 then the rank s of $\mathrm{H}\cap\mathrm{K}$ satisfies:
$s - 1 \leq 2(m - 1)(n - 1)$.
She also conjectured that the factor of 2 in the above inequality is not necessary and that one always has

s − 1 ≤ (m − 1)(n − 1).
This statement became known as the Hanna Neumann conjecture. The Strengthened Hanna Neumann conjecture, formulated by her son Walter Neumann in 1990 states that there exists a such bound that consider the ranks of all subgroups $H \cap K^g$. In 2011, the Strengthened Hanna Neumann conjecture was proved independently by Joel Friedman and by Igor Mineyev. In 2017, a third proof of the conjecture, based on homological arguments inspired by pro-p-group considerations, was published by Andrei Jaikin-Zapirain.
A subgroup H of a group G is called inert if for any finitely generated subgroup K of G the rank of intersection $H \cap K$ is at most the rank of K. Warren Dicks and Enric Ventura conjectured in 1996 that the subgroups of fixed points of a collection of endomorphisms of a free group are inert. This conjecture received the name the inertia conjecture. It was well-known that the inertia conjecture follows from the inertia of retracts.
In this paper Yago Antolín and Andrei Jaikin-Zapirain show that the Strengthened Hanna Neumann conjecture holds not only in free groups but also in non-solvable surface groups. In addition, they also show that a retract in a free group and in a surface group is inert. This implies the Dicks–Ventura inertia conjecture for free and surface groups.
The methods employed in this paper are based on the techniques introduced in Jaikin-Zapirain's 2017 paper. The most significant innovation of this work is the exploration of L^2-independence. Since the publication of the paper, this concept has been widely adopted by several researchers. Notably, Keino Brown and Olga Kharlampovich proved the corresponding version of the Strengthened Hanna Neumann conjecture for all hyperbolic limit groups.

"Improved bounds for the Kakeya maximal conjecture in higher dimensions"

Authors: Jonathan Hickman (University of Edinburgh), Keith Rogers (ICMAT-CSIC), Ruixiang Zhang (University of California-Berkeley)
Source: American Journal of Mathematics, vol. 144, n. 6, pp. 1511-1560

Link

Review: The Kakeya problem considers to what extent thin tubes which point in different directions can be compressed by positioning them strategically. C. Fefferman (1971) proved that too much compression would lead to the failure of certain types of Fourier convergence (whereby signals are recomposed from their component frequencies). N. Katz and K. Rogers (2018) proved that the volume of a semialgebraic set that contains the tubes must satisfy the expected lower bound. That is to say, the tubes cannot be compressed too much if they are positioned in an algebraic way. In the article under review, a refined version is proved that considers tubes which are only partially contained in nested semialgebraic sets at different scales. The proof employs deep results from real algebraic geometry including the Tarski-Seidenberg projection theorem and the Gromov-Yomdin algebraic lemma.
The authors were motivated to consider the nested refinement because they were also able to prove that the Kakeya maximal conjecture holds in the absence of algebraic structure. For this they employed a technique known as polynomial partitioning, pioneered in a different context by L. Guth and N. Katz (2015). The nested refinement can then be used to strike a balance between the algebraic and nonalgebraic extremes, improving the best-known bounds for the Kakeya maximal conjecture in higher dimensions. Only the two-dimensional version of the Kakeya maximal problem has been completely resolved, by A. Córdoba (1977).

The new maximal estimate is then applied to the Kakeya set conjecture which considers the minimal size of a set that contains a line segment in each direction. A. Besicovitch (1919) proved that such sets can have arbitrarily small volume, however the outstanding question is whether these so-called Kakeya sets could be even smaller in a fractal sense. The new results for the Kakeya set conjecture are surprisingly similar to those of N. Katz and T. Tao (2002), being slightly worse in certain dimensions and slightly better in others. In contrast to the algebraic-geometric approach adopted by the authors, Katz and Tao used a completely different arithmetic-combinatorial approach, pioneered by J. Bourgain (1999), and so it is curious that they give such similar results."

"Long-Term Regularity of 3D Gravity Water Waves"

Authors: Fan Zheng (ICMAT)
Source: Communications on Pure and Applied Mathematics, Vol. 75, Issue 5, pp. 1074-1180

Link
Review: Water waves are a fundamental and ubiquitous natural phenomenon, observed most evidently in the tides and ebbs of the ocean. The motion of water waves can be modeled by a time varying region of water, outside which there is air. The body of water moves according to the Euler equation in fluid mechanics. The

water is also under the constant, downward action of gravity, the water-air interface is held at a constant atmospheric pressure and moves according to the boundary values of the velocity field.
The whole model is a coupled system of nonlinear equations, with an equilibrium corresponding to a level interface without any motion of the water. The linearization around this equilibrium is a system of dispersive equations, suggesting that any small, localized deviation from the equilibrium will spread out and decay in time. However, it has taken more efforts to show this for the fully nonlinear system.
This paper studies the behavior of solutions evolving from initial data that is not too far away from the equilibrium, and shows that they will remain so after an extended period of time. Compared with previous work, ours is able to treat initial data that is less localized, or even periodic, which makes its dispersion even harder to show. Specifically, we showed almost global well posedness, that is, an exponential lifespan, for perturbations in Sobolev spaces, global well posedness for perturbations in Sobolev spaces with minimal weights. Moreover, in the periodic case, we obtained a lifespan that interpolates nicely between the (almost) global well posedness mentioned above, and a quadratic lifespan in the case of unit period.

“Non existence and strong ill-posedness in Ck and Sobolev spaces for SQG”

Authors: Diego Córdoba (ICMAT) y Luis Martínez-Zoroa (ICMAT)
Source: Advances in Mathematics, nº 108570, pp. 74

Link

Review: The Surface quasi-geostrophic model (SQG) is a fundamental model in geophysical fluid dynamics. Initially examined by Constantin, Majda, and Tabak (1994), it shares several characteristics with the 3-D incompressible Euler system, where local existence in the space H^{s} (s>2) was established, and in the case of $C^{k,\alpha}$ ($k\geq 1$ and $1>\alpha>0$) by Wu (2005). Chae and Wu (2012) extended this to the critical Sobolev space H^2 for a logarithmic inviscid regularization of SQG. However, both SQG and the 3-D incompressible Euler equations still present an unsolved challenge regarding the finite-time formation of singularities for smooth initial data with finite energy.
Due to the incompressibility and transport structure of SQG, the L^p ($1\leq p\leq \infty$) norms of the scalar θ and the L^2 norm of the velocity field $v=(-v_1,v_2)$ (kinetic energy) are conserved quantities for sufficiently regular solutions.
One of the principal objectives of this paper is to construct solutions in $\mathbb{R}^2$ for SQG, which are initially in $C^k\cap L^2$ ($k\geq 2$) but do not maintain C^{k} for $t>0$. It’s worth noting that if we consider a velocity field $v(\theta)=\nabla^{\perp}\Lambda^{-(1+\epsilon)}(\theta)$ with $\epsilon>0$, local existence in C^{k} for SQG is achieved. To ensure the meaningful existence of our solution, we require some additional regularity, specifically that $\theta_{0}\in H^{s}$ with $s>2$.

“Asymptotic Survival of Genuine Multipartite Entanglement in Noisy Quantum Networks Depends on the Topology”

Authors: Patricia Contreras-Tejada (ICMAT), Carlos Palazuelos (Universidad Complutense de Madrid- ICMAT), Julio I. de Vicente (Universidad Carlos III- ICMAT)
Source: Physical Review Letters, vol. 128, 220501

Link

Review: The study of entanglement in multipartite quantum states plays a major role in quantum information theory. In particular, multipartite entangled states are a crucial resource in many applications of quantum technologies such as quantum sensing, secure quantum communication or certain schemes for quantum computation. Genuine multipartite entanglement is considered a powerful form of entanglement since it corresponds to those states that are not biseparable, i.e. a mixture of partially separable states across different bipartitions of the parties.
In this work the authors introduce a particularly simple subclass of multipartite states, termed pair-entangled network (PEN) states, as those that can be created by distributing exclusively bipartite entanglement in a connected network. One such state can be described by means of a graph, where the vertices correspond to the parties of the state and each edge corresponds to a bipartite quantum state shared by the corresponding pair of vertices (parties). A particularly interesting case is that where all bipartite states are isotropic states with parameter p, which is usually understood as a noise parameter in the generation of bipartite entan-

glement. Then, it is showed that genuine multipartite entanglement in a PEN state depends on both the level of noise and the network topology and, in sharp contrast to the case of pure states, it is not guaranteed by the mere distribution of mixed bipartite entangled states.
The main result of the paper is a drastic feature of the previous phenomenon: the amount of connectivity in the network determines whether genuine multipartite entanglement is robust to noise for any system size or whether it is completely washed out under the slightest form of noise for a sufficiently large number of parties. This latter case implies fundamental limitations for the application of certain networks in realistic scenarios, where the presence of some form of noise is unavoidable.
Finally, in the last part of the paper, the authors illustrate the applicability of PEN states to study the complex phenomenology behind multipartite entanglement, by using these states to prove superactivation of genuine multipartite nonlocality for any number of parties.

