



© CRM 2024 Text and graphics: CRM Coordination: Pau Varela Design and graphics: Pau Varela Cover and Sections photographs © CRM Contributors: Pau Varela & Mariona Fucho

## DIRECTOR'S FOREWORD

he following report offers a comprehensive overview of the CRM's activities during 2023. This year has been characterized by significant growth and accomplishments for our institution, and this document serves as a chance to reflect on our journey so far while we prepare to tackle the challenges that lie ahead.

Our research output has been remarkable, with numerous publications providing valuable insights to the mathematical community and several new projects either starting or continuing their development. The dedication and expertise of our researchers have been crucial in advancing CRM's mission and maintaining its role as an international leader in mathematical research.

A cornerstone of our progress has been the Maria de Maeztu strategic plan. This year, we proudly welcomed seven new PhD students and twelve postdoctoral researchers, ensuring the continued growth and vitality of our research community. Additionally, six new senior researchers have joined the CRM as affiliated researchers, bringing diverse expertise that significantly enhances our collaborative efforts and strengthens our research capabilities.

This influx of new talent has consolidated and integrated our research groups which, as shown in this report, comprise researchers from the Universitat Autònoma de Barcelona, the Universitat de Barcelona, and the Universitat Politècnica de Catalunya, alongside CRM's own research staff. This spirit of unifying efforts across different institutions has enabled us to establish new relationships with other research entities, such as the Institut de Ciències del Mar (ICM).

One of our notable achievements this year was the successful renewal of the HR Excellence in Research (HRS4R) award. This underscores our ongoing commitment to creating an optimal working environment and maintaining high standards in our practices to attract and cultivate international talent in mathematics research. CRM's commitment to responsible research practices was further solidified by signing the COARA Agreement. This agreement aligns us with international standards and emphasizes our dedication to ethical research and open science.

In 2023, we reinforced the role of transferring knowledge from our research to bridge academic and real-world applications. Collaborating with various institutions and industries, we developed customized, mathematically-based research solutions addressing different challenges, from data compression to virus simulation. Additionally, we expanded the Knowledge Transfer Unit (KTU) team, enhancing its capacity to support innovative interdisciplinary research and applications, thereby increasing the social impact of CRM's work.

We have continued to host and organise international conferences and scientific activities that have allowed mathematicians from all over the world to come to the CRM. The centre's colloquium, in particular, adopted a new format this year, fostering more interaction and collaboration. This change has created a more dynamic and engaging intellectual environment, benefiting all participants and establishing a forum for the mathematics community in Barcelona to meet and exchange ideas.

We also initiated an exciting collaboration between marine research and mathematics, highlighted by a meeting organized with the Institut de Ciències del Mar (ICM). By integrating mathematical tools with other disciplines, we aim to tackle complex challenges and foster new spaces for collaboration among researchers with diverse backgrounds and expertise.

I extend my heartfelt gratitude to the entire CRM community. Thank you to everyone who organizes activities, supports our research efforts, and contributes to communication and dissemination. A special thanks to our support staff, whose patience and dedication facilitate our activities and promote our mission.

We've accomplished so much, yet there's still plenty more to achieve.

#### LLUÍS ALSEDÀ I SOLER CRM DIRECTOR



## INTRODUCTION

he Centre de Recerca Matemàtica was established in 1984 by Professor Manuel Castellet as a centre of the l'Institut d'Estudis Catalans (IEC, the Catalan Academy), in the premises of the Universitat Autònoma de Barcelona (UAB). It is the oldest mathematics research institute in Spain. Presently, the CRM is a consortium between the Generalitat de Catalunya (the Catalan Government), represented by its Minister of Enterprise and Knowledge, the IEC and the UAB. The CRM belongs to the CERCA Agency of Research Centres sponsored by the Catalan Government, and is a member of ERCOM (European Research Centres in Mathematics), a committee of the European Mathematical Society, together with other European centres of a similar nature. The CRM is currently the managing institution of the Barcelona Graduate School of Mathematics (BGSMath).

Since 2009, the CRM's budget has been part of the public budget of the Catalan Government. Core funding is provided by the Catalan government through yearly contracts. Other funding is obtained through competitive calls of the European Union, the Spanish Ministries or the Generalitat. The CRM was awarded in the year 2000 with the Narcis de Monturiol Plate Award to Scientific and Technological Merit. In 2016 the CRM received the María de Maeztu Unit of Excellence award from the Spanish Research Agency (AEI), a prestigious accolade that recognizes research institutions with highly competitive strategic programs operating at the frontiers of knowledge. In 2020 the CRM received the award for the second time. Since 2015, the CRM has held the HR Excellence in Research Award, granted by the European Commission to give public recognition to research institutions that have made progress in aligning their human resource policies with the principles set out in the "Charter & Code".

One of the core roles of the CRM is the organisation of international research programmes on selected topics in the field of mathematics, mathematical sciences and all its applications. The CRM hosts every year a number of leading researchers from all around the world to interact with local researchers over extended periods. The CRM, as a member of the CERCA network of research centres in Catalunya, is strongly committed to fostering and enhancing research throughout the country. Each research program held at the CRM spawns new collaborations among researchers from different backgrounds and levels of expertise during the lectures, seminars and informal interaction, which the CRM building has been designed specifically to encourage.

#### CRM's Mission Statement

The remit of the Centre de Recerca Matemàtica is to be a resource of excellence in mathematical research and training at international level. Its specific aims are:

1.- High-quality research of international standing in mathematics, including a special emphasis on real-world applications carried out in a collaborative or interdisciplinary context.

