ICMAT

INSTITUTO DE CIENCIAS MATEMÁTICAS

Annual Report 2023

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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 Dic. 2011-2024

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ICMAT Annual Report 2023

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
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1. INTRODUCTION

2023, full steam ahead

2023 has been a year of intense activity at ICMAT, compensating the slowdown caused by the COVID-19 pandemic. With over 40 conferences organized and approximately 1500 visitors hosted, ICMAT has consolidated its position as an internationally-recognized center for mathematical research.

The institute continues to produce cutting-edge research, in the form of top-level publications, invitations to conferences, prizes, and distinctions. Notably, in 2023 our colleague Diego Córdoba has been awarded with the “Julio Rey Pastor” National Research Prize in Mathematics and Information Technologies, the most important research distinction in Spain’s mathematics.

ICMAT maintains its strong commitment with the education and training of young researchers through our different formative programmes. In this direction, we highlight the Little Mathematics Institute (PIM), aimed at detecting and fostering mathematical talent among high-school students, with a weekly attendance of over 100 students.

Javier Aramayona, ICMAT director

2. ICMAT IN FIGURES

Scientific activities

35 Workshops

21 Colloquia

37 Courses

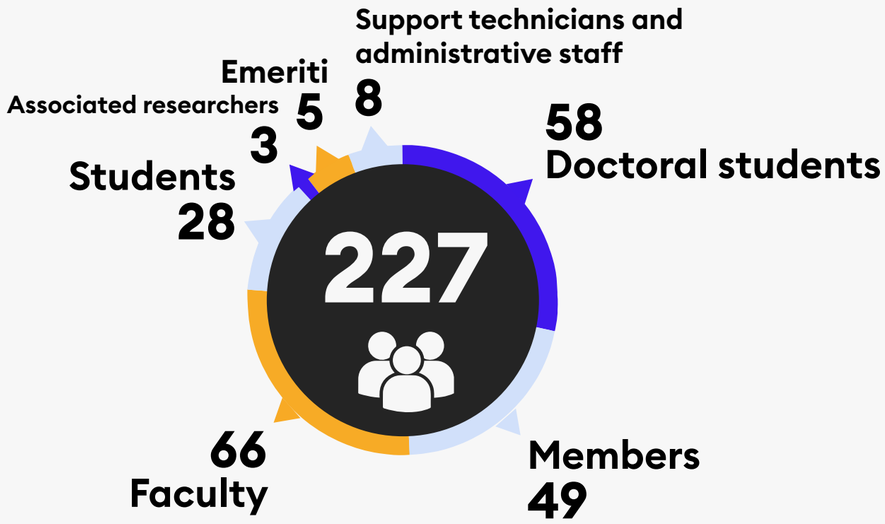
- **5** Joint Mathematics Colloquium
- **19** Joint Mathematics Junior Colloquium
- **3** Special Colloquium

2 Distinguished Lectures

138 Seminars

12 Thesis

Personnel



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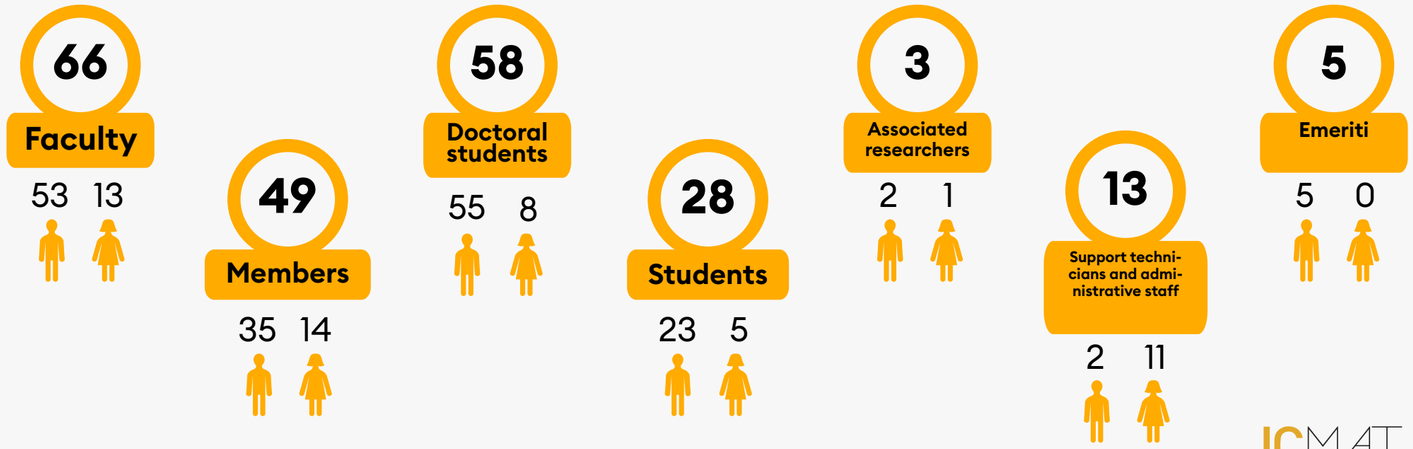


3. PERSONNEL

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 Antolín 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 Fernández
- 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 2023, 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
- Davide Barbieri
- Matteo Bonforte
- Pablo Candela Pokorna
- María Jesús Carro
- Ángel Castro Martínez
- Fernando Chamizo
- Diego Córdoba Gazolaz
- Alberto Enciso Carrasco
- Daniel Faraco Hurtado
- Eva Gallardo Gutiérrez
- María Ángeles García
- María del Mar González Nogueras
- Jesús Ángel Jaramillo
- José María Martell Berrocal
- Carlos Mora Corral
- Jesús Munárriz Aldaz
- Rafael Orive Illera
- Arturo de Pablo
- Javier Parcet Hernández
- Ana Primo Ramos
- Fernando Quirós Gracián
- Aníbal Rodríguez Bernal
- Keith Rogers
- F. Javier Soria
- Pedro Tradacete Pérez

Members
- Siddhant Govardhan Agrawal
- Glenier Lázaro Bello Burguet
- Mingming Cao
- Hon to Hardy Chan
- José Manuel Conde Alonso
- Maximiliano Contino
- Félix del Teso
- Antonio Jesús Fernández
- Claudia García
- Björn Gebhard
- Adrián González Pérez
- Nastasia Grubić
- Salvador López Martínez
- Teresa Elvira Luque Martínez
- María Medina de la Torre
- Yamilet Quintana
- Javier Ramos Maravall
- Guillermo Rey Ley
- Tomás Sanz Perela
- Fan Zheng

Doctoral students
- Antonio Álvarez
- Itahisa Barrios
- Norberto Clemente
- David de Hevia Rodríguez
- Laia Domingo Colomer
- Joaquín Domínguez de Tena
- Carlos Fuentes
- Alba Dolores García Ruiz
- Enrique García Sánchez
- Irene Gonzálvez
- Pablo Hidalgo Palencia
- Peio Ibarrondo Murguialday
- Andrés Laín
- José Antonio Lucas
- Miguel Martínez
- Jorge Pérez
- Jorge Ruiz
- Omar Sánchez Antonio
- Eduardo Tablate Vila

Master students
- Francisco Unai Caja
- Álvaro Carballeira
- Jesús Illescas
- Laura Sáenz
- Sofía Sirón

In 2023, 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 exploit quantum effects to develop new techniques in fields like cryptography, metrology, mate-

rial 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. This research includes 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 2023, 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: Javier Aramayona Delgado

Image: Íñigo de Amescua/ ICMAT

- Deputy director: Ana María Bravo

Heads of Department

- Fundamental Mathematics: Ángel Castro Martínez

- Applied Mathematics: Piergiulio Tempesta

Image: ICMAT

ICMAT Board

- Faculty representative: José María Arrieta

- Faculty representative: José Manuel Conde

Image: ICMAT

- Faculty representative: Daniel Peralta

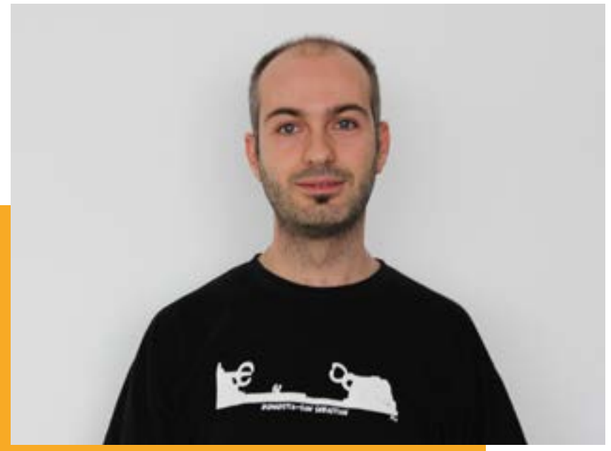


Image: ICMAT

- Secretary: Clara García Suelto

Image: Iñigo de Amescua/ICMAT

ICMAT Committees

Mathematical Culture Unit

Chairs:
- David Martín de Diego(ICMAT-CSIC)
- Javier Aramayona (ICMAT-CSIC)

Members:
- Alberto Enciso (ICMAT-CSIC)
- Emilio Franco (ICMAT-UAM)
- Alba Dolores García (ICMAT-CSIC)
- Pablo Hidalgo (ICMAT-CSIC)
- Laura Moreno Iraola (ICMAT-CSIC)
- Daniel Peralta (ICMAT-CSIC)
- Fernando Quirós (ICMAT-UAM)
- Ágata Timón (ICMAT-CSIC)