"Higher Haantjes Brackets and Integrability"

Authors: Piergiulio Tempesta (ICMAT-UCM), Giorgio Tondo (Università di Trieste)
Source: Communications in Mathematical Physics, vol. 389, pp. 1647-1671

Link

Review: In the last two decades, the study of the geometry of Nijenhuis and Haantjes tensors has experienced a resurgence of interest. Recently, new and conspicuous applications of Nijenhuis and Haantjes tensors have been found, for instance, in the characterization of integrable chains of partial differential equations of hydrodynamic type and in the study of infinite-dimensional integrable systems, in connection with the celebrated WDVV equations of associativity and the theory of Dubrovin–Frobenius manifolds.
A seminal result, due to Haantjes, states that in the case of a semisimple operator field, a necessary and sufficient condition for the Frobenius integrability of its eigen-distributions of constant rank is that its Haantjes tensor identically vanishes. However, in the general case of a non-semisimple operator, the previous condition is only sufficient. Thus, for the infinite class of operators whose Haantjes tensor is not vanishing, no conclusion can be drawn about integrability of their eigen-distributions.
Our main theorem fills this gap. Indeed, we shall prove that the vanishing of a generalized Nijenhuis torsion $\tau_A(m)$ of level m for some integer $m \geq 1$ provides us with a sufficient condition for the integrability of the generalized eigen-distributions (and their direct sums) of a given operator field A. The case m=1 corresponds to the standard Nijenhuis criterion; for m=2, we have the Haantjes one, whereas for $m \geq 3$ we obtain infinitely many new sufficient conditions. In this way, we are able to construct a tensorial test for the Frobenius integrability of a huge class of operator fields, which significantly extends the applicability of the original Haantjes's torsion criterion.
The interest of our result, in the spirit of the Nijenhuis and Haantjes theorems, relies crucially on the fact that, in order to ascertain the integrability properties of a given operator field, no knowledge a priori of the spectrum of this operator nor of its eigen-distributions is required.
Also, we present a new theory of higher order brackets, namely the Haantjes brackets of level m, which generalize the classical Frölicher–Nijenhuis bracket (corresponding to m=1), relevant in several geometric contexts, in particular the theory of almost-complex structures.
The generalized Nijenhuis torsions discussed in the article can be seen as reductions of the higher Haantjes bracket of the same level. Also, we prove that the vanishing of the second-level bracket is a necessary condition for the existence of vector spaces of Haantjes operators.
We expect that the geometric techniques developed in this article could shed new light on the problem of determining normal forms of operator fields on a differentiable manifold.

"Undecidability of the spectral gap"

Authors: Toby S. Cubitt (UCL), David Pérez-García (ICMAT-UCM), Michael M. Wolf (Technical University of Munich)
Source: Forum of Mathematics, Pi, vol. 10, E14, pp. 1-102

Link

Review: The spectral gap is one of the most important properties of a quantum many-body system. It plays a pivotal role in condensed matter, mathematical, and fundamental physics, and also in quantum computing. One of the main goals of condensed matter theory is to understand phase transitions and phase diagrams. The behaviour of the spectral gap is intimately related to the phase diagram of a quantum many-body system, with quantum phase transitions occurring at critical points where the gap vanishes.
The low-temperature physics of the system are also governed by the spectral gap: gapped systems exhibit "non-critical" behaviour, with low-energy excita-

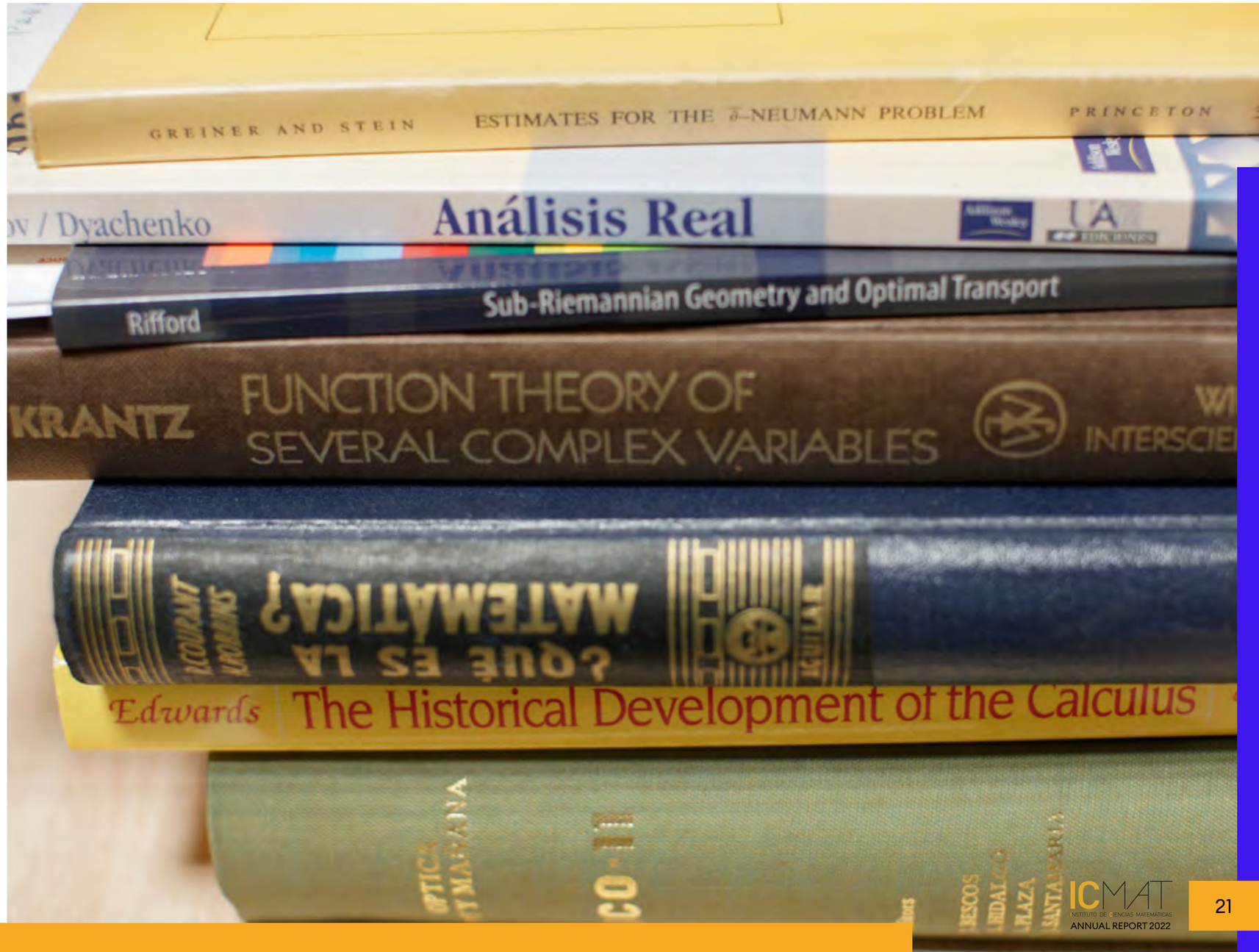
tions that behave as massive particles, preventing long-range correlations; gapless systems exhibit “critical” behaviour, with low-energy excitations that behave as massless particles, allowing long-range correlations.
The spectral gap also arises as a key quantity in quantum computing, via adiabatic quantum computation. In this type of computation, proven to be exactly as powerful as the usual circuit model for quantum computation, the system is initialised in the lowest energy state of an easy Hamiltonian, that is a Hamiltonian for which such state can be easily constructed. (A Hamiltonian is the mathematical object which encodes the interactions present in a system.) Then the interactions are slowly changed, to end up in a target Hamiltonian whose lowest energy state encodes the output of the computation. The key property controlling the efficiency of this method is the minimal spectral gap in the path of Hamiltonians connecting the initial Hamiltonian to the target. A computational problem has an efficient quantum algorithm if and only if there exists such a Hamiltonian path for which the minimal spectral gap is lower-bounded by an inverse-polynomial in the system size.
Thus understanding whether a given system is gapped or not is one of the fundamental questions in quantum many-body physics. Indeed, there are many famous open problems concerning the spectral gap. A paradigmatic example is the antiferromagnetic Heisenberg model. Even in 1D, the case of integer spin remains open as the “Haldane conjecture”, first formulated in 1983 by the Nobel Laureate F. D Haldane. The same question in the case of 2D non-bipartite lattices, such as the Kagome lattice, was posed by another Nobel Laureate, P. W. Anderson, in 1973. In the related setting of quantum field theory, determining if Yang-Mills theory is gapped is one of the Millennium Prize Problems, and is closely related to one of the most important open problems in high-energy physics: explaining the phenomenon of quark confinement.
All of these problems are specific cases of the general spectral gap problem: given a quantum many-body Hamiltonian, is the system it describes gapped or gapless? The main result of this paper is a proof that the spectral gap problem is undecidable. That is, there exist quantum many body Hamiltonians for which neither the presence nor the absence of a spectral gap is provable from the axioms of mathematics.