2.- Knowledge transfer based on validated mathematical research, with special emphasis on concrete implementations of justified models that address emergent problems with societal impact.

3.- Advanced training in the field of mathematics, through collaboration and synergies with other research institutions.

4.- Dissemination of the advances in mathematics within both the wider academic community and society in general.

## CRM IN NUMBERS

## **VISITING RESEARCHERS**



CRM ANNUAL REPORT 2023

CRM ANNUAL REPORT 2023

European 28.1%

Rest of the World 18.8%



# PhD THESIS DEFENDED

European 40.8%



**CRM CONSORTIUM** 



#### PARTNER INSTITUTIONS

UAB Universitat Autònoma de Barcelona



(bcam)



Sys biology

#### **AWARDS**



CRM ANNUAL REPORT 2023







UNIVERSITAT POLITÈCNICA DE CATALUNYA Departament de Matemàtiques







#### **SPONSORSHIP**



#### SIMONS FOUNDATION

CRM ANNUAL REPORT 2023

# **ORGANIZATIONAL CHART**

The structure to turn the aforementioned objectives into a reality can be seen in the organizational chart. A special mention to the Board of Trust-ees, from which some representatives conform the Governing Board, the highest level of decision of the CRM. It is conformed by Institut d'Estudis Catalans (IEC), CERCA centers, Universitat Autònoma de Barcelona (UAB) and Generalitat de Catalunya. As CRM closes the year 2021, negoti-ations are being carried out to include Universitat de Barcelona (UB) and Universitat Politècnica de Catalunya (UPC) to the Board of Trustees.



2010

j



#### **GOVERNING BOARD**

The Governing Board, the highest level of decision and management of the CRM, is responsible for overseeing the centre's activity. It's also responsible of electing a Director to serve for a period of four years.

#### The board consists of:

The president, who is the **Minister of Research and Universities** of the Generalitat de Catalunya, or its delegate.

The vice president, who is the **president of the Institut d'Estudis Catalans**, or its delegate.

Three representatives from the Generalitat of de Catalunya.

Two representatives from the Institut d'Estudis Catalans.

One representative from the Universitat Autònoma de Barcelona.



The current Director of the CRM is professor Lluís Alsedà, who was reelected unanimously for the period from 2020 to 2024 in the meeting of the Governing Board on July 2020.

Professor Manuel Castellet, who was the director of the CRM since its creation in 1984 until 2007, is the CRM Honorary Director.

#### SCIENTIFIC ADVISORY BOARD

Scientific Advisory Board is the organ responsible of defining the strategic direction of the centre and in advising on and shaping its scientific programme. It consists of prestigious personalities within the scientific scope of the Centre, appointed by the Governing Board, after proposal by the Director.



Professor Nicolas Brunel, from the Duke University Professor Helen Byrne, from the Oxford University Professor Albert Cohen, from the Université Pierre et Marie Curie Professor Kathryn Hess, from the École Polytechnique Fédérale de Lausanne Professor Ari Laptev from the Imperial College London Professor Gábor Lugosi, from the Universitat Pompeu Fabra Professor Robert MacKay, from the University of Warwick (Chairman) Professor Alessandra Micheletti, from the Università degli Studi di Milano Professor Carmen Miguel from the Universitat de Barcelona Professor Peregrina Quintela, from the Universidad de Santiago de Compostela Professor Mikhail Sodin, from the Tel Aviv University Professor Katrin Wendland from the Freiburg University

#### DIRECTORATE ADVISORY BOARD

The Directorate Advisory Board is composed of representatives from the CRM and the three universities with researchers affiliated at the CRM. The Board provides strategic guidance to the CRM Director on the different areas of action of the institution, including the Maria de Maezrtu project, the Internship programme, scientific activities and the BGSMath training unit.

The DAB is currently formed by:

Dr. Tomás Alarcón CRM, Deputy Director

Professor **Carmen Cascante** BGSMath Training Unit Director

Professor **Marcel Guardia** Maria de Maeztu Scientific Director

Professor Albert Ruiz Internship Program Responsible

Professor **Tere Martínez-Seara** Faculty Board Representative

Professor **Joaquim Ortega-Cerdà** Activities Director



## MARIA DE MAEZTU UNIT OF EXCELLENCE

The CRM was awarded by The State Research Agency (AEI) as a María de Maeztu Excellence Unit in the 2020 call. It was the second time that the CRM has hold the distinction. In 2022 the first batch of PhD candidates and postdoctoral researchers hired within the MdM project joined the institution.

The Centres and Units of Excellence 'Severo Ochoa' and Maria de Maeztu' programme aim to recognise public research organizations, in any scientific area, that stand out due to the relevance and impact of the results obtained during the previous reference period at an international level. Consequently, the CRM is part of the SOMMa Alliance, to internationally promote, strengthen and maximise the value of the ground-breaking research produced by the Spanish 'Severo Ochoa' Centres and 'María de Maeztu' Units of Excellence and the scientific, and the social and economic impact it generates.

The Award provides two million euros for the proposed strategic research plan, aimed at consolidating CRM scientific capacities and boosting its talent attraction capacity for the duration of the project. It is obtained following a rigorous evaluation process performed by an international committee comprised of world-class scientists, in accordance with the most demanding standards.

The MdM programme is driven by the changes experienced by the CRM in recent years, aimed at tackling challenges presented by society and the need of blending pure and applied techniques to advance at the Frontiers of science. With the affiliations of more than sixty mathematicians from three renowned universities in Barcelona, the CRM has dramatically improved the quality and scope of the research carried out at the center, serving as a mathematical hub.