Equality Committee

Chair:
- Nuria Torrado (ICMAT-UAM)

Members:
- Ana Bravo (ICMAT-UAM)
- José Manuel Conde (ICMAT-UAM)
- Edmundo Huertas (Universidad de Alcalá, ICMAT visitor until January 2024)
- Marta Macho-Stadler (UPV)
- David Martín de Diego (ICMAT-CSIC)
- Yamilet Quintana (ICMAT-UC3M)

Postgraduate Committee

Chair:
P. Tradacete (ICMAT-CSIC)

Members:
- Enrique González Jiménez (ICMAT-UAM)
- Julio de Vicente (ICMAT-UC3M)
- Carlos Palazuelos (ICMAT-UCM)

Library Committee

Members:
- Nuno Freitas Barroso (ICMAT-CSIC)
- Mario García (ICMAT-CSIC)

Support Staff:
- Esther Ruiz

Scientific Committee

Chairs:
- Alberto Enciso (ICMAT-CSIC)
- Javier Aramayona (ICMAT-CSIC)

Members:
- Diego Córdoba (ICMAT-CSIC)
- Oscar García-Prada (ICMAT-CSIC)
- Andrei Jaikin (ICMAT-UAM)
- David Pérez (ICMAT-UCM)
- David Ríos (ICMAT-CSIC)

Committee of Internal Institutional Relations

Chair:
- Fernando Quirós (ICMAT-UAM)

Members:
- Luis Álvarez-Cónsul (ICMAT-CSIC)
- Eva Gallardo (ICMAT-UCM)
- Fernando Lledó (ICMAT-UC3M)

Committee of External Institutional Relations

Members:
- Javier Aramayona (ICMAT-CSIC)
- José María Arrieta (ICMAT-UCM)
- Daniel Peralta (ICMAT-CSIC)

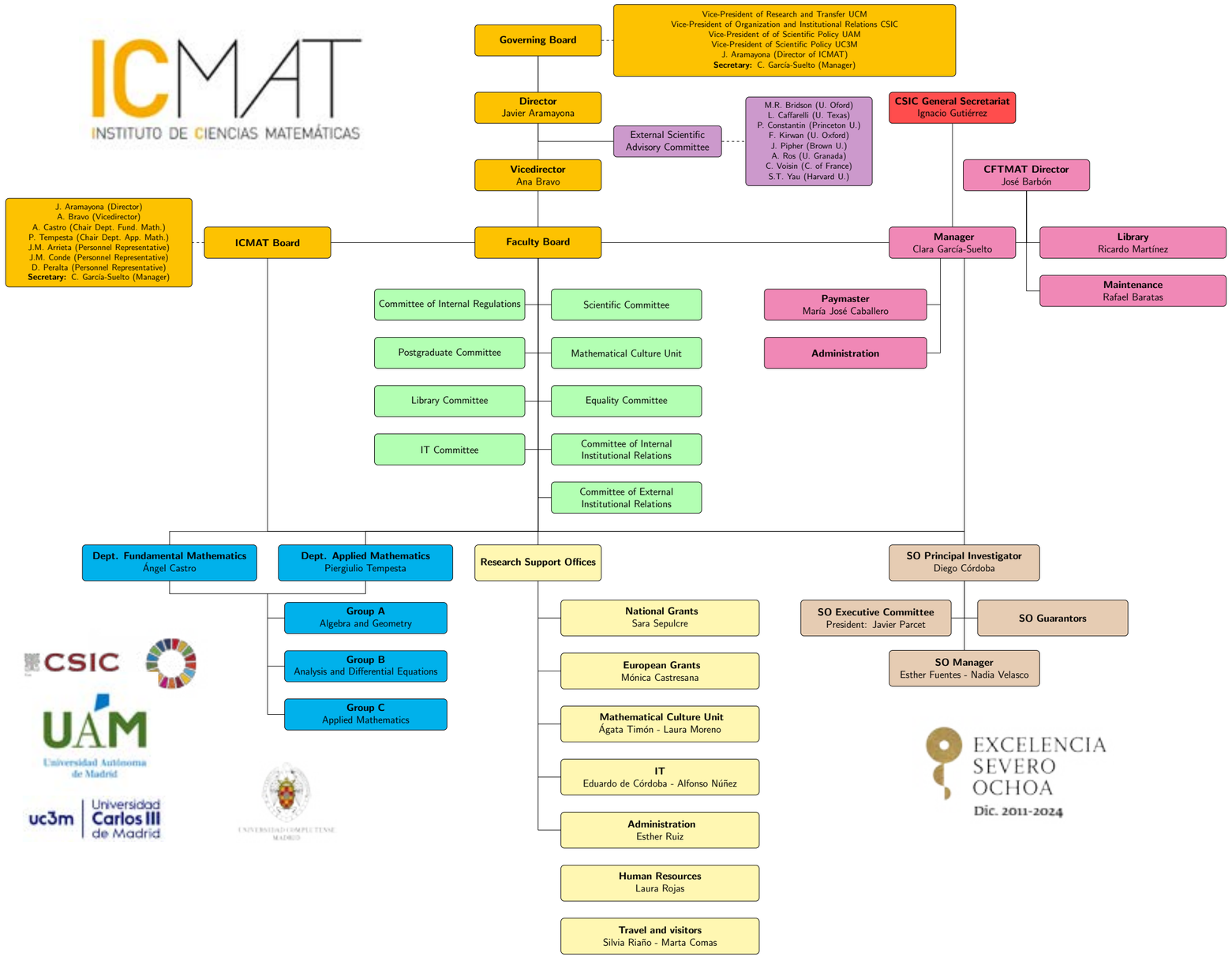
Committee of Internal Regulations
Chair:
- Tomás Gómez (ICMAT-CSIC)

Members:
- Luis Guijarro (ICMAT-UAM)
- Ignacio Villanueva (ICMAT-UCM)
- Alberto Ibort (ICMAT-UC3M)

IT Committee
Chair:
- Ángel Castro (ICMAT-CSIC)

Members:
- Davide Barbieri (ICMAT-UAM)
- Daniel Macías (ICMAT-UAM)

Support Staff:
- Eduardo de Córdoba, Alfonso Núñez



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 Ma-

thematical 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
- Laura Rojas
- Silvia Riaño
- Marta Comas

ICT Office
- Eduardo de Córdoba
- Alfonso Núñez

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

Severo Ochoa Office
- Esther Fuentes
- Nadia Velasco

Project Management Office
- Mónica Castresana (International projects)
- Sara Sepulcre (National projects)

AXA Office
- Marta Sanz González

Image: Iñigo de Amescua/ICMAT

4. SCIENTIFIC RESULTS

Reviews of the scientific production of ICMAT in 2023:

"Arakelov–Milnor inequalities and maximal variations of Hodge structure"

Authors: Olivier Biquard (Sorbonne Université and Université Paris Cité), Brian Collier (University California Riverside), Oscar García-Prada (Instituto de Ciencias Matemáticas, ICMAT), Domingo Toledo (University of Utah)
Source: Compositio Mathematica, vol. 159, 1005 - 1041
Link
Review: Since their introduction more than 35 years ago, Hitchin moduli spaces of Higgs bundles over compact Riemann surfaces have been of tremendous interest in geometry, topology and theoretical physics. These spaces have an extremely rich geometry coming from the fact that they are hyper-Kähler, they define completely integrable systems, and by the non-abelian Hodge correspondence, they are identified with character varieties of surface group representations. These moduli spaces also play a central role in mirror symmetry and Langlands duality.

Within the moduli space of Higgs bundles there is a special subvariety determined by the fixed points of the $\mathbb{C}^*$-action obtained by scaling the Higgs field. These fixed points are called Hodge bundles and correspond to holonomies of complex variations of Hodge structure. They are part of the global nilpotent cone, and coincide with critical points of a natural energy function on the moduli space. Another importance of the $\mathbb{C}^*$-fixed points stems from the fact that, roughly speaking, the subvariety of Hodge bundles determines the topology of the moduli space of Higgs bundles via different localization methods.

In this paper, the authors establish some basic properties of Hodge bundles and their moduli spaces. They introduce a topological invariant for Hodge bundles that generalizes the Toledo invariant appearing for Hermitian Lie groups. A main result of this paper is a bound on this invariant which generalizes the Milnor–Wood inequality for a Hodge bundle in the Hermitian case, and is analogous to the Arakelov inequalities of classical variations of Hodge structure. When the generalized Toledo invariant is maximal, the authors establish rigidity results for the associated variations of Hodge structure which generalize known rigidity results for maximal Toledo Higgs bundles and their associated maximal representations in the Hermitian case. The theory developed in this paper opens the door to a systematic study of the topology of moduli spaces of Hodge bundles, and hence the topology of the moduli spaces of Higgs bundles for arbitrary reductive groups.