5. BOOKS

During 2022, the following books were published with ICMAT researchers as authors or coauthors. These are the references:

Books

- F. Arteaga, D. Ríos Insua, *El analista de inteligencia en la era digital*, Real Instituto Elcano, Centro Nacional de Inteligencia, 2022.
- M. M. Jiménez Sarmiento, N.E. Campillo, M. Cañalles, *Las vacunas*, Los Libros de la Catarata, Editorial CSIC, 2022.
- D. Ríos Insua, R. Naviero, *Análisis de riesgos*, CSIC; Los Libros de la Catarata, 2022.



6. AWARDS AND DISTINCTIONS

Charles Fefferman, director of one of ICMAT labs, receives the Frontiers of Knowledge award 2022 from the BBVA foundation

Charles Fefferman. Image courtesy of Fefferman

The BBVA Foundation awarded its Basic Sciences Frontiers of Knowledge Award to Charles Fefferman, professor at Princeton University (USA), director of one of ICMAT laboratories and member of ICMAT scientific advisory board. Fefferman shared the award with mathematician Jean-François Le Gall, professor at the University of Paris-Saclay.
The jury highlighted his introduction of "powerful analytical techniques to solve mathematical problems with a long history, some of which are motivated by fundamental questions in theoretical physics."
More info

Alberto Enciso, appointed académico correspondiente of the Real Academia de Ciencias Exactas, Físicas y Naturales de España

Alberto Enciso. Image : ICMAT

Alberto Enciso, profesor de investigación of CSIC at ICMAT, was appointed académico correspondiente of the Real Academia de Ciencias Exactas, Físicas y Naturales de España in the Mathematics Section on 26th October 2022.
"His research focuses on partial differential equations, fluid mechanics and spectral theory. He has received the J. L. Rubio Prize from France in 2011, being the only physicist with this distinction. He also received the SeMa Antonio Valle Award in 2013, the FpdGi Scientific Research Award 2014 and in 2015 he shared the Barcelona Dynamical Systems Prize for his work on knotted vorticity tubes in stationary solutions of the incompressible Eurler equation in three dimensions," the RAC highlighted.
More info

Ángela Capel receives one of the RSME and BBVA Foundation Vicent Caselles mathematical research awards for her thesis developed at ICMAT

Ángela Capel. Image : University of Tübingen

The Royal Spanish Mathematical Society (RSME) and the BBVA Foundation awarded Ángela Capel with one of the Vicent Caselles Mathematical Research Awards 2022. Capel completed her doctoral studies at ICMAT under the supervision of David Pérez-García (ICMAT-UCM) and Angelo Lucia (ICMAT-UCM), in 2019, focusing on quantum information theory and many-body quantum systems. Capel is currently a junior professor at the University of Tübingen (Germany).
These awards annually recognize the work of six mathematicians who are in the early stages of their scientific careers. It is a way to acknowledge "creativity, originality, and excellence in mathematics in the early years of their research careers," as stated on the BBVA Foundation's website.
More info

David Ríos and José Manuel Camacho receives the best paper award at the 12th International Defense and Homeland Security Simulation Workshop

David Rios Insua, profesor de investigación at CSIC and José Manuel Camacho Rodríguez, predoctoral researcher at ICMAT, along with Roi Naveiro, associated professor at CUNEF, received the best paper award at the 12th International Defense and Homeland Security Simulation Workshop for the contribution "Augmented probability simulation for adversarial risk analysis in general security games". In this work, it is presented an algorithmic framework that employs the augmented probability simulation technique to obtain general security game solutions within the context of adversarial risk analysis.
This recognition is given by the Best Paper Award International Committee "based on originality, scientific quality and impact on the manufacturing domain".

Pedro Tradacete receives a BBVA Foundation Leonardo Grant at ICMAT to study ordered structures

Pedro Tradacete. Image : Íñigo de Amescua/ICMAT

The project "Ordered structures in analysis, geometry and applications," led by Pedro Tradacete, distinguished researcher at ICMAT, was one of the 60 Leonardo grants awarded by the BBVA Foundation in its 2022 call. It will be dedicated to studying fundamental theoretical problems coming from functional analysis and metric geometry, which involve the existence of certain order structures. The aid is endowed with 40,000 euros and will last between 12 and 18 months.
Leonardo grants for Researchers and Cultural Creators "are intended to directly support the work of researchers and cultural creators between 30 and 45 years old who, being in intermediate stages of their career, develop a markedly personal and innovative project." In 2022 call, 884 applications submitted in total, in all modalities.
More info

Ana María Mancho and Guillermo García Sánchez, members of ICMAT, win the technology-based companies award (EBTONSIC) from CSIC

Guillermo García Sánchez and Ana María Mancho during the award ceremony. Image: CSIC

Digital Earth Solutions project, conceived by ICMAT researchers Ana María Mancho and Guillermo García Sánchez, was awarded the EBTONSIC Prize, promoted by the Vicepresidencia Adjunta de Transferencia de Conocimiento of CSIC, which consists of €20,000 to advance their business idea and try to bring it to the market.
The software was developed for predicting the movement of any oil spill on the ocean's surface and thus reducing the environmental, social, and economic impact by up to 50%.
More info

7. RESEARCH PROJECTS

Competitive funding

National and regional Plan

Code/Acronym	Project	PR	Start-final date
MTM2017-82105-P	Estructuras Algebraicas, Analíticas y o-Minimales STRNAO”	José Francisco Fernando Galván	01/01/2018 -
MTM2017-85934-C3-1-P	Análisis y geometría con aplicaciones a problemas inversos	Keith Rogers	01/01/2018 - 30/09/2022
MTM2017-82105-P	Estructuras Algebraicas, Analíticas y o-Minimales STRNAO	José Francisco Fernando	01/01/2018
S2018/TCS-4342	Quantum Information Technologies Madrid+ (QUITEMAD+-CM).	David Martín de Diego	01/01/19-31/12/22
EIN2019-103354	The interface between Kähler and non-Kähler geometry	Mario García-Fernández	01/06/2019 - 31/05/2022
IND2018/TIC-9901.	Grant from the Madrid Government for Industrial Doctorate. Researcher: Bruno Flores	David Ríos	26/02/19-25/02/22
RED2018-102810-T	Red Temática de Geometría y Física	Oscar García Prada	01/01/2020 - 31/07/2022
PID2019-109339GB-C31	Espacios de Moduli y Teoría de Gauge	Oscar García Prada & Luis Alvárez Consul	01/01/2020 -
CEX2019-000904-S	Apoyo a Centros de Excelencia Severo Ochoa	Diego Córdoba Gazolaz	01/01/2020 - 31/12/2023
PID2019-109339GB-C31	Espacios de Moduli y Teoría de Gauge	Oscar García Prada	01/01/2020 - 31/12/2022
SI1/PJI/2019-00514	Desigualdades de martingalas no conmutativas.	José Manuel Conde Alonso	01/01/2020 – 31/12/2022
PID2019-103860GB-I00	Aspectos Lineales y no Lineales en Ecuaciones en Derivadas Parciales. Dinámica Asintotica y Perturbaciones	José María Arrieta Algarra & Aníbal Rodríguez Bernal	01/01/2020 - 31/12/2022
PID2019-109339GA-C32	Non-Kähler geometry and mirror symmetry	Mario García-Fernández	01/01/2020 - 31/12/2022
PID2019-105979GB-I00	Operadores y Geometría en Análisis Matemático	Eva Gallardo	01/01/2020 -31/12/2022
SI1/PJI/2019-00514	Desigualdades de martingalas no conmutativas	José Manuel Conde	01/01/2020 - 31/12/2022
PID2019-110712GB-I00	Ecuaciones con perturbaciones de potencias de Laplaciano	Fernando Soria de Diego & Ana Primo Ramos	01/06/2020