The scientific goals of the MdM structure are fundamental open problems which will be explored by the CRM research groups in the period 2021-2024. They are topics at the frontier of the current knowledge, which will rely on the training and recruitment actions to be achieved. The scientific direction of the project is led by its Scientific Director, Marcel Guardia. Each area has several coordinators combining the different teams at CRM together with recently affiliated researchers. The best research is done across different fields, leaving the comfort zone and thinking outside the box. This research can only be done through crossfertilization.

The CRM does and will continue fostering such approach in the period 2021-2024.





## COARA



## COARA'S COMMITMENT

Expanding on earlier initiatives like the San Francisco Declaration on Research Assessment (DORA) and the Leiden Manifesto, the Coalition for Advancing Research Assessment (CoARA) broadens its scope beyond a simple declaration of intent. It actively encourages organizations to commit to reforming their research assessment methods from 2022 to 2027. The Centre de Recerca Matemàtica (CRM) has joined CoARA, which unites diverse research institutions and their associations to reimagine the research evaluation landscape.

Traditional metrics like journal impact factors and citation counts have long been criticized for inadequately capturing research quality. The CoARA agreement, structured around ten core commitments, emphasizes recognizing a wide array of research practices and professional paths. It advocates for qualitative benchmarks to reduce the reliance on journal-based metrics, urging the use of qualitative peer reviews complemented by responsible quantitative indicators.

The agreement also calls for significant resource allocation for research assessment reform and the continuous review and improvement of evaluation criteria and processes. It promotes transparency, communication, and training to raise awareness and support the implementation of these reforms. CoARA members are committed to sharing best practices, facilitating mutual learning, and evaluating their assessment practices based on robust evidence.

## NETWORKS & INSTITUTIONAL COLLABORATIONS

#### European Mathematical Society

The European Mathematical Society (EMS) promotes the development of all aspects of mathematics in Europe, in particular mathematical research, the links between mathematics and society, the relations among European institutions, and mathematical education.

### EUROPEAN MATHEMATICAL SOCIETY

#### **ICREA**

The Catalan Institution for Research and Advanced Studies (ICREA) is a foundation supported by the Catalan Government whose aim is to recruit top scientists for the Catalan R & D system. The CRM participates actively in all the ICREA calls by presenting renowned mathematical researchers as candidates for ICREA positions.

In 2022, the CRM has counted with six ICREA Research Professors.



#### ERCOM

ERCOM is the acronym of the European Research Centers on Mathematics committee of the European Mathematical Society (EMS), composed by the scientific directors of European research centers in mathematics. The CRM has been a member of ERCOM since its foundation in 1997.



#### SCM

The Catalan Mathematics Society (SCM) is a branch of the Institut d'Estudis Catalans (IEC). The main objective of the SCM is to cultivate mathematical science in a broad sense. That means and spreading the knowledge to Catalan society, promote its teaching and both theoretical and applied research. It is done by publishing all kinds of work that are oriented toward these goals.



#### REM

The Red Estratégica en Matemáticas (REM) was The Spanish Mathematics-Industry Network established in 2017 as a network made up of all the relevant nodes of research and mathematical transfer in Spain, effectively integrating the entire research community in this field, and taking advantage of its structure. The following challenges are proposed for Spanish mathematics in the next two years (2020-2021).



#### MATH-IN

(math-in) was born, as a private non-profit association, on September 30, 2011 with the signing of its Constitution Act in Santiago de Compostela. The network is currently made up of around forty research groups belonging to twenty Spanish universities and research centres. math-in focuses its activity on promoting and carrying out mathematical technology transfer to companies, organisations and institutions, thus fostering an increase in the competitiveness of both the research groups involved and the industry itself.



#### SOMMa

SOMMa's mission is to internationally promote, strengthen and maximise the value of the groundbreaking research produced by the Spanish 'Severo Ochoa' Centres and 'María de Maeztu' Units of Excellence and the scientific, social and economic impact it generates.





COMPUTATIONAL AND MATHEMATICAL BIOLOGY PHYLOGENETICS NEUROSCIENCE ANALYSIS AND PDE's COMBINATORICS, LOGIC AND ALGORITHMICS ALGEBRA, GEOMETRY AND NUMBER THEORY DYNAMICAL SYSTEMS CLIMATE CHANGE AND NATURAL HAZARDS

# MATHEMATICAL AND COMPUTATIONAL BIOLOGY

#### DESCRIPTION

The dynamics of biological systems is driven by interactions between many elements at a given level of biological organisation (e.g. molecular, cellular, organismc), but also by the couplings that exist between said levels (e.g. from molecules to cells to populations). Such couplings are highly non-linear and make the analysis of complex biological systems extremely challenging. The remit of the Mathematical and Computational Biology is the development of new theory, models, techniques, and tools that are relevant to biologists and clinicians. For this purpose we use a plethora of mathematical techniques including stochastic multiscale models, dynamical systems theory, singular perturbation analysis, bifurcation analysis, morphometrics, dimensional reduction tools and efficient simulation methods, as well as statistics, machine learning or optimization. We tackle issues such as understanding how genetic variation leads to variation in the characteristics of organisms, the so-called genotype-phenotype map, the arising of such map in embryonic development, its influence in the direction of phenotypic evolution. We also formulate new models of virus evolution and therapies that account for intrinsic heterogeneity and noise, we study the design of new strategies to avoid drug resistance induced by cancer-cell heterogeneity and analyze the mechanisms of ageing. Our research is collaborative in nature and we make an effort to keep close collaborations with both biologists and medical practitioners.