"Universality of Euler flows and flexibility of Reeb embeddings"

Authors: Robert Cardona (Universitat Politècnica de Catalunya, UPC), Eva Miranda (UPC), Daniel Peralta-Salas (Instituto de Ciencias Matemáticas, ICMAT), Francisco Presas (ICMAT)
Source: Advances in Mathematics, vol. 428, paper n. 109142, 109142(1-40)
Link
Review: The dynamics of an inviscid and incompressible fluid flow on a Riemannian manifold is governed by the Euler equations. Recently, Terry Tao launched a programme to study the dynamical universality and the Turing completeness of the Euler and the Navier-Stokes equations. Inspired by this proposal, in this article we prove that the stationary Euler equations exhibit several universality features. More precisely, we show that any non-autonomous flow on a compact manifold can be extended to a smooth stationary solution of the Euler equations on some Riemannian manifold of possibly higher dimension. The solutions we construct are of Beltrami type, and being stationary they exist for all time. Using this result, we establish the Turing completeness of the steady Euler flows, i.e., there exist solutions that encode a universal Turing machine and, in particular, these solutions have undecidable trajectories. Our proofs deepen the correspondence between contact topology and hydrodynamics, which is key to establish the universality of the Reeb flows and their Beltrami counterparts. An essential ingredient in the proofs, of interest in itself, is a novel flexibility theorem for embeddings in Reeb dynamics in terms of an h-principle in contact geometry.

"Rigidity of acute angled corners for one phase Muskat interfaces"

Authors: Siddhant Agrawal (ICMAT), Neel Patel (University of Maine), Sijue Wu (University of Michigan)
Source: Advances in Mathematics, vo. 412, paper n. 108801, 71
Link

Review: The one phase Muskat equation is an equation which models the interface between a porous medium and air, where the dynamics is driven by Darcy's law. The equation is also equivalent to the Hele Shaw equation, with injection happening at infinity. This is a free boundary problem, as the fluid domain changes as a function of time. After writing the equation in an appropriate coordinate system, one can see that the equation is a nonlinear nonlocal parabolic equation. Previously this equation was shown to have unique global in time weak solutions for Lipschitz initial interfaces, and it was shown that for initial interfaces with slope less than 1, the interface instantaneously smoothens out.
In this paper, we study the problem when the initial interface has an acute angled corner or a cusp. We show that in this case, the interface does not smoothen out instantaneously, but rather the corner remains a corner with the same angle, at least for a short period of time. This is surprising as one generally expects smoothing to happen, due to the fact that the equation is parabolic in nature. This result shows that in this regime, the nonlinearity in the equation dominates the linear behavior.
We prove this result, by first writing the equation in Riemann mapping coordinates and then proving suitable weighted energy estimates. The fact that the weighted energy remains finite for a short time is then used to show that the corner remains a corner and does not smoothen out.

"Traveling waves near Couette flow for the 2D Euler equation"

Authors: Ángel Castro (ICMAT), Daniel Lear (Universidad de Cantabria)
Source: Communications in Mathematical Physics, vol. 400, 2005-2079
Link
Review: The study of the mathematical stability of the Couette flow for the 2D Euler equation started in the 19th century with the works of Kelvin, Orr, Reynolds, Rayleigh, Stokes, Sommerfeld and others. In their pioneering investigations they found that the linear problem is stable. However, experiments showed instabilities and transition to turbulence for any size of disturbance when the Reynolds number is large. This contradiction between theory and experiment is nowadays referred as the "Sommerfeld paradox".
The stability of the Couette flow for 2D Euler has been intensely studied in the last decade and substantial progress has been made. J. Bedrossian and N. Masmoudi proved that solutions starting close to the Couette flow (at the vorticity level) in a Gevrey space, tend to a shear flow close to the Couette flow. The assumption on the Gevrey regularity is es
sential to get this result. Y. Deng and M. Masmoudi showed that the previous result does not hold, in general. If the distance to the Couette flow is measured in Sobolev spaces, there are several results in the literature studying the existence of nontrivial stationary or traveling solutions. Here trivial means that the velocity takes the form (u(y), 0).
C. Li and Z. Lin proved the existence of smooth nontrivial traveling waves close to the Couette flow in L2 (at the level of the velocity). Z. Lin and C. Zeng proved the existence of nontrivial smooth stationary solutions of 2D Euler close to the Couette flow in Hs, for s<3/2 (at the level of the vorticity). In addition, they proved that, for s>3/2, if there is a traveling wave close to the Couette flow then this traveling wave is trivial. In our paper, we prove the existence of nontrivial smooth traveling waves arbitrarily close to the Couette} in Hs (at the level of the vorticity), with s<3/2, and with a speed of traveling of order 1.

"Thermalization in Kitaev's quantum double models via tensor network techniques"

Authors: Angelo Lucia (UCM-ICMAT), David Pérez-García (UCM-ICMAT), Antonio Pérez-Hernández (UNED)
Source: Forum of Mathematics Sigma, vol.11: e107, 1–71
Link
Review: Noise is one the main obstacles to scale current quantum computers to the relevant sizes needed to exploit their full potential beyond the reach of current classical computers. An important question in that direction is whether self-correcting quantum memories exist, where no active error correction is needed.
Self-correcting quantum memories can only exist in systems with so-called "topological order", in which the excitations behave as particles that are neither bosons or fermions, and are called anyons.
In a breakthrough result from 2001, Dennis, Kitaev, Landahl and Preskill showed that self-correcting quantum memories do exist in four dimensions. However, to make them practical, it is needed to find them in two or three dimensions; a problem which is still open.
The search for those memories in three dimensions has led to the discovery, by Jeongwan Haah, of a totally new type of quantum phase of matter, currently known as "fractons".
In two dimensions, it is an extended belief that self-correcting quantum memories cannot exist, though this had only been proven rigorously for models which are not capable of universal topological quantum computation in which the anyons are associated to an abelian group.
In this work, that result is extended to cover the case of

non-abelian groups, which can support universal computation. The proof is based on a representation of those models as tensor networks, together with tools to estimate spectral gaps in the infinitesimal generator of the noise evolution based on an holographic principle for tensor networks. “

“Schur multipliers in Schatten–von Neumann classes”

Authors: José Manuel Conde Alonso (UAM-ICMAT), Adrián González Pérez (UAM-ICMAT), Javier Parcet Hernández (ICMAT), Eduardo Tablate (ICMAT)
Source: Annals of Mathematics, vol. 198 (2023), pages 1229-1260
Link
Review: Schur multipliers are linear maps on matrix algebras with a great impact on functional analysis, operator algebras, geometric group theory and harmonic analysis. Their definition is rather simple on discrete spaces:

$$A \to (M(j,k)A_{jk})$$

for any matrix A and certain function $M\colon Z \times Z \to C$. More general index sets $\Omega \times \Omega$ correspond to operators A acting on $L_2(\Omega,\mu)$ for some σ-finite measure space (Ω,μ).

Schur multipliers have played a key role in landmark results since the mid 20th century. The celebrated Grothendieck’s inequality (1956) is intimately connected to a striking characterization of the operator boundedness of Schur multipliers. The impact of Schur multipliers in geometric group theory and operator algebras was early recognized by Haagerup. His pioneering work on free groups and the research thereafter on semisimple lattices (1979-1989) encoded deep geometric properties of these groups in terms of approximation properties for Toeplitz-like Schur multipliers on their matrix algebras. In a different direction, Schur multipliers of divided differences were essential in Potapov/Sukochev’s celebrated solution (2011) of Krein’s conjecture on operator-Lipschitz functions. More recently, due to a close connection between Fourier and Schur multipliers, the remarkable work of Lafforgue/de la Salle unraveled unprecedented pathologies in the Lp-convergence of Fourier series over semisimple Lie groups by analyzing Schur Sp-approximation. The Lp-theory has gained a considerable momentum since then.

The main result of this paper gives an unexpected and strikingly simple criterion for the boundedness of Schur multipliers on Schatten p-classes, which solves a conjecture proposed by Mikael de la Salle and goes beyond best-known to date Sp-estimates for divided differences and Toeplitz-like Schur multipliers. Given $1 < p < \infty$, a simple form our main result implies for $R^n \times R^n$ matrices that the Sp-norm of the Schur multiplier with symbol M is dominated (up to absolute constants) by the quantity

$$\sum_{|\gamma|\le[\frac{n}{2}]+1} \| \, |x-y|^{|\gamma|}\{|\partial_x^\gamma M(x,y)| + |\partial_y^\gamma M(x,y)|\}\|_\infty,$$

whenever the latter is finite. In this form, it is a full matrix (nonToeplitz/nontrigonometric) amplification of the fundamental Hörmander-Mikhlin multiplier theorem, which admits lower fractional differentiability orders $\sigma > n/2$ as well. This implies a one-line proof of Krein's conjecture for Sp-multipliers and moreover extends it to α -divided differences. It also leads to strong applications in harmonic analysis for high rank simple Lie group algebras which are left to a forthcoming paper.