Code/Acronym	Project	PR	Start-final date
PID2019-108936GB-C21	Simetrías e Invariancia en Aritmética y Geometría: Fundamento	Francisco Presas & Daniel Macías	01/06/2020 - 30/11/2023
PID2019-106715GB-C21	Geometric Structures in Dynamical Systems, Mechanics and Hydrodinamics	David Martín de Diego & Daniel Peralta	01/06/2020 - 29/02/2024
PID2019-107914GB-I00	Fronteras del Análisis Armónico	Javier Parcet y José Mª Martell	01/06/2020 - 31/05/2023
PID2019-107297GB-I00	Modularidad de Representaciones de Galois y Ecuaciones Diofanticas de tipo Fermat, conjetura de Sato-tate, problema 12 de Hilbert	Nuno Barroso Freitas	01/06/2020 - 31/05/2023
PID2019-109387GB-I00	Estadística infinito-dimensional: modelos matemáticos y computación	José Ramón Berredero & Antonio Cuevas	01/06/2020 - 31/05/2023

Code/Acronym	Project	PR	Start-final date
EIN2020-112197	Análisis y Geometría de la Ecuación de Hamilton-Jacobi	Manuel de León	01/11/2020 - 31/10/2022
EIN2020-112392	"Hacia el motivo de los Espacios de Moduli de Fibrados de Higgs2	Oscar García Prada	01/11/2020 - 31/10/2022
EIN2020-112235	Ayuda Europa Investigación para la preparación de una propuesta ERC SYNERGY GRANT	Ana María Mancho	01/11/2020 - 31/10/2022
EUR2020-112265	El Interfaz entre la geometría compleja Kahler y no-Kahler	Mario García-Fernández	01/12/2020 - 30/11/2022
PID2020-116949GB-I00	Difusión no lineal: problemas locales y no locales	Fernando Quirós Gracián	01/09/2021
PID2020-113350GB-I00	Análisis armónico, combinatoria y aritmética	Pablo Candela & Fernando Chamizo	01/09/2021 - 31/08/2024

Code/Acronym	Project	PR	Start-final date
PID2020-113523GB-I00	Análisis Matemático y Teoría de Información Cuántica	Carlos Palazuelos & David Pérez García	01/09/2021 - 31/08/2024
PID2020-118193GA-I00	Counting Conjectures (COCO)	Carolina Vallejo	01/09/2021 - 31/08/2023
PID2020-114032GB-I00	Métodos Profinitos y Analíticos en Teoría de Grupos	Andrei Jaikin	01/09/2021
PID2020-116398GB-I00	Aplicaciones del Análisis Funcional en problemas de Geometría y Teoría de la Información	Pedro Tradacete & José Ignacio Villanueva	01/09/2021 – 31/08/2025
PID2020-114703GB-I00	Dinámicas de fluidos incompresibles	Ángel Castro & Diego Córdoba	01/09/2021
PID2020-116949GB-I00	Difusión no Lineal: Problemas locales y no locales	Fernando Quirós Gracián	01/09/2021 - 31/08/2024
PID2020-113350GB-I00	Análisis armónico, combinatoria y aritmética	Pablo Candela & Fernando Chamizo	01/09/2021 - 31/08/2024

Code/Acronym	Project	PR	Start-final date
PID2020-113523GB-I00	Análisis Matemático y Teoría de Información Cuántica	Carlos Palazuelos & David Pérez García	01/09/2021 - 31/08/2024
PID2020-118193GA-I00	Counting Conjectures (COCO)	Carolina Vallejo	01/09/2021 - 31/08/2023
PID2020-114032GB-I00	Métodos Profinitos y Analíticos en Teoría de Grupos	Andrei Jaikin	01/09/2021 - 31/0/2025
PID2020-116398GB-I00	Aplicaciones del Análisis Funcional en problemas de Geometría y Teoría de la Información	Pedro Tradacete y Jose Ignacio Villanueva	01/09/2021 - 31/08/2025
PID2020-114703GB-I00	Dinámicas de fluidos incompresibles	Ángel Castro y Diego Córdoba	01/09/2021 - 31/08/2024
PID2020-113596GB-I00	EDPs no-lineales: difusión, geometría y aplicaciones	Mª del Mar González	01/09/2021 - 31/08/2024

Code/Acronym	Project	PR	Start-final date
PID2020-117477GB-I00	Grupoids, von Neumann algebras and the mathematical foundations of Quantum Mechanics: Theory and application	Alberto Ibort	01/09/2021 - 31/08/2024
PID2020-112796RB-C21	Methods and models for biomathematical applications	Ana Mª Carpio	01/09/2021 - 31/08/2025
PID2020-113048GB-I00	Espacios de Funciones y Técnicas de Acotación de Operadores en Análisis	María Jesús Carro	01/09/2021 - 31/08/2025
PID2021-124662OB-I00 (MDRI15)	Un nuevo paradigma para el aprendizaje automático adversario	David Ríos	01/09/2022 - 31/08/2024
PID2021-124195NB-C33	Análisis de Fourier con aplicaciones a Teoría de Medida Geométrica y Problemas Inversos	Keith Rogers	01/09/2022 - 31/08/2025

Code/Acronym	Project	PR	Start-final date
PID2021-123348OB-I00	Herramientas matemáticas para la observación de la Tierra	Ana Mª Mancho	01/09/2022 - 31/08/2025
PID2021-124662OB-I00	Un nuevo paradigma para el aprendizaje automático adversario	David Ríos	01/09/2022 - 31/08/2025
PID2021-126254NB-I00	Infinite groups from the algebraic, geometric, and combinatorial viewpoints	Javier Aramayona	01/09/2022 - 31/08/2025
PID2021-124195NB-C32	Análisis Variacional y geometría aplicada a problemas inversos y mecánica	Daniel Faraco & Luis Guijarro	01/09/2022 - 31/08/2025
PID2021-122154NB-I00	Ortogonalidad y aproximación con aplicaciones en machine learning y teoría de la probabilidad	Manuel Mañas	01/09/2022 - 31/08/2025

Code/Acronym	Project	PR	Start-final date
Programa INVESTIGO CM	Ayuda contratación Pablo Varas Pardo	David Ríos	16/10/2022 - 15/10/2023
TED2021-129970B-C21 (MNCM2)	Hacia una economía circular: tecnología digital disruptiva como herramienta para la innovación en el diseño y desarrollo de fármacos (DIGIDREV)	Nuria Campillo y David Ríos	01/12/2022 - 30/11/2024
TED2021-131530B-I00	Modelización y simulación de electrolisis alcalina en configuracion de Zero Gap	Marco Antonio Fontelos	01/12/2022 - 30/11/2024

CSIC (I-Link, I-Coop and Extraordinary Grants) Calls

Code/Acronym	Project	PR	Start-final date
COOPB20617	Applications of Ordered Structures in Mathematical Economy and Machine Learning	Pedro Tradacete	01/01/2022 - 31/12/2023
202250E001	Modelos Oceánicos de Alta resolución y aplicaciones (MODAL)	Ana Mª Mancho	01/01/2022 a 31/12/2024