#### **RESEARCH LINES**

#### Cancer Modeling | Tomás Alarcón

This research line aims at investigating the mechanisms of cancer and ageing, with an emphasis on their therapeutic aspects. Specifically, we focus on the effects of heterogeneity and noise in the emergence of drug resistance. We have investigated the application of stochastic/multiscale modelling to tumour growth and angiogenesis to analyse these issues in relation to resistance to therapies such as immuno-therapy, oncolytic viruses, and anti-angiogenic therapy. We have also applied our expertise in stochastic modelling to study cell reprogramming, virus dynamics, and ageing.

#### Mathematics of Development and Evolution | Isaac Salazar

The main question we want to address is: how did complex organisms arise in evolution? Or more in general, how can complexity evolve also in other systems like culture, society and molecular pre-biotic systems? This process cannot be understood by looking at single genes. Embryonic development involves the interaction between huge numbers of genes and cells. Therefore, we build multi-scale models of embryonic development. Each such model includes a set of differential equations describing how genes regulate each other's expression and a set of differential equations describing how cells move, change shape and activate cell behaviours. Each cell contains the same set of genes and equations, but, as a result of model dynamics, different cells end up expressing genes at different intensities.

#### Nonlinear Dynamics and Evolution (NoDE) | Josep Sardanyés

Our laboratory is interested in understanding biological nonlinear phenomena. Our research is focused on Biomedicine (including cancer and viruses), in systems and synthetic Biology as well as in theoretical ecology. To do so we use the qualitative theory of dynamical systems and computer simulations (stochastic dynamics and spatially-extended systems). We are especially interested in characterizing both asymptotic and transient dynamics of these systems and their sensitivity to parameter changes. That is, understand which bifurcations govern transitions in biological systems.

#### MEMBERS

Senior Researchers: Tomás Alarcon | Isaac Salazar | Josep Sardanyés Postdoctoral Researchers: Ielyaas Cloete | Giovanni Dalmasso | Filip Ivančić | Daria Stepanova PhD Students: Juan Arellano | Oriol Llopis | Kevin Martínez | Stefano Pedarra | Amaia Vielba Research Technicians: Laura Orrit | Pau Reig

#### PROJECTS

#### PDC2022-133020-100

Sistemas dinámicos y matemática computacional para la optimización de partículas interferentes terapéuticas como terapia antiviral Pls: Josep Sardanyés / Tomás Alarcón Funded by MICINN

#### PDC2022-133020-100

Sistemas dinámicos y matemática computacional para la optimización de partículas interferentes terapéuticas como terapia antiviral PIs: Josep Sardanyés / Tomás Alarcón Funded by MICINN

#### PID2021-1278960B-100

HENOCANDYN: Heterogeneity and noise as engines of cancer evolution: A multiscale dynamical systems approach PIs: Tomás Alarcón / Josep Sardanyés Funded by MICINN

#### PCI2022-132926

MPA4SUSTAINABILITY: Enhancing Marine Protected Areas' role in restoring biodiversity while maintaining access to ecosystem services PI: Josep Sardanyés Funded by IFD, ANR, FCT, AEI, SEPA

2021-SGR-00874 Los puntales matemáticos de la biología integrativa de sistemas Pls: Tomás Alarcón Funded by MINECO

PID2021-122930NB-I00 Predicting the evolution of complex phenotypes by contrasting and combining quantitative genetics and mathematical models of development PI: Isaac Salazar Funded by Ministerio de Ciencia, Innovación y Universidades

CNS2022-135397 Testeando la predicibilidad de la evolución y del mapa genotipofenotipo PI: Isaac Salazar Funded by Ministerio de Ciencia, Innovación y Universidades

#### **ASSOCIATED RESEARCH UNITS**

Dynamical Systems and Computational Virology, DysCoVir https://sites.google.com/view/i2sysbio-crm-au/home

i2SysBio - CRM CSIC Associated Unit

#### **PUBLICATIONS**

Calsina, À & Cuadrado, S. & Vidiella, B. & Sardanyés. J. (2023). About ghost transients in spatial continuous media. Chaos, Solitons & Fractals, 166, 112915. doi: http://dx.doi.org/10.1016/j.chaos.2022.112915

Carrasco-Mantis, A. & Alarcón, T. & Sanz-Herrera, J.A. (2023). An in silico study on the influence of extracellular matrix mechanics on vasculogenesis. Computer Methods and Programs in Biomedicine. 231, 107369. doi: https://doi.org/10.1016/j.cmpb.2023.107369

Lázaro, T. J. & Alarcón, T. & Garay, C.P. & Sardanyés, J. (2023). Semiclassical theory predicts stochastc ghosts scaling. Proceedings of the Royal Society A. 479: 20220621. doi: http://doi.org/10.1098/rspa.2022.0621

Chakraborty, S. & Ivančić F. & You, Y-J. (2023). Role of surface tension effect at the deformed free surface of chemotaxis coupling flow system: weakly nonlinear study. Physics of Fluids 35, 091908. doi: https:// doi.org/10.1063/5.0166650.