“Nilspace factors for general uniformity seminorms, cubic exchangeability and limits”

Authors: Pablo Candela (UAM-ICMAT), Balázs Szegedy (Alfréd Rényi Institute of Mathematics)
Source: Memoirs of the American Mathematical Society, vol. 287, Number 1425 (2023)
Link
Review: This work unifies two principal results stemming from Szemerédi’s theorem. This theorem, proved by Szemerédi in 1975, guarantees the existence of arbitrarily long finite arithmetic progressions in any set of integers of positive upper density. The impact of this result has been profound, notably via the interactions that it has generated between diverse mathematical areas. In particular, Furstenberg’s famous alternative proof of Szemerédi’s theorem (1977) initiated a vibrant exchange between combinatorics and the theory of dynamical systems. Another landmark in this topic is the effective proof of Szemerédi’s theorem given by Gowers in the late 1990s. One of the outstanding aspects of this proof is the introduction of new analytic tools, known as the Gowers norms (or U^d norms), which led to a generalization of classical Fourier analysis. In the classical theory, a function on a compact abelian group is decomposed into fundamental harmonics (the Fourier characters) whose underlying structure is based on the circle group. The smallest of the Gowers norms, the U^2 norm, is closely related to this classical theory. However, the U^d norms of higher order (i.e. for d > 2) cannot be analyzed in terms of classical Fourier characters, requiring instead more subtle underlying objects, such as nilmanifolds. This motivated the above-mentioned generalization, a theory known as higher-order Fourier analysis, which includes as a cen-

tral result the so-called Inverse Theorem for the Gowers norms, proved first in the integer setting by Green, Tao and Ziegler in 2010. Parallel to this, the aforementioned exchange between combinatorics and dynamical systems continued to unfold, with highlights in the 2000s including the work of Host and Kra, proving the Ergodic Structure Theorem, which establishes a deep connection between nilmanifolds and certain counterparts of Gowers norms in ergodic theory (the Host--Kra seminorms for measure-preserving systems). Intriguing analogies between the Ergodic Structure Theorem and the Inverse Theorem for Gowers norms led to a desire for a conceptual framework that could unify these two results. The paper of Candela and Szegedy offers such a framework, based on new measure-theoretic structures called cubic couplings. The Gowers norms and the Host--Kra seminorms are all obtained from cubic couplings. A general structure theorem is proved which describes cubic couplings as essentially coming from underlying algebraic and topological objects called compact nilspaces, a generalization of nilmanifolds introduced by Szegedy and Antolín Camarena. From this theorem, one can then deduce and extend the Inverse Theorem for Gowers norms and the Ergodic Structure Theorem.

"Local wellposedness for the free boundary incompressible Euler equations with interfaces that exhibit cusps and corners of nonconstant angle"

Authors: Diego Córdoba (ICMAT), Alberto Enciso (ICMAT), Nastasia Grubic (ICMAT)
Source: Advances in Mathematics, 433 (2023), paper n. 109299, page 119
Link
Review: We prove that free boundary incompressible Euler equations are locally well posed in a class of solutions in which the interfaces can exhibit corners and cusps. Contrary to what happens in all the previously known non-C^1 water waves, the angle of these crests can change in time.

"Noncommutative Poisson vertex algebras and Courant-Dorfman algebras"

Authors: Luis Álvarez-Cónsul (ICMAT-CSIC), David Fernández (Luxembourg, currently at UPM), Reimundo Heluani (IMPA)
Source: Advances in Mathematics, 433 (2023), paper n. 109269, page 76
Link
Review: This paper is devoted to noncommutative variants of Courant–Dorfman algebras and Poisson vertex algebras. A Courant–Dorfman algebra is an algebraic version of a Courant algebroid, i.e., a symplectic Lie 2-algebroid. This is a geometric object motivated by work on Dirac manifolds (by Courant) and integrable systems (by Dorfman), that has become relevant in geometry and physics, specifically in generalized complex geometry, supergravity, conformal field theory and higher gauge theory. A Poisson vertex algebra is the underlying algebraic structure of a classical field theory. It provides a unifying approach to integrable Hamiltonian partial differential equations, and receives its name because the quasi-classical limits of Borcherds' vertex algebras are always of this type. Courant–Dorfman algebras and Poisson vertex algebras are intimately related. Indeed, graded Poisson vertex algebras freely generated in degrees 0 and 1 are in bijection with Courant–Dorfman algebras.
It is a remarkable fact that many integrable Hamiltonian equations admit generalizations in which the field variables take their values in a (noncommutative) associative algebra, that can be viewed as quantized versions of the classical integrable systems. The intricate calculations involved in these generalizations can be interpreted with tools that originate in the geometric study of the moduli stacks parametrizing the algebra representations. The Kontsevich–Rosenberg principle is a guiding rule, used in this context, whereby a structure on an associative algebra is 'geometric' if it induces the corresponding geometric structure on the representation moduli stacks. Crawley-Boevey–Etingof–Ginzburg (2007), Van den Bergh (2008) and De Sole–Kac–Valeri (2015) have constructed noncommutative variants of symplectic, Poisson, quasi-symplectic and Poisson vertex algebras that satisfy the Kontsevich–Rosenberg principle. They are given by noncommutative structures that do not reduce to the standard commutative structures when the algebras are commutative, but still they induce the corresponding geometric structures on the representation moduli stacks. The central mathematical concept introduced in the paper under review is a 'double Courant–Dorfman algebra'. The authors show that this concept satisfies the Kontsevich–Rosenberg principle and that it is equivalent to a noncommutative Poisson vertex algebra freely generated in degrees 0 and 1. In order to get nontrivial examples, the authors prove a new Cartan identity for noncommutative differential calculus. Together with identities previously obtained by Crawley-Boevey–Etingof–Ginzburg (2007) and Van den Bergh (2008), they uncover a noncommutative variant of the Cartan differential calculus used in ordinary geometry.

"A class of locally inhomogeneous complete quaternionic Kähler manifolds"

Authors: Vicente Cortés (Universität Hamburg); Alejan-

dro Gil-García (Universität Hamburg) ; Arpan Saha (ICMAT)
Source: American Mathematical Society, Mathscinet, Mathematical Reviews, Comm. Math. Phys. 403 (2023), n. 3, pages 1611–1626
Link
Review: We prove that the one-loop deformation of any quaternionic Kähler manifold in the class of c-map spaces is locally inhomogeneous. As a corollary, we obtain that the full isometry group of the one-loop deformation of any homogeneous c-map space has precisely cohomogeneity one.

Image: Iñigo de Amescua/ICMAT

5. BOOKS

During 2023, the following books were published with ICMAT researchers as authors or coauthors. These are the references:

Books

D. González-Álvaro, L. Guijarro, "On the Double Soul Conjecture", New Trends in Geometric Analysis, Spanish Network of Geometric Analysis 2007-2021, RSME Springer Series, vol. 10, pp. 227-244

Image: Íñigo de Amescua/ICMAT

6. AWARDS AND DISTINCTIONS

Diego Córdoba, National Research Award winner for his work deciphering fluid equations

Image: ICMAT

n September 2023, Diego Córdoba Gazolaz, profesor de investigación at the Spanish National Research Council (CSIC) at the Institute of Mathematical Sciences (ICMAT), and scientific director of the Severo Ochoa programme at ICMAT, received the JJulio Rey Pastor National Research Award in the area of Mathematics and Information and Communication Technologies. With this award, the most prestigious in Spain in the field of scientific research, the Ministry of Science and Innovation recognizes "the originality and impact of his research and methods introduced in the area of fluid mechanics equations, as well as his extraordinary educational work."

More info

Mar González Nogueras (ICMAT-UAM) receives the 2022 Mastercard and Royal Academy of Sciences of Spain Foundation Young Female Scientific Talent Award

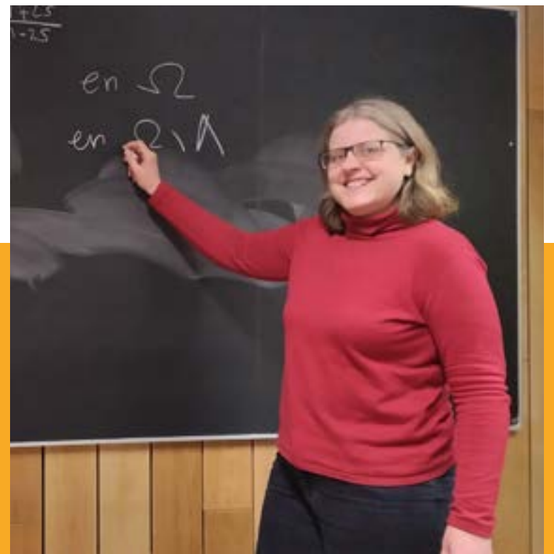


Image: Courtesy of Mar González

For the third consecutive year, Mastercard and the Royal Academy of Sciences of Spain Foundation (FRACE) awarded their Young Female Scientific Talent Awards. Mar González Nogueras, a researcher at ICMAT and associate professor at the Autonomous University of Madrid (UAM), was one of the four recipients of this award in the 'Mathematics' category. The jury has highlighted González Nogueras's "contribution to the Einstein equation and its application to the physics of black holes."

More info

David Ríos receives one of the prizes for operational research from BBVA Foundation and SEIO

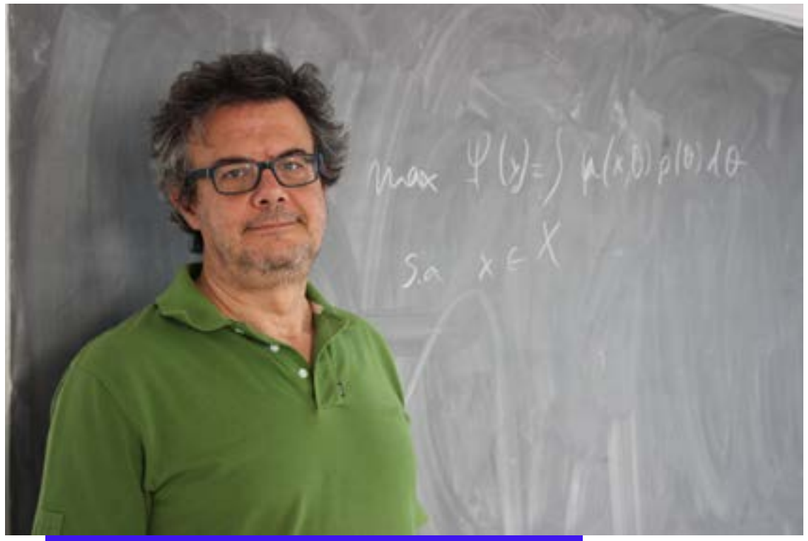


Image: SINC

A recent work by David Ríos Insua, a research professor at the Spanish National Research Council (CSIC) at the Institute of Mathematical Sciences (ICMAT), a member of the Royal Academy of Sciences, and AXA-ICMAT Chair; along with Tahir Ekin (Texas State University, USA), Alberto Torres-Barrán, an associate professor at IE University and former postdoctoral researcher at ICMAT; and Roi Naveiro, an associate professor at CUNEF and former pre and postdoctoral researcher at ICMAT, was recognized award for methodological contribution in operational research from the BBVA Foundation and the Spanish Society of Operational Research (SEIO). The article, "Augmented probability simulation methods for sequential games," was published in the European Journal of Operational Research last April.