International Funding

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

European Research Council Grants

Code/ Acronym	Reference	Project	PR	Start-final date
GAPS	ERC-Consolidator Grant 648913	Spectral gaps in interacting quantum systems	David Pé-	01/09/2015 – 28/02/2022
FLUSPEC	ERC-Consolidator Grant 862342	Analysis of geometry-driven phenomena in fluid mechanics, PDEs and spectral theory	Alberto Enciso	01/03/2021-28/02/2026
NONFLU	ERC- Advanced Grant 788250	Non-local dynamics in incompressible fluids	Diego Córdoba	01/09/2018–31/08/2023
QUAMAP	ERC- Advanced Grant 834728	Quasiconformal Methods in Analysis and Applications	Kari Astala. ICMAT members: Daniel Faraco and Keith Rogers	01/09/2019-31/08/2024

Marie-Sklodowska Curie actions

Code/Acronym	Reference	Project	PR	Start-final date
tech-FRONT	Marie Curie - Individual Fellowship	Novel techniques for quantitative behaviour of convection-diffusion equations	Matteo Bonforte	01/09/2020 - 31/08/2022
ROBOT-TOPES	Marie Curie - Individual Fellowship	The momentum polytopes of non-holonomic systems	Amna Shaddad and Manuel de León	16/09/2020-15/09/2022
RRMAP	Marie Curie - Individual Fellowship	Riemann-Roch and motives for arithmetic problems	Alberto Navarro and José Ignacio Burgos	01/01/2021-31/12/2022
TraX	Marie Cu-	Stability and Transitions in Physical Processes	Florentino Borondo	01/03/2017 - 31/10/2022
GHAIA	Marie Cu-	Geometric and Harmonic Analysis withInterdisciplinary Applications	Matteo Bonforte	001/10/2017-30/04/2022

H2020 Societal Challenges Pillar

Code/Acronym	Project	PR	Start-final date
ONCOSREEN (MDRI 16)	A European “shield” against colorectal cancer based on novel, mor precise and affordable risk-based screening methods and viable policy pathways	David Ríos	01/12/2022 - 30/11/2025
Trustonomy	Building Acceptance and Trust in Autonomous Mobility	David Ríos	01/05/2019 – 30/04/2022

Other projects

Code/Acronym	Project	PR	Start-final date
RC2APD (MDRI 2)	Robust Command and Control under Adversarially Perturbed Data	David Ríos	22/09/2021-21/09/2024

Private funding

Code/Acronym	Project	PR	Start-final date
ADVENCED MODEL SOLUTIONS, S.A.	Apoyo tecnológico dentro del proyecto H2020 denominado Starlight	Nuria Campillo	01/07/2022-16/03/2022
DISID CORPORATION, S.L.	Desarrollo de un algoritmo para la gestión de stocks en farmacias	David Ríos	20/06/2022 - 19/12/2022
MYTRA CONTROL SL.	Machine Learning Detección de anomalías	David Ríos	01/12/2022 - 31/12/2022

Code/Acronym	Project	PR	Start-final date
DENEXUS TECH S.L.	Modelización del riesgo unitario y acumulación de riesgo derivado de la ciberseguridad para el desarrollo de la versión 4 del producto De-RISK.	David Ríos	24/10/2021-24/02/2022
Fundación BBVA – Becas Leonardo	Garantías de Seguridad con Controles Basados en Datos para Sistemas Cooperativos	Leonardo Colombo	
Fundación La Caixa. Becas de doctorado INPhINIT	Dynamical and Numerical Aspects of Multi-agent Control Systems with Applications to Robotics	Jacob Goodman	28/01/2020-27/01/2023
Fundación La Caixa. Becas de doctorado INPhINIT	The smooth topology of symplectic 4-manifolds with a fixed contact boundary	Didac Violan y Francisco Presas	01/10/2020-30/09-2022
Fundación La Caixa. Becas de doctorado INPhINIT	Machine learning for partial differential equations	Laia Domingo y Florentino Borondo	15/10/2020-14/10/2022
Fundación BBVA MDRI	AMALFI: Adversarial Machine Learning: Methods, Computations and Applications to Malware, Fake News and Autonomous Vehicles	David Ríos	
XEERPA MARKETING SOLUTIONS, SL.	Recomendador de Contenidos Basado en el Perfil Digital de un Usuario/ Content Recommender Based on a User's Digital Profile	David Ríos	29/09/2019-28/02/2022
Fundación La Caixa. Junior Leather	Decentralized Strategies for Cooperative Robotic Swarms	Leonardo Colombo	01/05/2019
Axa Permanent Chair	AXA: Adversarial Risk Analysis	David Ríos	01/09/2014-31/12/2023

8. SEVERO OCHOA PROGRAMME

In December, 2020, and for the third consecutive time, ICMAT was awarded the Severo Ochoa seal of excellence by the Spanish Ministry of Science and Innovation. The purpose of the "Severo Ochoa Centres of Excellence and the María de Maeztu Units of Excellence" awards is to provide funding and accreditation to 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.

This accreditation is endowed with four million euros for the development of a programme, with the objective of strengthening institutional capacity over a four-year period, and includes 14 predoctoral contracts. This enables the creation and implementation different scientific programmes, which will make a huge contribution towards consolidating ICMAT's position as a leading international centres in mathematical research.

As on previous occasions, a big part of the funding this year is devoted to hiring personnel, including management experts, and pre- and post-doc researchers whose role is central to the development of ICMAT's programme of excellence. Likewise, this funding has also covered temporary transfers of contracted research personnel, as well as seven collaboration grants for master students, who have had their fees covered and received a monthly stipend. Funding has also been provided for students in the final year of their degree to attend the JAE School and undertake research stays with members of ICMAT.

In 2021, ICMAT launched a third programme of Laboratories and Distinguished Professors that will last until 2023, with funds provided by the Severo Ochoa project.

The chairs of the Labs are: Ian Agol (University of California, Berkeley, USA); Ngô Bo Châu (University of Chicago, USA); Ignacio Cirac (Max Planck Institute of Quantum Optics, Germany); Charles Fefferman (Princeton University, USA) and Nigel Hitchin (University of Oxford, UK).

The Distinguished Professors are: Kari Astala (University of Helsinki); Anthony Bloch (University of Michigan); Filippo Bracci (Università di Roma); Anthony Carbery (University of Edinburgh); Juncheng Wei (University of British Columbia).

Examples of activities funded by the Severo Ochoa during 2022 are the visit of the Distinguished Professor K. Astala, the Groups in Madrid workshop, the costs of different ICMAT seminars and colloquia, and the disthinguished lecture of Claire Voisin. In addition, funding was provided for ICMAT's visitors scheme, which in 2022 enabled nine researchers to carry out stays at the institute. Costs arising from outreach and communication activities conducted at the centre have also been covered, as well as those stemming of the Institute's gender plan, consumables and computer equipment, training costs of centre members, and representation costs.

Since October, 2017, 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.

EXCELENCIA SEVERO OCHOA

SOMMa

SOMM EXCELLENCE ALLIANCE

Since October 2017, 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.

9. SCIENTIFIC ACTIVITIES

The following activities were organized in ICMAT in 2022:

Workshops

• HITCHIN-NGÔ LAB: Young Researchers Workshop
3 - 4 March 2022
• IGNACIO CIRAC LAB: Functional Analysis, Quantum Computing and beyond. PhD and Young Researchers Workshop
16 – 18 March 2022
• AGAPI day VII
16 March 2022
• Las matemáticas de la materia viva
21 - 23 March 2022
• Workshop on Banach spaces and Banach lattices II
9 – 13 May 2022

Image : ICMAT

• Geometric Aspects of the Swampland 2022
23 – 26 May 2022
• Conferencia final NET4IMPACT. Impacto social de la investigación científica
3 June 2022
• 11th International Conference on Harmonic Analysis and Partial Differential Equations
6 – 10 June 2022
• Geometric Aspects of the Swampland 2022. Part II
8 – 10 June 2022
• Generalized Geometry in Interaction
13 – 17 June 2022
• Regularity for Nonlinear Diffusion Equations. Green Functions and Functional Inequalities
13 – 17 June 2022
• Focused research group on Geometric Structures and Their Applications
20 – 23 June 2022

Image courtesy of the workshop

• Poisson 2022 Conference
25 – 29 July 2022

Image courtesy of the workshop

• XXX International Fall Workshop in Geometry and Physics
29 August – 2 September 2022

Image : ICMAT

• Intercity Seminar on Arakelov Geometry 2022
12 – 16 September 2022
• Moduli spaces and geometric structures Conference in honour of Oscar García-Prada on the occasion of his 60th birthday
12 – 16 September 2022