Cano-Fernández, H. & Tissot, T. & Brun-Usan, M. & Salazar-Ciudad, I. (2023). On the origins of developmental robustness: modeling buffering mechanisms against cell-level noise. Development 15 December 2023; 150 (24): dev201911. doi: https://doi.org/10.1242/dev.201911

Stepanova, D. & Byrne, H. M. & Maini, P. K. & Alarcón, T. (2023). Computational modeling of angiogenesis: The importance of cell rearrangements during vascular growth. WIREs Mechanisms of Disease, 16(2), e1634. doi: https://doi.org/10.1002/wsbm.1634

#### SCIENTIFIC ACTIVITIES

BioMat 2023: MULTISCALE METHODS AT THE FRONTIER BETWEEN DATA AND MATHEMATICAL MODELS June 12-16, 2023

Centre de Recerca Matemàtica | Barcelona Co-organizer: Tomás Alarcón (ICREA-CRM)

#### 13TH INTERNATIONAL CONFERENCE ON NONLINEAR MATHEMATICS AND PHYSICS | NOLINEAL 2023

26-28 June 2023 Centre de Recerca Matemàtica | Barcelona Josep J. Masdemont (UPC-CRM), Angel Jorba (UB-CRM) as part of the Scientific Committee Inma Baldomà (UPC-CRM), Jezabel Curbelo (UPC-CRM), Pau Martín (UPC-CRM), Mercè Ollé (UPC-CRM) as part of the Organizing Committee Speakers: Tomás Alarcón (ICREA\_CRM) | Amadeu Delshams (UPC-CRM) | Marc Jorba-Cuscó (CRM)| Gemma Huguet (UPC-CRM)

#### FITTING DATA WITH DYNAMICAL MODELS: TEN LESSONS ON MATHEMATICAL FIELD WORK

October 24 - December 05, 2023 Centre de Recerca Matemàtica | Onlien Speakers: Lluís Alsedà (UAB-CRM) | Marc Jorba-Cuscó (UPC-CRM) | Josep Sardanyés (CRM)

#### ICM-CRM MEETING: New bridges between Marine Sciences and Mathematics 02-10 November, 2023

Institut de Ciències del Mar (CRM) | Centre de Recerca Matemàtica (CRM) Speakers: Lluís Alsedà (UAB-CRM) | Álvaro Corral (UAB) | Jezabel Curbelo (UPC-CRM) | Filip Ivancic (CRM) | Àngel Jorba (UB-CRM) | Marc Jorba-Cuscó (UPC-CRM) | Pere Puig (UAB-CRM) | Josep Sardanvés (CRM)

Organizer: David Romero (CRM) | Josep Sardanyés (CRM)

#### X Complexitat Day

21 June, 2023 La Lleialtat Sansenca Barcelona. Scientific Committee: Álvaro Corral Speakers: Josep Sardanyés (CRM-UAB) | Giovanni Dalmasso (CRM-UAB)

#### SIJIMAT Seminar

Organizers: Lucía Arancibia, Juan Arellano, Giovanni Dalmasso, Gerard Farré, Alfonso Garmendia, Dídac Gil. Roser Homs

#### **OUTREACH ACTIVITIES**

SIJIMAT: Portes Obertes al CRM 16. November, 2023 Centre de Recerca Matemàtica | Barcelona Speakers: Lucía Arancibia (CRM) | Giovanni Dalmaso (CRM) | Dídac Gil (CRM) | Roser Homs (CRM)

#### Giovanni Dalmasso

Interview on podcast "Just Sciencing" by Sherezade MR. March 8, 2023. Youtube. Talk on Nit de la Recerca Europea. Museu de la Ciència CosmoCaixa. September, 29, 2023.

#### Josep Sardanyés

Talk and workshop at ESCOLAB program: 21 November, 2023. Centre de Recerca Matemàtica.



#### DESCRIPTION

Our research group develops and improves methods of phylogenetic reconstruction based on mathematical tools, especially algebraic, semi-algebraic and geometrical tools. This involves studying molecular substitution models from a mathematical point of view to guarantee parameter identifiability and to provide model selection tools (including both the evolutionary model and the tree or network selection). Our research lies at the borders of phylogenetic reconstruction, algebraic statistics, algebraic geometry and computational algebra.

#### **MEMBERS**

Senior Researchers: Marta Casanellas | Jesús Fernández Postdoctoral Researchers: Roser Homs | Angélica Torres

#### PROJECTS

PID2019-103849GB-100 *Geometría, Álgebra, Topología y Aplicaciones Multidisciplinares (GATA-TECH)* Agencia Estatal de Investigacion

#### PUBLICATIONS

Casanellas, Marta & Fernández-Sánchez, Jesús & Garrote-López, Marina & Sabaté-Vidales, Marc. (2023). *Designing weights for quartet-based methods when data is heterogeneous across lineages.* Bull Math Biol 85, 68 (2023). doi: https://doi.org/10.1007/s11538-023-01167-y

Casanellas, M. & Fernández-Sánchez, J. & Roca-Lacostena, J. (2023). *The embedding problem for Markov matrices*. Publicacions Matemàtiques. Volume 67, Issue 1 (2023) pp. 411-445. doi: 10.5565/PUBLMAT6712308

#### SCIENTIFIC ACTIVITIES

#### SIJIMAT Seminar

Organizers: Lucía Arancibia, Juan Arellano, Giovanni Dalmasso, Gerard Farré, Alfonso Garmendia, Dídac Gil, <mark>Roser Homs</mark>

#### **OUTREACH ACTIVITIES**

#### Marta Casanellas

Conference "De Darwin a les matemàtiques de l'evolució" held at the Jornades Vicent Caselles, Gata de Gorgos, as part of the event "Les matemàtiques dels éssers vius 2023". Interview for Centre de Recerca Matemàtica on 11F.

#### SIJIMAT: Portes Obertes al CRM

16, November, 2023 Centre de Recerca Matemàtica | Barcelona Speakers: Lucía Arancibia (CRM) | Giovanni Dalmaso (CRM) | Dídac Gil (CRM) | <mark>Roser Homs</mark> (CRM)

# NEUROSCIENCE

#### DESCRIPTION

The greatest challenge in neuroscience is to understand how the collective activity of neurons gives rise to behavior. Experimentalists now record large-scale neuronal activity while animals make decisions or remember and manipulate information. This data allows us to develop models of the circuits underlying these cognitive processes. This collaboration between experiment and theory is a promising strategy for achieving a mechanistic understanding of brain function.