More info

Daniel Peralta-Salas, appointed as a distinguished speaker by the European Mathematical Society (EMS) at the Nordic Congress of Mathematicians

Image: ICMAT

The Executive Committee of the European Mathematical Society (EMS) appointed Daniel Peralta-Salas, a research scientist at the Spanish National Research Council (CSIC) in the Institute of Mathematical Sciences (ICMAT), as a distinguished speaker of the EMS at the Nordic Congress of Mathematicians. The meeting is held once every four years and is organized by the national mathematical associations of Denmark, Finland, Iceland, Norway, and Sweden. In 2023, it took place from 3 July to 7 July, in Aalborg, Denmark.

More info

Diego Córdoba, Margarita Salas Medal for Research Supervision

Image: ICMAT

The Consejo Superior de Investigaciones Científicas (CSIC) has established in 2023 the Margarita Salas Medal for outstanding research supervision. Among the eight awardees of this inaugural edition is Diego Córdoba, a research professor at the CSIC Institute of Mathematical Sciences (ICMAT) and scientific director of the Institute's Severo Ochoa programme. The six researchers who have completed their theses with Córdoba have been awarded two prestigious Starting Grants from the European Research Council (ERC), two José Luis Rubio de Francia prizes from the Royal Spanish Mathematical Society (RSME), three SeMA Antonio Valle awards for Young Researchers, two Vicent Caselles Medals from the RSME and the BBVA Foundation, and three Ramón y Cajal contracts.

More info

Special Prize for Introduction to Research from the Ministry of Universities for Enrique García Sánchez (ICMAT-CSIC)

Image: Íñigo de Amescua/ICMAT

Enrique García Sánchez, a predoctoral researcher at the Spanish National Research Council (CSIC) at the Institute of Mathematical Sciences (ICMAT), received the Special Prize of the XX Arquímedes Contest for Introduction to Scientific Research. The award is endowed with 8000 euros and granted by the Ministry of Universities. TThe prize recognizes his work on Banach lattices, a topic within the field of functional analy-

sis, within the framework of a JAE Intro ICMAT Severo Ochoa master's scholarship, under the supervision of Pedro Tradacete (ICMAT-CSIC), now his thesis advisor, who has also received one of the awards for tutors in this call, worth 2000 euros.

More info

Robert Cardona (ICMAT-UPC), one of the six young mathematicians recognized with the Vicent Caselles Award from the RSME (Spanish Royal Mathematical Society) and the BBVA Foundation

Image: Courtesy of Robert Cardona

Awardees in the IX edition of the Vicent Caselles Awards were announced in june. These awards are granted by the BBVA Foundation and the Spanish Royal Mathematical Society (RSME) to young Spanish mathematicians or those who pursue their careers in Spain. Among them is Robert Cardona Aguilar, a postdoctoral researcher at the Margarita Salas Institute of Mathematical Sciences (ICMAT) and the Polytechnic University of Catalonia (UPC). Cardona, an expert in geometric hydrodynamics, three-dimensional flows on manifolds, and symplectic and contact geometry, achieved a result of great international relevance in 2021, alongside Eva Miranda (UPC), Daniel Peralta (ICMAT-CSIC), and Francisco Presas (ICMAT-CSIC), where they found, for the first time, solutions for a fluid capable of simulating any Turing machine.
More info

Ángel Castro receives a Leonardo Fellowship from the BBVA Foundation to study two-dimensional fluid equations

Image: Íñigo de Amescua/ICMAT

Ángel Castro Martínez, a research scientist at the Spanish National Research Council (CSIC) at the Institute of Mathematical Sciences (ICMAT), was awarded one of the 58 Leonardo Fellowships from the BBVA Foundation in 2023. These fellowships are intended to support personal projects of researchers and cultural creators who are in intermediate stages of their careers, between 30 and 45 years old. The researcher's project, "Inestabilities in 2D incompressible flows," falls within the field of fluid mechanics and is the only one in mathematics selected in this call, which received a total of 1116 applications.

More info

Alba García Ruiz's video on spectral theory wins the fourth edition of the Yo investigo. Yo soy CSIC contest

Frame of Alba's García video

Alba García Ruiz's video, a researcher at the ICMAT, produced in collaboration with the Mathematical Culture Unit of the Institute, was one of the thirteen winners out of more than 75 entries of the Yo investigo. Yo soy CSIC contest. Organised by the CSIC Postgraduate Department, in this contest predoctoral students explain, in an informative way, the topic of their thesis in a video of less than three minutes. In her video, Alba explains the topic of her research: spectral theory, a branch within the field of equation analysis that serves, for example, for the study of wave equations used to describe sound.

More info

David Pérez García, appointed as a full member of the Royal Academy of Exact, Physical, and Natural Sciences

Image: UCM

In March 2023, David Pérez García, a member of ICMAT and a professor at the Complutense University of Madrid (UCM), was appointed as a full member of the Royal Academy of Exact, Physical, and Natural Sciences. He delivered his entry lecture, titled "Non-local games: a link between mathematics, physics, and computer science," at a session held at the RAC headquarters on 8 March, with a response from academic and mathematician Fernando Bombal Gordón.

More info

7. RESEARCH PROJECTS

Competitive funding

National and regional

Code/Acronym	Project	PR	Start-final date
CEX2019-000904-S	Apoyo a Centros de Excelencia Severo Ochoa	Diego Córdoba Gazolaz	01/01/2020 - 31/03/2024
PID2019-109339GB-C31	Espacios de moduli y teoría Gauge	Oscar García-Prada	01/01/2020 - 30/06/2023
PID2019-105979GB-I00	Operadores y geometría en análisis matemático	Eva Gallardo	01/06/2020 - 30/06/2023
PID2019-107914GB-I00	Fronteras del análisis armónico	Javier Parcet Hernández	01/06/2020 - 31/05/2023
PID2019-108936GB-C21	Simetrías e invariancia homotópica en aritmética y geometría: fundamento	Francisco Presas and Daniel Macias	01/06/2020- 31/11/2023
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 Berrendero and Antonio Cuevas	01/06/2020 - 31/05/2023
PID2020-114703GB-I00	Dinámica de fluidos incompresibles	Ángel Castro and Diego Córdoba	01/09/2021- 31/08/2024
PID2020-118193GA-I00	Counting Conjectures (COCO)	Carolina Vallejo	01/09/2021 - 31/08/2023
PID2020-113523GB-I00	Análisis matemático y teoría de información cuántica	Carlos Palazuelos and David Pérez	01/09/2021- 31/08/2024
PID2020-114032GB-I00	Métodos profinitos y analíticos en teoría de grupos	Andrei Jaikin	01/09/2021- 31/08/2025
PID2020-113350GB-I00	Análisis armónico, combinatoria y aritmética	Fernando Chamizo and Pablo Candela	01/09/2021- 31/08/2024
PID2020-116949GB-I00	Difusión no lineal: Problemas locales y no locales	Fernando Quirós Gracian	01/09/2021- 31/08/2024
PID2020-113596GB-I00	EDP no-lineales: difusión, geometría y aplicaciones	María del Mar González	01/09/2021- 31/08/2024
PID2020-117477GB-I00	Grupoids, von Neumann algebras and the mathematical foundations of Quantum Mechanics: Theory and applications	Alberto Ibort	01/09/2021- 31/08/2024
PID2020-112796RB-C21	Methods and models for biomathematical applications	Ana María 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
PID2020-116398GB-I00	Aplicaciones del análisis funcional en problemas de geometría y teoría de la información	Pedro Tradacete	01/09/2021 - 31/08/2025

Code/Acronym	Project	PR	Start-final date
PID2021-123348OB-I00	Herramientas matemáticas para 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
PID2021-124195NB-C33	Análisis de Fourier con aplicaciones a teoría de medida geométrica y problemas inversos	Keith Rogers	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 and Luis Guijarro	01/09/2022-31/08/2025