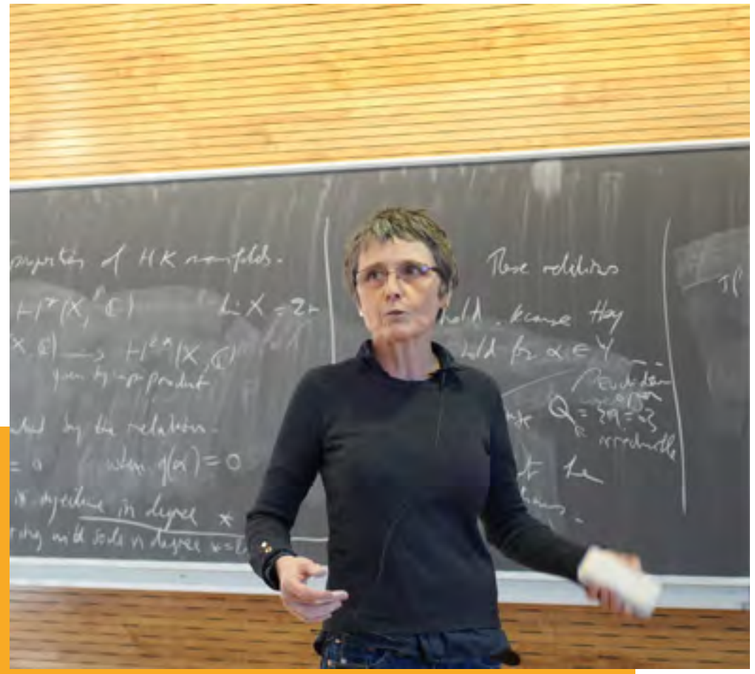
Image : ICMAT

• Recent Trends in Fluid Mechanics
26 -30 September 2022
Groups in Madrid
20 – 21 October 2022

Distinguished Lectures

ICMAT continued in 2022 this activity, a series of talks given by leading figures of international standing in mathematics.

• "Hyper-Kähler manifolds",
Claire Voisin (Institut de Mathématiques de Jussieu-Paris Rive Gauche, CNRS)
1 April 2022



Claire Voisin. Image: ICMAT

Colloquia

The following colloquia were celebrated during 2022:

• Special colloquia

• "Quantum Circuits, Cellular Automata and Tensor Networks"
Ignacio Cirac (Max Planck Institute of Quantum Optics)
29 March 2022

Ignacio Cirac. Image: ICMAT

• "On the functional equation of automorphic L-functions"
Ngô B9 Châu (University of Chicago)
29 April 2022

Ngô Bảo Châu. Image : ICMAT

• "Hyperbolic knots and links"
Ian Agol (University of California, Berkely)
20 May 2022

• Joint Mathematics Colloquium (ICMAT-UAM-UC3M-UCM)

Coordinators: José Ignacio Burgos Gil (ICMAT-CSIC), José Manuel Conde Alonso (ICMAT-UAM), Fernando Lledó Macau (ICMAT-UC3M) and Piergiulio Tempesta (ICMAT-UCM)

• "Funciones E, o qué tiene que ver la trascendencia con los modos de vibración de una membrana"
Javier Fresán (Centre de Mathématiques Laurent Schwartz, École Polytechnique)
4 February 2022

• "Computers and mathematics in fluid mechanics: new developments and challenges"
Javier Gómez Serrano (Brown University)
24 March 2022

• "Positive solutions of parametric polynomial systems and biochemical reaction networks"
Elisenda Feliu (University of Copenhagen)
6 May 2022

Elisenda Feliu. Image : ICMAT

• "Rigidity theory for von Neumann algebras"
Stefaan Vaes (KU-Leuven, Belgium)
22 September 2022

• "A survey of the Calderón inverse problem"
Niky Kamran, Department of Mathematics, McGill University (Montréal, Canada)
14 December 2022

• Joint Mathematics Junior Colloquium (ICMAT-UAM-UC3M-UCM)

Coordinators: Manuel Lainz (ICMAT-CSIC), Adrián Linares (UAM), Alba García (ICMAT) & Ismael Cano (ICMAT-UAM)

• "Autofunciones de alta energía y localización inversa"
Alba García (ICMAT)
17 February 2022

• "Euler podría ser un Data Scientist"
María Teresa Arias (UAM)
10 March 2022

• "Explorando nuevas conexiones entre estructuras dinámicas invariantes y la cuantificación de la incertidumbre"
Guillermo García Sánchez (ICMAT)
31 March 2022

• "Higher order elliptic boundary regularity and free boundaries"
Daniel E. Restrepo Montoya (University of Texas at Austin)
28 April 2022

• "Comportamiento a largo plazo de problemas de reacción-difusión tipo KPP: existencia y convergencia a perfiles de onda viajera"
Irene Gonzálvez Martínez (UAM)
19 May 2022

• "Periodic dynamics for the Lorentz Force equation"
Manuel Garzón Martínez (Universidad de Granada)
26 May 2022

• "Matemáticas para limpiar los océanos"
Guillermo García Sánchez (ICMAT)
21 September 2022

• "El problema de la aguja de Kakeya y los conjuntos de Besicovitch"
Javier Minguillón Sánchez (UAM)
5 October 2022

• "Del polinomio de Jones al espectro de Khovanov"
Sergio García Rodrigo (UAM)
26 October 2022

• "Espectro de Berkovich del anillo de enteros"
Bilson Castro (ICMAT)
10 November 2022

• "Un cuento de amenabilidad"
Jorge Pérez (ICMAT)
23 November 2022

• "Introducción a la teoría geométrica de grupos"
Rodrigo de Pool (ICMAT)
14 December 2022

Schools

• Graduate school on Geometric Group Theory and Low Dimensional Topology
16-27 May 2022
• Escuela JAE de Matemáticas 2022
27 June – 8 July 2022

JAE School. Image : ICMAT

Courses

• Ian Agol Laboratory: Study Seminar on Sylvester Rank Functions and L2 Betti-numbers
Every Friday
• Study Group in Iwasawa Theory
14, 21 and 28 January 2022
• Mathematical Modelling and Simulation in Geophysical Flows: Mathematical concepts
1, 4, 7, 8 March; 1, 4, 5, 6 July; 5- 9 September; 12- 16 September 2022; 3-20 October 2022
• Mathematical Modelling and Simulation in Geophysical Flows: Computational issues
14, 18, 21, 25, 28 March; 1, 4, 8, 11, 18, 22, 25, 29 April; 6 May 2022
• Reading Group in Causal Inference and Machine Learning
Every Friday from December 2022
• Christmas Trees minicourse: Bass-Serre Theory
13-14 December; 16 December 2022

Seminars

Seminars are held every week at ICMAT on different areas of research:

• Analysis and applications seminar. Coordinator: Adrián González (ICMAT - UAM)
• Analysis and PDE's seminar. Coordinators: Ángel Castro (ICMAT-CSIC), Ana Primo (ICMAT-UAM), José María Arrieta (ICMAT-UCM) and Matteo Bonforte (ICMAT-UAM)
• Applied Mathematics. Coordinators: Florentino Borondo (ICMAT-UAM), Makrina Agaoglou (ICMAT-CSIC) and Guillermo García Sánchez (ICMAT-CSIC)
• Communtative Algebra-Algebraic and Aritmetic Geometry seminar UAM-ICMAT. Coordinator: Ana Bravo (ICMAT-UAM)
• DataLab Seminar. Coordinator: Simón Rodríguez (ICMAT-CSIC)
• Geometry seminar. Coordinators: Benjamin Bode (ICMAT-CSIC), Mario García Fernández (ICMAT-UAM), Os-

car García-Prada (ICMAT-CSIC), Ángel Gonzalez Prieto (ICMAT-UCM) and Daniel Peralta (ICMAT-CSIC)
• Geometric mechanics and control seminar. Coordinators: Manuel de León (ICMAT-CSIC), Juan Carlos Marrero (IMA-ULL), David Martín De Diego (ICMAT-CSIC)
• Group theory seminar. Coordinators: Leo Margolis (ICMAT-CSIC) and Alejandra Garrido (ICMAT-UAM)
• Machine Learning seminar. Coordinators: Matteo Bonforte (ICMAT-UAM), Davide Barbieri (ICMAT-UAM) and Mar González (ICMAT-UAM)
• Number theory seminar. Coordinators: Enrique González Jiménez (UAM), Daniel Macías (ICMAT-UAM) and Pablo Candela (ICMAT-UAM)
• PDEs and fluid mechanics seminar. Coordinators: Ángel Castro (ICMAT-CSIC) and Diego Córdoba (ICMAT-CSIC)
• PDE UAM-ICMAT. Coordinators: Félix del Teso (UAM), Salvador López Martínez (UAM-ICMAT) and Tomás Sanz Perela (UAM-ICMAT)
• Q-Math seminar. Coordinator: Juan Manuel Pérez Pardo (ICMAT-UC3M)

10. THESES

Three researchers completed their PhD theses at ICMAT in 2022.