We address issues such as a theoretical framework to account for both memory formation and long time-scale behavior, to propose network models of perception and perceptual learning that can perform at human performance for naturalistic stimuli, developing mechanistic computational models of working memory and age-related working memory decline, synchronization among groups of oscillatory neurons, and parameter estimation and model discrimination.

#### **RESEARCH LINES**

#### **Computational Neuroscience**

Research in the computational neuroscience unit is largely focused on systems-level neuroscience. Broadly speaking, this involves investigating how large assemblies of interacting neurons give rise to animal and human behaviour. Our approach is generally to combine computational modelling with data analysis. One research focus is on dynamical and network mechanisms in systems neuroscience. Another research focus is on the neural network dynamics underlying perceptual decision making and working memory. Finally, we have an interest in understanding the core computations that underlie perception, decision-making and cognitive control in humans and mammals in general. The unit is an active member of a larger, Barcelona-wide Neuroscience community (www.barccsyn.org).

#### Mathematical Neuroscience

We study mathematical aspects of computational neuroscience using mainly tools from dynamical systems. Current projects involve the development and analysis of mathematical models to elucidate the role of oscillations in cognitive tasks and inverse problems such as the estimation of synaptic conductances. We also use machine learning tools in order to identify neuronal dynamics from data and to learn synchronization patterns. Our research also extends to theoretical biology.

#### MEMBERS

Senior Researchers: Antoni Guillamon | Gemma Huguet | Alexandre Hyafil | Alex Roxin | Klaus Wimmer
Postdoctoral Researchers: Gloria Cecchini | Maria de los Ángeles da Fonseca | Sara Ibañez | Aikaterini Kalou | Manuel Molano
PhD Students: Lucia de Arancibia | Alexandre Garcia-Duran | Nicolás Pollán | Citlalli Vivar | Pan Ye Research Technicians: Miguel Donderis | Neus Pou | Anna Wilson

#### **DEFENDED THESES**

*Prefrontal circuits underlying working memory encoding and maintenance* Nicolás Pollán Hauer Supervisor: Klaus Wimmer Defended at Universitat Autònoma de Barcelona

#### **PROJECTS**

PID-2021- 122954NB-100. IMNHEA. "Invariant Manifolds, Hamiltonian systems and dynamics in Neuroscience, Epidemiology and Atmosphere" Funded by MCIN/AEI/ 10.13039/501100011033 and by "ERDF A way of making Europe".

PID2019-111629GB-100. *Deciphering the brain mechanisms for perceptual inference through bistable perception.* PI: Alexandre Hyafil Funded by MICINN

*Modelos computacionales de fluctuaciones diarias de los estados psicológicos* PI: Alexandre Hyafil Funded by Fundación BBVA

#### PID2021-1247020B-100

*El orígen y el papel de la dinámica a largo plazo de la representación neuronal en circuitos corticales* PI: Alex Roxin Funded by MICINN

PCI2023-145967-2 *The role of muscarinic acetylcholine receptors on CA1 pyramidal neurons in shaping memory formation* and stability. PI: Alex Roxin Funded by AGE

PID2020-112838RB-100 Estrategias flexibles para la integración de la evidencia sensorial en la toma de decisiones perceptuales. PI: Klaus Wimmer Funded by MICINN

PCI2020-112035 *CRCNS project: Age-related changes in the underlying cortical dynamics of working memory,* PI: Klaus Wimmer Funded by MICINN

#### PUBLICATIONS

Fonseca, M. & Maffei, G. & Moreno-Bote, R. & Hyafil, A. (2023). Mood and implicit confidence independently fluctuate at different time scales. Cognitive, Affective, & Behavioral Neuroscience. 23. doi: 10.3758/ s13415-022-01038-4.

Scott, H. & Wimmer, K. & Pasternak, T. & Snyder, A. C. (2023). Altered task demands lead to a division of labour for sensory and cognitive processing in the middle temporal area. European Journal of Neuroscience, 57(9), 1561–1576. doi: https://doi.org/10.1111/ejn.15964

Moore, T.L. & Medalla, M. & Ibañez, S. & Wimmer, K. & Mojica, C.A. & Killiany, R.J. & Moss, M.B. & Luebke, J.I. & Rosene, D.L. (2023). Neuronal properties of pyramidal cells in lateral prefrontal cortex of the aging rhesus monkey brain are associated with performance deficits on spatial working memory but not *executive function.* GeroScience 45, 1317–1342 (2023). doi: https://doi.org/10.1007/s11357-023-00798-2

Vich, C. & Giossi, C. & Massobrio, P. & Guillamon, A. (2023). Effects of short-term plasticity in UP-DOWN cortical dynamics. Communications in Nonlinear Science and Numerical Simulation, Volume 121 (107207), 1007-5704. doi: https://doi.org/10.1016/j.cnsns.2023.107207.