Code/Acronym	Project	PR	Start-final date
PID2021-122154NB-I00	Ortogonalidad y aproximación con aplicaciones en machine learning y teoría de la probabilidad	David Gómez-Ullate and Manuel Mañas	01/09/2022-31/08/2025
PID2021-124662OB-I00 (MDRI15)	Un nuevo paradigma para el aprendizaje automático adversario	David Ríos	01/09/2022 - 31/08/2024
PID2021-124662OB-I00 (MDRI15)	Un nuevo paradigma para el aprendizaje automático adversario	David Ríos	01/09/2022 - 31/08/2024
Programa INVESTIGO CM	Ayuda contratación Pablo Varas Pardo	David Ríos	16/10/2022 - 15/10/2023
Programa INVESTIGO CM	Ayuda contratación Pablo Varas Pardo	David Ríos	16/10/2022 - 15/10/2023
TED2021-129970B-C21	Desarrollo de un marco basado en inteligencia artificial para acelerar el desarrollo de fármacos	Nuria Eugenia Campillo Martín y David Ríos Insúa	01/12/2022-30/11/2024
TED2021-131530B-I00	Modelización y simulación de electrólisis alcalina en configuraciçon de Zero Gap	Marco Antonio Fontelos López	01/12/2022-30/11/2024

Code/Acronym	Project	PR	Start-final date
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 and David Ríos	01/12/2022 - 30/11/2024
Programa Doctotado Industrial CM IND2023/IND-27975	Ayuda contratación Pablo Varas Pardo	David Ríos	01/12/2022 - 30/11/2024
Programa Doctotado Industrial CM IND2023/IND-27975	Ayuda contratación Pablo Varas Pardo	David Ríos	01/12/2022 - 30/11/2024
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 and David Ríos	01/12/2022 - 30/11/2024

Code/Acronym	Project	PR	Start-final date
RED2022-134784-T	Red de Ecuaciones en Derivadas Parciales no Locales y Aplicaciones	Diego Córdoba Gazolaz	01/06/2023-31/05/2025
PID2019-106715GB-C21	GESDYSYHYS	David Martín de Diego y Daniel Peralta	01/06/2023-29/02/2024
RED2022-134301-T	Geometría, Dinámica y Teoría de Campos	Daniel Peralta Salas	01/06/2023-31/05/2025
RED2022-134463-T	Red temática de geometría y físicas	Oscar García Prada	1/06/2023-31/05/2025
PID2022-136795NB-I00	Aspectos geométricos de teoría espectral e hidrodinámica	Daniel Peralta Salas and Alberto Enciso Carrasco	01/09/2023-31/08/2026
PID2022-137909NB-C21	Geometría de sistemas dinámicos: de la teoría a las aplicaciones	David Martin de Diego	01/09/2023-31/08/2027
PID2022-141354NB-I00	Fronteras del análisis armónico	Javier Parcet Hernandez and José María Martell Berrocal	01/09/2023-31/08/2027
PID2022-141387NB-C21	Pares de Higgs, integrabilidad y métricas canónicas	Oscar García Prada and Luis Alvarez Consul	01/09/2023-31/08/2026
PID2022-142024NB-I00	Simetrías e invariantes en geometría y aritmética	José Ignacio Burgos Gil and Daniel Macias	01/09/2023-31/08/2027
PID2022-137331OB-C33	Diseño de novo mediante Inteligencia Artificial y síntesis de moduladores de la interacción proteina-proteina dirigidos a NCS-1	Nuria Eugenia Campillo Martín	1/09/2023-31/08/2026
CNS2022-135784	Simetría espejo No-Kahler y teoría de Gauge superior	Mario García Fernández	1/09/2023 - 31/08/2025

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

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
NONFLU	ERC- Advanced Grant 788250	Non-local Dynamics in Incompressible Fluids	Diego Córdoba	01/09/2018–301/08/2024
QUAMAP	ERC- Advanced Grant 834728	Quasi-conformal Methods in Analysis and Applications	Kari Astala. ICMAT members: Daniel Faraco and Keith Rogers	01/09/2019-31/08/2025
FLUSPEC	ERC-Consolidator Grant 862341	Analysis of Geometry-Driven Phenomena in Fluid Mechanics, PDEs and Spectral Theory	Alberto Enciso	01/03/2021-28/02/2026

Marie-Sklodowska Curie actions

Code/ Acronym	Referencia	Project	PR	Start-final date
KNOTDYNAPP	101023017	Tracking the Time Evolution of Knots in Electromagnetism and Quantum Mechanics	Daniel Peralta and Benjamin Bode	16/03/2022-15/03/2024

H2020 Societal Challenges Pillar

Code/ Acronym	Project	PR	Start-final date
ONCOSREEN	A European “shield” against colorectal cancer based on novel, mor precise and affordable risk-based screening methods and viable policy pathways	David Ríos Insua	01/12/2022 - 30/11/2025

Other projects

Code/ Acronym	Project	PR	Start-final date
AXA Chair	AXA: Adversarial Risk Analysis	David Ríos Insua	01/09/2014 - 31/12/2023
RC2APD	Robust Command and Control under Adversarially Perturbed Data	David Ríos Insua	22/09/2021 - 21/09/2024

Private funding

Code/ Acronym	Project	PR	Start-final date
La Caixa Inphinit Incoming	Dynamical and Numerical Aspects of Multi-agent Control Systems with Applications to Robotics	Jacob Goodman	29/01/2020 - 28/01/2023
Fundación BBVA	AMALFI: Adversarial Machine Learning: Methods, Computations and Applications to Malware, Fake News and Autonomous Vehicles	David Ríos Insua	30/04/2020 - 29/03/2023
La Caixa Inphinit	Machine learning for partial differential equations	Laia Domingo and Florentino Borondo	01/10/2020 -30/09/2023

Code/ Acronym	Project	PR	Start-final date
La Caixa Inphinit	Contributions to Adversarial Machine Learning	José Manuel Camacho (PR: David Ríos)	16/01/2022 - 15/01/2025
Beca Leonardo 2022 BBVA Foundation	Estructuras ordenadas en análisis, geometría y aplicaciones	Pedro Tradacete	01/07/2023 - 30/06/2024
Becas Leonardo 2023 BBVA Foundation	Instabilities in 2D incompressible fluids	Ángel Castro	29/09/2023 - 28/03/2025
La Caixa Inphinit	Schwinger’s picture of quantum mechanics and the foundations of classical and quantum field theories: Groupoids, algebroids and categories	Arnau Mas (PR: Alberto Ibort)	01/10/2023 - 30/09/2026
La Caixa Inphinit	Higgs bundles, big algebras and involutions	Miguel González González (PR: Oscar García Prada)	01/11/2023 - 31/10/2026

8. SEVERO OCHOA PROGRAMME

In December 2019, and for the third consecutive time, ICMAT received the Severo Ochoa seal of excellence from the Ministry of Science, Innovation and Universities. The "Severo Ochoa Centers of Excellence and María de Maeztu Units of Excellence" awards aim to provide funding and accreditation to research centers and units in any field of science that demonstrate impact and scientific leadership at an international level, and actively collaborate with their social environment and business sectors.

This accreditation is endowed with four million euros for the development of a program, with the objective of strengthening institutional capacity over a period of four years. This allows the creation and implementation of different scientific programs, which greatly contributes to consolidate ICMAT's position as an international reference center in mathematical research.

Among the major milestones of this latest accreditation from 2020 to 2023, it is worth highlighting the continuation of the Distinguished and Laboratories Programme through which four laboratories have been set up with the following chairs: Ian Agol (University of California, Berkeley, USA); Ngô Bảo Châu (University of Chicago, USA) and Nigel Hitchin (University of Oxford, UK); Ignacio Cirac (Max Planck Institute for Quantum Optics, Germany); and Charles Fefferman (Princeton University, USA).

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

In addition, a large number of postdoctoral and predoctoral contracts have also been carried out during this period.

In 2023, ICMAT received 1,500 visitors who participated in the scientific activities carried out at the institute. We have organised 4 thematic research programmes, 134 seminars, 25 colloquia, 35 conferences and workshops, 11 courses and 6 schools.

As in previous years, a significant part of this year's funding has been allocated to the recruitment of staff, including management experts and pre- and post-doctoral researchers whose role is fundamental to the development of ICMAT's programme of excellence. This funding has also covered temporary secondments of contracted research staff and attendance at events held at ICMAT for 140 students, including Master's students from all over Spain and final year students at the JAE School, as well as research stays with ICMAT members. It also covered the expenses derived from the dissemination and communication activities carried out at the centre, as well as those derived from the Institute's gender plan, fungible and computer material, training expenses for members of the centre and representation expenses.

Since October 2017, ICMAT has been part of the alliance between the Severo Ochoa centres and the María de Maeztu units, known as SOMMa, which brings together more than 50 leading Spanish research institutions with more than 8,500 researchers. Since 2023, ICMAT has a seat on its Executive Committee.