The titles, authors and supervisors of which are listed below:

• "Contributions to Approximate Bayesian Inference for Machine Learning", Simón Rodríguez
Advisors: Daniel Hernández Lobato (UAM) and David Gómez-Ullate (Universidad de Cádiz)
Date: 18 January 2022

• "Asymptotic probability techniques in monochromatic waves and fluid mechanics", Álvaro Romaniega
Advisors: Alberto Enciso (ICMAT-CSIC) and Daniel Peralta-Salas (ICMAT-CSIC)
Date: 16 September 2022

Álvaro Romaniega with his PhD advisors, Daniel Peralta (left) and Alberto Enciso. Image courtesy of Romaniega

• "Contact Hamiltonian System", Manuel Lainz Valcázar
Advisor: Manuel de León (ICMAT-CSIC)
Date: 20 September 2022

Manuel Lainz and his PhD advisor, Manuel de León. Image courtesy of De León

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.

International consortiums

In 2021, ICMAT participated in two international consortiums:

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.

Web

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

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).

Moreover, in 2022 the group of David Ríos launched the following transfer projects:

- Contract: Xeerpa Marketing Solutions, S.L. "Recomendador de contenidos basado en el perfil digital de un usuario". 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". 30/04/2020 - 30/04/2022.
- Modelling unit risk and accumulation of risk derived from cybersecurity for the development of version 4 of the DeRISK product. DENEXUS TECH S.L. PR: David Ríos. 24/10/2021-24/02/2022.
- Development of an algorithm for stock management in pharmacies. DISID CORPORATION, S.L. 20/06/2022 – 7/11/2022
- Analysis of standard methodologies for assessing threats and risks in information systems. ADVANCED MODEL SOLUTIONS, S.A. PR: Nuria Campillo. 30/06/2022 – 31/12/2022.
- Predictive tool for risk management. AERONAUTICAL ENERGY ENGINEERING SERVICES, S.L., RAC. 30/06/2022 – 31/12/2022.
- Machine Learning Anomaly Detection. MYTRA CONTROL S.L. 30/11/2022 -22/12/2022.

Others:
David Ríos was elected in 2022 as member of the National Statistical Plan 2025-2029.

12. COMMUNICATION AND OUTREACH

Throughout 2022, ICMAT continued its intense outreach and communication activity through the Culture Mathematical Union Office. Regular organization of activities continued with the publication of press releases, ICMAT Newsletter, the 'Café y Teoremas' section in *El País*, and events, such as the Researchers' Night, the Science Week or Matemáticas en la Residencia. A full list of the activities is as follows:

ICMAT Newsletter

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 ICMAT, as well as a team of professional journalists in the field of mathematical communication and outreach.
One issue of ICMAT newsletter was published in 2022: Newsletter #23

Press releases

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 2022, 13 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 ICMAT website.

'Café y Teoremas', *El País*

CAFÉ Y TEOREMAS

'Café y Teoremas' is a weekly publication coordinated by ICMAT 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. 37 articles appeared in 2022.

News

ICMAT regularly publishes news on its website about the scientific and outreach activity conducted at the centre. In 2022, 33 news items were published.

Social networks

ICMAT maintains active profiles on the main social networks. The number of followers as of December 2022, is shown below:
Facebook: 31 022 followers
Twitter: 30 286 followers
Instagram: 993 followers
YouTube: 3412 subscribers; 208 689 views
Linkedin: 309 followers
An average of three different contents are usually posted every day on Facebook and Twitter, dealing with current mathematical issues about both ICMAT occasionally and in general, and exclusively about ICMAT on Instagram. Videos made by ICMAT are uploaded onto YouTube.

OUTREACH ACTIVITIES

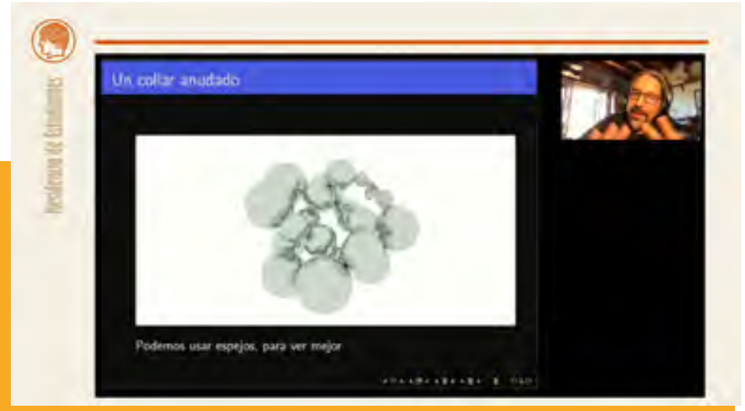
Mathematics at the Residencia

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

In 2022, the following talks were organised:

- "Nudos mansos y nudos salvajes" (online)

Speaker: Aubin Arroyo (Instituto de Matemáticas de la Universidad Nacional Autónoma de México)
Date: 10 March 2022



Aubin Arroyo during his talk. Image: Residencia de Estudiantes

- "Cinco años sin Maryam Mirzakhani, exploradora de superficies"

Speaker: Javier Aramayona (ICMAT-CSIC)
Date: 12 May 2022

- "

Javier Aramayona gave a talk about Maryam Mirzakhani. image: ICMAT

ticas del siglo XX"

Speaker: Yvette Kosmann-Schwarzbach & Tudor Ratiu (Shanghai Jiao Tong University, China)
Date: 26 July 2022

European Researchers' Night

This yearly activity is aimed at bringing the general public closer to researchers in person in a festive and entertaining way in order to show the benefits they provide for society and their influence on daily life. Researchers' Night is associated with the European celebration of this event.

In 2022, the European Researchers' Night was celebrated on 30 September. ICMAT participated in the feria organized by the CSIC centres at Campus de Cantoblanco. This edition took place in CSIC Campus, in downtown Madrid, entitled "Una noche de ciencia en el CSIC".

ICMAT organised the workshop "Matemáticas para limpiar los océanos", given by Guillermo García Sánchez, predoctoral researcher at ICMAT.

Álvaro Romaniega with his PhD advisors, Daniel Peralta (left) and Alberto Enciso. Image courtesy of Romaniega

Also, the Red de Igualdad Intercentros CSIC+UAM organised the escape-road: “A la búsqueda de las científicas Nobel y no Nobel”.

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, ICMAT is participating in the organization of this dissemination activity. The 2022 competition took place on 7-9 October 2022 in Viladecans (Barcelona).

Science Week

The Science and Technology Week is one of the leading events in social communication of science and technology held in Spain. 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.

On 10, 11, and 14 November 2022, the Institute organised two activities:

• **Outreach workhops: “Simetrías, rocas y otras herramientas para el desarrollo sostenible”**, 10-11 November. Activity organised together with the Instituto Geológico y Minero de España (IGME), in collaboration with Matemorfosis (Centro de Investigación en Matemáticas, Guanajuato, México).
For primary and secondary school students and the elderly.

Geometric bubbles workshop. Image: ICMAT

• **Debate session: “El lugar de la ciencia básica en la investigación y en el desarrollo sotenible”**, 14 November. Activity organised together with the Real Academia de Ciencias Exactas, Físicas y Naturales de España. For general public.

One of the round tables of the debate session. Image: ICMAT

Equality Committee outreach actions

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

ICMAT has joined in celebrating 11 February, International Day of Women and Girls in Science since 2018. In 2022, the Institute organised the following activity:
• “Las matemáticas que curan: de Florence Nightingale a la pandemia de la COVID 19”, by Ana Bravo (ICMAT-UAM). Talk-workshop for secondary students.