Hyafil, A. & de la Rocha, J. & Pericas, C. & Katz, L.N. & Huk, A.C. & W Pillow, J.W. (2023) Temporal integration is a robust feature of perceptual decisions eLife 12:e84045. doi: https://doi.org/10.7554/eLife.84045

Reyner-Parra, D. & Bonet, C. & Seara, T.M. & Huguet, G. (2023); Traveling waves in a model for cortical spreading depolarization with slow-fast dynamics. Chaos 1 August 2023; 33 (8): 083154. doi: https://doi. org/10.1063/5.0160509

Gasull, A. & Guillamon, A. & Mañosa, V. (2023). Counting configurations of limit cycles and centers. Buletinul Academiei de Stiinte A republicii Moldova. Matematica. Number 1(101), 2023, Pages 78–96 ISSN 1024-7696, E-ISSN 2587-4322. doi: https://doi.org/10.56415/basm.y2023.i1.p78

Li PY. & Roxin A .(2023) Rapid memory encoding in a recurrent network model with behavioral time scale synaptic plasticity. PLOS Computational Biology 19(8): e1011139. doi: https://doi.org/10.1371/journal. pcbi.1011139e12215.

Díaz, Ó. & Martín, V. & Renault, P. & Romero, D. & Guillamon, A. & Giraldo, J. (2023). Allosteric binding cooperativity in a kinetic context. Drug Discovery Today. Volume 28, Issue 2, 2023, 103441, ISSN 1359-6446. doi: https://doi.org/10.1016/j.drudis.2022.103441.

#### **OUTREACH ACTIVITIES**

SIJIMAT: Portes Obertes al CRM 16. November, 2023 Centre de Recerca Matemàtica | Barcelona Speakers: Lucía Arancibia (CRM) | Giovanni Dalmaso (CRM) | Dídac Gil (CRM) | Roser Homs (CRM)

Festa de la Ciència: "Neural Code" workshop and talk 11 June. 2023 Barcelona Speakers: Lucía Arancibia (CRM) | Anna Wilson (CRM) | Klaus Wimmer (CRM)

#### SCIENTIFIC ACTIVITIES

#### BARCCSYN 2023

May 25-26, 2023 Institut d'Estudis Catalans | Barcelona Organizers: Gemma Huguet (UPC-CRM) | Klaus Wimmer (CRM)

#### 8TH COMPUTATIONAL NEUROSCIENCE RETREAT

February 16-18, 2023 Sant Feliu de Guíxols Organizer: Citlalli Vivar (CRM)

#### 13TH INTERNATIONAL CONFERENCE ON NONLINEAR MATHEMATICS AND PHYSICS | NOLINEAL 2023 26-28 June, 2023

Centre de Recerca Matemàtica | Barcelona Josep J. Masdemont (UPC-CRM), Angel Jorba (UB-CRM) as part of the Scientific Committee Inma Baldomà (UPC-CRM), Jezabel Curbelo (UPC-CRM), Pau Martín (UPC-CRM), Mercè Ollé (UPC-CRM) as part of the Organizing Committee Speakers: Tomás Alarcón (ICREA\_CRM) | Amadeu Delshams (UPC-CRM) | Marc Jorba-Cuscó (CRM)| Gemma Huguet (UPC-CRM)

#### BARCELONA INTRODUCTION TO MATHEMATICAL RESEARCH 2023 SUMMER PROGRAM

03-28 July, 2023 Universitat de Barcelona | Barcelona Courses hosted by: Natàlia Castellana (UAB-CRM) | Jezabel Curbelo (UPC-CRM) | Francesc Fité (UB-CRM) | Juanjo Rué (UPC-CRM) Organizers: Paloma Bengoechea (UB-CRM) | Gemma Huguet (UPC-CRM) | Xavier Ros-Oton (UB-CRM)

#### BAMB!

16-25 July, 2023 Barcelona Biomedical Research Park | Barcelona Course directors and Faculty: Alex Hyafil (CRM) | Klaus Wimmer (CRM)

#### JORNADA DE PORTES OBERTES AL CRM

13 November, 2023 Centre de Recerca Matemàtica | Barcelona Speakers: Jezabel Curbelo (UPC-CRM) | Xavier Jargue (UB-CRM) | David Romero (UAB) | Alex Roxin (CRM) | Sergey Tikhonov (ICREA-CRM)

#### 9TH COMPUTATIONAL AND SYSTEMS NEUROSCIENCE RETREAT

23-25 November, 2023 Falset, Tarragona Organizers: Katerina Kalou (CRM) | Alex Roxin (CRM) | Anna Wilson (CRM)

#### SIJIMAT Seminar

Organizers: Lucía Arancibia, Juan Arellano, Giovanni Dalmasso, Gerard Farré, Alfonso Garmendia, Dídac Gil. Roser Homs

## ATTEN ATTEN ANALYSIS & PARTIAL DIFFERENTIAL EQUATIONS

#### DESCRIPTION

The research in Analysis and Partial Differential Equations at the CRM covers a broad range of topics, from classical function theory in one and several complex variables to the study of Banach spaces and its operators. The interplay between singular operators and geometric function theory has been very succesful. On PDE's the research is centered around reaction-diffusion and integro-differential equations (regularity and gualitative properties of solutions), population dynamics and biological evolution, as well as several wave problems in mathematical physics and mathematical modelling.

#### **RESEARCH LINES**

#### Analysis

The research group in Analysis has a long and consolidated trajectory, with very relevant results, as shown by the many publications in top journals.

The research lines cover different areas of Analysis as Harmonic Analysis, Geometric Function Theory in one complex variable, Geometric measure Theory and PDEs with special focus in the following lines:

- · Singular integrals, square functions, and
- rectifiability.
- · Geometric properties of harmonic and elliptic measures.
- Boundary behaviour of analytic functions
- and its connection to Stochastic Processes.