EXCELENCIA SEVERO OCHOA

Dic. 2011-2024

9. SCIENTIFIC ACTIVITIES

The following activities were organized in ICMAT in 2023:

Thematic Research Programmes

Quantum Information Theory (QIT)

27 February – 31 March

Research Programme on Moduli Spaces and Geometric Structures (RPMSGS)

1 April – 30 June

2023 Thematic period on PDEs. Diffusion, Geometry, Probability and Free Boundaries

June - December

Geometric group theory and low-dimensional geometry and topology (GGTLDGT)

8 May – 7 July

Workshops

- 19th Recent Trends in Nonlinear Science (RTNS)

23 January

- QIT - Tensor Networks

6-10 March

- QIT - Quantum many body systems and quantum information

13 - 17 March

- AGAPI Workshop on Magnetohydrodynamics

15-16 March

- QIT - Functional Analysis and Quantum Information

20-24 March

- RPMSGS - The Hitchin system, Langlands duality and mirror symmetry

Image: ICMAT

24-29 April

- 13th Bayesian Inference for Stochastic Processes

22-24 May

- Arithmetic of L-functions

22-26 May

- RPMSGS - Higgs bundles, character varieties and higher Teichmüller spaces

22-26 May

- 7 Games and Decisions in Risk and Reliability

24-26 May

- AGAPI day X

25 May

- 2023 Thematic Period on PDEs, Diffusion, Geometry, Probability and Free Boundaries: BIRS-ICMAG Workshop

29 May - 2 June

- Geometric Valuation Theory - from convex sets to functions

5- 9 June

- GGTLDGT - Orderings and Groups

12-16 June

- RPMSGS - Gauge theory, canonical metrics and geometric structures

19 - 23 June

- GGTLDGT - Profinite Rigidity

26 -30 June

- GGTLDGT - Group actions and low-dimensional topology

3-7 July

- Mathematical Analysis of Fluid Dynamics

4 July

- Geometry Day

5 July

- Non-linear Elliptic PDE

10-14 July

Image: ICMAT

- Dynamical Systems, Mechanics and Control. A workshop in honor to Anthony Bloch

12-14 July

- Encuentro de la Red de EDPs No Locales y Aplicaciones

20-22 September

- Young Researchers in PDes - Week1

25-29 September

- Agapi Day XI

29 September

- Young Researchers in PDes - Week2

2-6 October

- Workshop on Degenerate and Singular Diffusion

10-13 October

- EURO-JAPANESE Conference on Nonlinear Diffusions

16-20 October

Image: ICMAT

- Workshop Stability of Functional Inequalities

23-26 October

- Groups in Madrid

26-27 October

- Fifth BYMAT Conference Bringing Young Mathematicians Together

13-16 November

Image: ICMAT

- The many challenges of Artificial Intelligence. A workshop to evaluate the challenges and repercussions of the "new" Artificial Intelligence (AI)

13-15 November

- Probabilistic and game theoretical interpreTation of PDes

20-24 November

- Workshop Holomorphic Flows vs. Semigroup (Operator) Theory

30 November - 1 December

- DeLeonfest 2023 an interdisciplinary conference on geometric mechanics and related fields

11 - 13 December

Image: ICMAT

- Closing Workshop of 2023 Thematic Period PDEs

18-20 December

Distinguished Lectures

Distinguished lectures are a series of talks given by leading figures of international standing in mathematics. The following lecture took place in 2023:

- "Conformally symplectic dynamis", Marie-Claude Arnaud (Université Paris-Cité)

31 march 2023

Colloquia

The following colloquia were celebrated during 2023:

Special colloquia

- "Gromov hyperbolicity theory in complex analysis and semigroup-fication of univalent self-maps of the unit disc"

Filippo Bracci (Dipartimento di Matematica, Univeritá di Roma)

15 February

Image: ICMAT

- QIT Research Programme - "Quantum computing in the presence of errors"

Ignacio Cirac (Max Planck Institute of Quantum Optics)

9 March

Image: IFT

- 1st CFTMAT Joint Colloquium - "Unraveling Singularities: A Deep Dive into 3D Incompressible Euler equations"

Diego Córdoba (ICMAT)

21 December

Image: IFT

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)

- "On the birational geometry of matroids

Annette Werner (Goethe Universität Frankfurt)

10 March

- "Randomness and structure in combinatorics, analysis and computer science"

Jop Briët (CWI, Amsterdam)

24 March

- "Analytic approach to extremal combinatorics"

Daniel Král' (Masaryk University)

23 June

- "Suppression of chemotactic blow-up by active advection"

Yao Yao (National University of Singapore)

29 September

- "Birkhoff normal form and almost global existence in Hamiltonian PDEs"

Dario Bambusi (Milan University)

26 October

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

Coordinators: Alba García (ICMAT-CSIC), Asier López (ICMAT-CSIC), Jorge Pérez (ICMAT-UAM) & Sergio García (UAM)

- "Objetos libres en análisis funcional"

Enrique García (ICMAT)

11 January

- "Pérdida de compacidad en subconjuntos débil-compactos de L2"

Santiago Verdasco (UCM)

25 January

- "Una introducción al σ_k-Problema de Yamabe"

María Fernanda Espinal Florez (Pontificia Universidad Católica de Chile)

1 February

- "Topological Data Analysis (TDA) and air traffic"

Manuel Mellado Cuerno (UAM)

15 February

- "Objetos matemáticos de tipo superior"

Roberto Téllez Domínguez (ICMAT)

1 March

- "Álgebra universal: más allá de grupos y anillos"

Iván Chércoles (ICMAT)

15 March

- "¿Quién se ha llevado mis raíces? Una invitación al mundo profinito"

Henrique Augusto Mendes da Silva e Souza (UAM)

29 March

- "Teoría de interconexión de Lagrange–Dirac: cómo construir modelos complejos a partir de subsistemas simples"

Álvaro Rodríguez Abella (ICMAT)
12 Abril

- "El teorema del encaje de Nash"

Javier Peñafiel Tomás (ICMAT)

26 abril

- "Análisis Armónico y la teoría de clasificación de las álgebras de operadores"

Eduardo Tablate Vila (ICMAT)

10 May

- "Cómo la geometría nos permite entender la dinámica: una introducción a los sistemas integrables"

Asier López (ICMAT)

24 May

- "Teoría de juegos aplicada a EDP"

Jorge Ruiz (UAM)

8 June

- "Entendiendo el teorema de geometrización de Thurston"

José S. Santiago (UJA)
27 September

- "Integrales de Fourier y el contraejemplo de Fefferman"

Fernando Ballesta (UCM)
11 October

- "Más allá de las funciones armónicas"

Pablo Hidalgo Palencia (ICMAT)
25 October

- "Constantes óptimas en algunas desigualdades del tipo Hardy"

Achraf Ben Said (UCM)

8 November

- "Compacidad: geometría y topología"

Miguel Martínez González (ICMAT)
22 November

- "Sobre el 'cómo' y el 'porqué' de buscar grupos residualmente finitos"

Ismael Morales (University of Oxford)
20 December

Schools

- QIT - Advanced School on Optimization Methods in Quantum Information

27 February - 3 March

Image: ICMAT

- QIT - Advanced School on Operator algebras, quantum information and quantum many body systems

27-31 March

- Escuela JAE de Matemáticas

26 June - 7 July

Image: Íñigo de Amescua/ICMAT

- XV International ICMAT Summer School on Geometry, Dynamics and Field theory

10-11 July

- Summer School: Non-linear elliptic and parabolic PDEs

17-19 July

Courses

- Reading group in Causal Inference and Machine Learning

Every Friday

- Introduction to Machine Learning

20 January - 28 April

- Bayesian Data Science

21 April - 30 June

- ICMAT-IMAG Doc-Course in Functional Analysis

12-30 June

Image: ICMAT

Seminars

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

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

Image: Íñigo de Amescua/ICMAT

10. THESES

12 researchers completed their PhD theses at ICMAT in 2023.

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

- Weak Hopf algebras, matrix product operators and the classification of quantum phases of matter, Alberto Ruiz de Alarcón Torregrosa

Advisors: David Pérez (ICMAT-UCM) and András Molnár (University of Vienna)
Date: 19 January 2023

- Invariant subspaces for classes of operators: finite rank perturbations of normal operators and positive operators, Francisco Javier González Doña

Advisor: Eva Gallardo (ICMAT-UCM)
Date: 20 January 2023

Francisco Javier González Doña during his defense

- On the propagation of the local Rayleigh condition for the hydrostatic Euler equations Víctor Cañulef Aguilar

Advisor: Diego Córdoba Gazolaz (ICMAT-CSIC)
Date: 27 April 2023

- Global aspects of bracket-generating distributions, Francisco Javier Martínez Aguinaga

Advisors: Francisco Presas (ICMAT-CSIC) and Álvaro del Pino (Universidad de Utrecht)
Date: 28 April 2023

- Supersymmetric Vertex Algebras and Killing Spinors, Andoni De Arriba De La Hera

Advisors: Luis Álvarez Cónsul (ICMAT-CSIC) and Mario García Fernández (ICMAT-CSIC)
Date: 5 May 2023

- Finite dimensional Approximations of Operators related to Groups and their Applications, Jan Paul Boschheidgen

Advisor: Andrei Jaikin
Date: 23 June 2023

- Free boundary and turbulence for incompressible viscous fluids, Elena Salguero Quirós

Advisor: Francisco Gancedo García (Universidad de Sevilla)
Date: 29 June 2023

Elena Salguero and her advisor, Francisco Gancedo

- Noncommutative Analysis Techniques in the Geometry of Lp Spaces and Calderón-Zygmund Theory, Antonio Ismael Cano Mármol

Advisors: Jose Manuel Conde Alonso (ICMAT-UAM) an Javier Parcet (ICMAT-CSIC)
Date: 30 June 2023

- Non-existence, strong ill-posedness and loss of regularity for active scalar equations, Luis Martínez Zoroa

Advisor: Diego Córdoba Gazolaz (ICMAT-CSIC)
Date: 5 July 2023

- Fixed points in Higgs bundle moduli spaces and the Prym-Narasimhan-Ramanan construction, Guillermo Barajas Ayuso

Advisor: Oscar García-Prada (ICMAT-CSIC)
Date: 14 July 2023

- Path Planning on Riemannian Manifolds with Applications to Quadrotors Load Transportation, Jacob Goodman

Advisors: Leonardo Colombo (CAR-CSIC) and Manuel de León (ICMAT-CSIC)
Date: 22 September 2023

Jacob Goodman (centre) and his PhD advisors: Leonardo Colombo (left) and Manuel de León

- Fibrados de Higgs multiplicativos, monopolos e involuciones, Guillermo Gallego Sánchez

Advisors: Enrique Arrondo (UCM) and Oscar García-Prada (ICMAT-CSIC)
Date: 25 October 2023

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.