Ana Bravo helping one of the participants in her workshop. Image: ICMAT

May 12, Celebrating Women in Mathematics
For the third year running, the Day of Women in Mathematics was held on 12 May, the birthday of the Iranian mathematician Maryam Mirzakhani, the first woman to win a Fields Medal and who passed away in 2017. Throughout the month, and with the slogan Celebrating Women in Mathematics, a series of activities were organized all over the world – many of which, given the circumstances, were virtual events – with the aim of highlighting the work of women mathematicians, profiling outstanding figures and helping in the struggle to close the gender gap that exists in the discipline. The idea for this celebration came from the Women's Committee of the Iranian Mathematical Society and was approved at the World Meeting for Women in Mathematics (WM)2, one of the satellite congresses that was held at the last International Congress of Mathematicians (ICM), held in Rio de Janeiro (Brazil) in 2018.

In 2022, ICMAT organized the following activity:
• Dialogue with Christina Brech (Sao Paulo University): "Sesgos inconscientes de género y de matemáticas". Available on this link.

She Does Maths

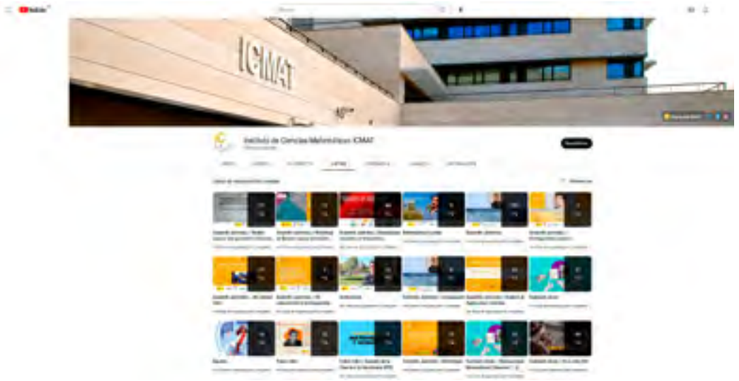
'She Does Maths' is a permanent section of ICMAT Newsletter in which a portrait of a women mathematician (preferably at her place of work) is given, together with a brief description of her research work. This content is also available on the blog 'Mujeres con Ciencia'.

In 2022, Sara Abdelsalam (British University in Egypt) was the protagonist of this section.

Sara Abdelsalam. Image ICMAT

Audiovisual communication

ICMAT Mathematical Culture Unit (UCMAT) produces mathematical culture (public talks, interviews, about mathematics and art, etc.), equality (talks, activities, interviews, etc.), institutional, dissemination of calls and scientific videos (workshops, colloquiums, seminars, etc.) that are posted on the ICMAT YouTube channel and on social media. 55 videos were published on YouTube in 2022. Also, ICMAT uploads to its YouTube channel the talks of Matemáticas en la Residencia, with the allowance of the Residencia de Estudiantes, host of this audiovisual material.



Graphic communication

ICMAT Mathematical Culture Unit produces posters to produced to announce the activities of the centre, which follow the institutional line of ICMAT, and facilitate the transmission of information directed to the research community and the general public.

13. EQUALITY COMMITTEE

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. ICMAT is committed to equal opportunities for all and believes that mathematical talent is distributed equally without regard to sex (neither gender, nor race, nor geographical location), so the current situation signifies 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 ICMAT board and the Severo Ochoa programme, executed through the centre's Gender Committee (now, Equality Committee), which demonstrates the institutional commitment of ICMAT to equality and diversity. The CSIC has awarded in 2021 its Seal of Accreditation for Gender Equality 2021 to ICMAT, after it gained the "highest score from the panel," as stated in the official announcement of the decision, in which it was also stated that "it met the requirements set out in the National Plan for Equality" and highlighted "the commitment of both the management and the personnel of the institute in matters of equality."

In 2022, ICMAT continued as an institutional member of the European Women in Mathematics (EWM). The main objective of the EWM is to increase the presence of women in mathematics. For that purpose, different initiatives have been undertaken to encourage the pursuit of this discipline among women students, to support women in their careers, to contribute to setting up a network of specialists in the field and to make the presence of women more visible in mathematics.

In 2022, the Equality Committee consisted of the following members: Ana Bravo (ICMAT-UAM, chairperson); Javier Aramayona (ICMAT-CSIC); 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 ICMAT Strategic Gender Plan.

The Equality Committee organized or collaborated with the following activities in 2022:

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

For seven consecutive years, ICMAT has participated in the Science by Women programme 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, ICMAT welcomes women from African countries who are selected to come to the centre for six months to collaborate with ICMAT researchers in accordance with their fields of research.
In the 2021 edition (7th), Narjisse Amahjour (Morocco) was elected. She worked with Ana Mª Mancho to develop the project "Computational Fluid Dynamics modeling to reduce risk of the spread COVD-19 of different isolation room in the hospital" from 10 May 2022 to 6 November 2022. In addition, Sara Abdelsalam (The British University Egypt), who was elected in the 2020 edition of the programme, joined ICMAT from 6 June to 6 September 2022 to work with Ángel Castro's research team.
In 2022, Yuliya Zelenyuk was selected to enjoy a research stay at ICMAT in 2023 (VIII edition).

Narjisse Amahjour. Image : ICMAT

STEMatEsElla

STEMatesElla 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 ICMAT and the Basque Center for Applied Mathematics (BCAM).

The IV Edition of the programme STEMatesElla was sponsored by ICMAT, BCAM and ACKERMANN INTERNATIONAL. This edition was launched in October 2022 and the closing ceremony took place at ICMAT in July 2023. A total of 50 mentees participated.
At the ceremony, in addition to the speeches of Cristina Sancho (president of EJE&CON) and Eva Gallardo, there were:
1. Talk by Mr. Javier Pérez de Vargas. Director of the Royal Academy of Engineering of Spain (RAING)
2. A panel titled “Technological Vanguards and Institutional Collaboration in Science and Engineering” with the participation of Pilar Véle (Director Professor of Applied Mathematics and University Defender University of Nebrija); Mrs. Elena Carta (Deputy Vice President of the Higher Centre for Scientific Research, CSIC); Ms. Beatriz Arias (Director of the Nokia Business and Digital Operations Centre of Excellence); Mrs. Nuria Alonso Martínez-Losa (Director of Dissemination and Institutional Cooperation of the RACE Foundation)

STEMatesElla is a scheme for promoting the professional scientific and business careers of women degree students and female master and PhD students of mathematics as well as other related disciplines (grouped under the acronym CTIM). It combines mentoring, coaching, webinars and visibility of reference points, while also working on soft skills. The aim is to put women students into contact with STEM professionals, both in the academic sphere (female researchers and teachers belonging into the RSME and ICMAT) and in the business sector (EJE&CON executives and counsellors) by means of regular tutorial sessions during the academic year. (more information in page xx of this annual report).

“She Does Maths”, ICMAT Newsletter

This is a permanent section of 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 Mujeres con Ciencia.

In 2022, two mathematicians appear on the section.
More information in page 42 of this annual report.

Commemoration of 11 February - International Day of Women and Girls in Science
More information in page 41 of this annual report.

May 12, Celebrating Women in Mathematics
More information in page 41 of this annual report.

Equality Intercentre Network of the Cantoblanco Campus
ICMAT equality committee also collaborates with the CSIC Equality Intercentre Network of the Cantoblanco Campus in various activities. Among others:
• The Escape Road: “A la búsqueda de las científicas Nobel y no Nobel”. This is a contest based on the biographies and contributions of some women who have won the Nobel Prize in Sciences o who had deserved it but whose contributions where ignored. ICMAT has contributed preparing material and by translating the content of the posters into English.
• 11 February. Colloquium: “De Budapest a Filadelfia: La vida de una investigadora tenaz cuyo trabajo posibilitó las vacunas de ARNm”, by Lluís Montoliu (researcher at Centro Nacional de Biotecnología, CNB)
• 8 March. ICMAT distributed to its members purple masks and badges for the 8M together with the UAM.
• 25 November, Round table with Ángela Bernardo, author of the book Harassment: #MeToo in Spanish science, on the occasion of the International Day for the Elimination of Violence against Women.

ICMAT

INSTITUTO DE CIENCIAS MATEMÁTICAS

www.icmat.es

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EXCELENCIA SEVERO OCHOA