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 2023 the group of David Ríos launched the following transfer projects:

- Reading Group in Causal Inference and Machine Learning. ICMAT, Madrid. 20 January-31 March 2023.
- Course: Bayesian Data Science. ICMAT, Madrid. April-June 2023.
- 7th Games and Decisions in Risk and Reliability. Real Academia de las Ciencias. (Madrid). 24-26 May 2023.
- 13th Bayesian Inference for Stochastic Processes. Real Academia de las Ciencias. (Madrid). 22-24 May 2023.
- Workshop: The many challenges of Artificial Intelligence. La Cristalera. 13-15 November 2023.

In addition, David Ríos has received the BBVA Foundation 2023 Award from the Society for Statistics and Operations Research for 'Best methodological contribution in the field of operations research'.

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).

12. MATHEMATICAL CULTURE

Over 2023, ICMAT continued working to increase the mathematical culture in society through its Culture Mathematical Unit (UCMAT).

COMMUNICATION AND OUTREACH

'Café y Teoremas', El País

'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. 28 articles appeared in 2023.

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 2023, 11 press releases were prepared and issued, covering a wide variety of topics: from reports on new scientific results to information about events, the award of grants and prizes, etc. All these press releases are available on the ICMAT website.

News

ICMAT regularly publishes news on its website about the scientific and outreach activity conducted at the centre. In 2022, 50 news items were published.

ICMAT Newsletter

ICMAT publishes a monthly 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. This newsletter is sent to all institute staff and subscribers.

Social networks

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

- Facebook: 31 707 followers
- Twitter: 30 665 followers
- Instagram: 1342 followers
- YouTube: 3870 subscribers; 290 434 views
- Linkedin: 922 followers

An average of three different contents are usually posted every day, dealing with current mathematical issues about both ICMAT occasionally and in general. 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 2023, the following talks were organised:

"Clima, caos y covid"

Speaker: Chris Budd

Date: 24 April 2023

Chris Budd during his talk. Image: Residencia de Estudiantes

"Matemáticas y magia: Remezclados"

Speakers: Nelo Maestre and Carlos Vinuesa

Date: 15 November 2023

Carlos Vinuesa (left) and Nelo Maestre in Matemáticas y magia: Remezclados. Image: ICMAT

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 2023, the European Researchers' Night was celebrated on 29 September. ICMAT participated in this festival organized by the CSIC centres at Campus de Cantoblanco. This edition took place in Hospital 12 de Octubre, in Madrid, entitled "Todo ciencia. La Noche del CSIC en el 12"

Concretely, ICMAT organised the workshop "Las matemáticas frente a las epidemias", given by Pablo Hidalgo, predoctoral researcher at ICMAT and Universidad Complutense de Madrid.

Pablo Hidalgo in the European Researchers Night workshop. Image: ICMAT

Also, the Red de Igualdad Intercentros CSIC+UAM, to which ICMAT belongs, organised the activity 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. In 2023, the competition took place on 27-29 October 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 7 and 15 November 2023, the Institute organised two activities:

- **Mathematical scavenger hunt,** 7 November. Activity organised together with the QED Association of the Universidad Autónoma de Madrid (UAM). Secondary school students were the participants in this activity.

One of the activities of the mathematical scavenger. Image: ICMAT

Matemáticas en la Residencia: "Matemáticas y magia: Remezclados", 15 November.

Equality 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. More information in page 40 of this annual report.

- **She Does Maths**

'She Does Maths' is a permanent section of ICMAT Newsletter in which a portrait of a woman 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 web 'Mujeres con Ciencia'.

More information in page 40 of this annual report.

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. 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.

Furthermore, ICMAT produced an institutional video introducing the Institute, which was produced by the company Scienseed, at the end of 2023.

Frame of the institutional video

GRAPHIC COMMUNICATION

From ICMAT Mathematical Culture Unit, posters are produced to announce the scientific 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.

In 2023, ICMAT updated its institutional image, which involved a redesign of all graphic content and institutional materials (posters, images for social media, brochure, typography, annual report...). For this, the Institute enlisted the work of a professional designer, Tábata Pardo.

13. EQUALITY ACTIONS

During approximately the first half of the year 2023, the Equality Committee of ICMAT was composed of 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). Starting from the second half of the year 2023, the equality committee includes Ana Bravo (ICMAT-UAM), Jose M. Conde (UAM-ICMAT), Edmundo J. Huertas (UAH), Marta Macho-Stadler (Universidad del País Vasco), David Martín de Diego (ICMAT-CSIC), Yamilet Quintana (UC3M-ICMAT), and Nuria Torrado (ICMAT-UAM, chairperson).

The Equality Committee organized or collaborated with the following activities in 2023:

STEMatEsElla

The STEMatesElla programme is operated by the Spanish Association of Executives and Counselors (EJE&CON) and the Royal Spanish Mathematical Society (RSME), in collaboration with ICMAT and the Basque Center for Applied Mathematics (BCAM). The IV Edition of the STEMatesElla mentoring program. The bulk of the program took place during the first half of 2023, and the closing ceremony was held at ICMAT in July 2023. At this ceremony, in addition to the speeches by Cristina Sancho (president of EJE&CON) and Eva Gallardo (president of the RSME), Javier Pérez de Vargas (Director of the Royal Academy of Engineering of Spain), Pilar Vélez (Director Professor of Applied Mathematics and University Defender at the University of Nebrija), Elena Carta (Deputy Vice President of the Higher Centre for Scientific Research, CSIC), Beatriz Arias (Director of the Nokia Business and Digital Operations Centre of Excellence), and Nuria Alonso Martínez-Losa (Director of Dissemination and Institutional Cooperation of the RACE Foundation) also participated.

On November 6, 2023, the V edition of the STEMatesElla program was launched. The program will last for 6 months, during which participants will have the opportunity to connect with experienced mentors and establish valuable relationships in the STEM world. The program began on January 29, 2024, and will conclude on July 4, 2024.

'She Does Maths' section

'She Does Maths' is a permanent section of ICMAT Newsletter in which a portrait of a woman 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 web 'Mujeres con Ciencia'.

In 2023, Marie-Claude Arnaud (Université Paris Cité and Institut de Mathématiques de Jussieu-Parisd Rive Gauche) and Yuliya Zelenyuk (University of The Witwatersrand, Johannesburg, South Africa) were the protagonists of this section.

Commemoration of 11 February - International Day of Women and Girls in Science

On February 10, 2023, in celebration of the International Day of Women and Girls in Science (11F), Eva Elduque, a researcher at ICMAT and an assistant professor at the Autonomous University of Madrid, conducted a workshop aimed at students from 9th grade onwards. She presented the mathematical theory of knots as part of the activity titled "When Can a Knot Be Untied?".

Image: ICMAT

Additionally, Pablo Hidalgo, a predoctoral researcher at the ICMAT, gave a talk where he explored the life and mathematical work of Maryna Viazovska (Ukraine, 1984),

who in 2022 became the second woman in history to receive the Fields Medal, the highest recognition in the field of mathematics.

Image: ICMAT

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

Additionally, the Equality Committee also participates in the Women for Africa programme. Thanks to this project, ICMAT invites women from African countries who are selected to spend six months at the centre collaborating with ICMAT researchers in their respective fields of research.

In the 9th edition of the Science by Women programme launched in September 2023, Zamurat Adegboye was selected and will collaborate with the ICMAT group led by David Martín de Diego. Zamurat Adegboye's main areas of research are Numerical Analysis, Harmonic Analysis, Partial Differential Equations, and Computational Mathematics.

Besides, the researcher Yuliya Zelenyuk (School of Mathematics, University of the Witwatersrand, Johannesburg, South Africa), participant in the 8th edition of Science by Women, completed her stay at ICMAT in the last semester of 2023.

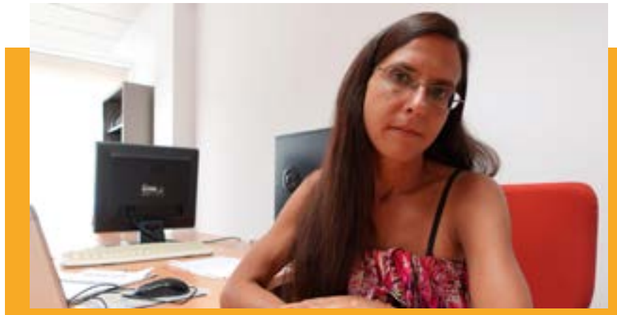


Image: ICMAT

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:

- 11 February 2023. Colloquium: "Carolyn Bertozzi: cuando la química hace click", by Fernando Herranz (Instituto de Química Médica-CSIC).
- 8 March 2023. ICMAT distributed to its members purple masks and badges for the 8M together with the UAM.
- 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.

ICMAT

INSTITUTO DE CIENCIAS MATEMÁTICAS

www.icmat.es

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AGENCIA ESTATAL DE INVESTIGACIÓN

CSIC Consejo Superior de Investigaciones Científicas

UAM Universidad Autónoma de Madrid

Universidad Complutense Madrid

uc3m Universidad Carlos III de Madrid

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