#### Partial Differential Equations

The PDE's group research deals with applications to Mathematical Biology. Two problems have received most atention: on the one hand, the rigourous definition and computation of the basic reproduction number in continuously structured populations, as the spectral radius of the next generation operator, and a new method to do this by means of a sequence of models when the latter cannot be defined properly as a bounded operator; on the other hand, the equivalence between the usual formulation of Structured Population Dynamics based on pdes for the densities of individuals and the delay formulation based on Volterra type integral equations for the birth rates.

#### Mathematical Modelling and Numerical Analysis

Motivated by problems in different disciplines, mathematical modeling seeks to explain and understand phenomena in nature and technology by means of the mathematical language. This is an interdisciplinary field, that uses mathematical concepts for the progress of other sciences, including biology, physics, engineering, business, economics and risk management... This is as well an interdisciplinary topic as tools from different areas in mathematics can be exploited, e.g. differential equations, statistics, data science, numerical analysis, discrete mathematics, algebra and geometry.

#### **MEMBERS**

Senior Researchers: Xavier Cabré | Àngel Calsina | Carme Cascante | Albert Clop | Gyula Csato | Joan J. Donaire | Jordi Marzo | Albert Mas Blesa | Joan Mateu | Artur Nicolau | Joan Orobitg | Joaquim Ortega | Jordi Pau | Laura Prat | Martí Prats | Xavier Ros-Oto | Olli Saari | Susana Serna | Sergev Tikhonov | Xavier Tolsa | Joan Verdera

Postdoctoral Researchers: Egor Kosov | Alberto Maione | Niyaz Tokmagambetov PhD Students: Miquel Saucedo | Iñigo Urtiaga-Erneta

#### **PROJECTS**

ERC Starting Grant (2019 - 2024) Regularity and singularities in elliptic PDE's PI: Xavier Ros-Oton European Research Council

PID2021-125021NA-100 PDE and Fluid Mechanics Agencia Estatal de Investigación PI: Xavier Ros-Oton, Javier Gómez Serrano Ministerio de Ciencia e Innovación (MICINN)

#### PID2020-114948GB-100 MTM

Teoría de la aproximación y análisis armónico: métodos y aplicaciones IP: Sergey Tikhonov Funded by AGE

PID2021-123151NB-100 IP: Artur Nicolau Ministerio de Ciencia e Innovación (MICINN) PID2021-123903NB-100

#### Ecuaciones en Derivadas Parciales: problemas de reacción-difusión, integro-diferenciales, y de la física matemática

Ministerio de Ciencia e Innovación IP: Xavier Cabré, Albert Mas

PID2021-123903NB-100 IP: Xavier Cabré Ministerio de Ciencia e Innovación (MICINN)

PID2021-123405NB-100 Varias variables complejas y distribución óptima de puntos **IP: Joaquim Ortega** 

#### Ministerio de Ciencia e Innovación (MICINN)

RYC2021-032950-1 *Harmonic analysis and time-dependent problems in PDE* IP: Olli Saari

PID2020-114167GB-100 Integrales Singulares, Teoria Geométrica de la Medida y EDP'S IP: Xavier Tolsa Ministerio de Ciencia, Innovación y Universidades

2021 SGR 00087 *Teoria de Funcions i Equacions en Derivades Parcials* IP: Carme Cascante Generalitat de Catalunya

2021-SGR-00071 *Anàlisi real i complexa, i equacions en derivades parcials. ARC-EDP* Generalitat de Catalunya

PID2020-112881GB-100 *Analisis y ecuaciones en derivadas parciales* IP: Joan Mateu, Joan Verdera Ministerio de Ciencia i innovación

ERC Advanced Grant *Geometric analysis and Potential Theory* IP: Xavier Tolsa European Research Council

PID2020-118236GB-100 IP: *Susana Serna* Ministerio de Ciencia i innovación

PID2021-123405NB-100 Varias variables complejas y distribución óptima de puntos IP: Carme Cascante, Joaquim Ortega

#### **PUBLICATIONS**

Arrizabalaga, N. & Mas, A. & Sanz-Perela, T. & Vega, L. (2023). *Eigenvalue Curves for Generalized MIT Bag Models.* Commun. Math. Phys. 397, 337–392 (2023). doi: https://doi.org/10.1007/s00220-022-04526-3

Calsina, À. & Cuadrado, S. & Vidiella, B. & Sardanyés, J. (2023). *About ghost transients in spatial continuous media*. *Chaos, Solitons & Fractals, Volume 166 (112915), 0960–0779. doi: https://doi.org/10.1016/j. chaos.2022.112915.* 

Dyachenko, M. & Nursultanov, E. & Tikhonov, S. & Weisz, F. (2023). *Hardy–Littlewood-type theorems for Fourier transforms in Rd.* Journal of Functional Analysis, Volume 284 (4), 109776. doi: https://doi.org/10.1016/j.jfa.2022.109776

Kolomoitsev, Y. & Lomako, T. & Tikhonov, S. (2023). *Sparse Grid Approximation in Weighted Wiener Spaces.* Journal of Functional Analysis, Volume 29 (19). doi: https://doi.org/10.1007/s00041-023-09994-2

Molero, A. & Mourgoglou, M. & Puliatti, C. & Tolsa, X. (2023). *L2-Boundedness of Gradients of Single Layer Potentials for Elliptic Operators with Coefficients of Dini Mean Oscillation-Type*. Arch Rational Mech Anal 247, 38 (2023). https://doi.org/10.1007/s00205-023-01852-1

Verdera, J. (2023). *The global regularity of vortex patches revisited*. Advances in Mathematics Volume 416, 108917. doi: https://doi.org/10.1016/j.aim.2023.108917

Donaire, J.J. & Nicolau, A. (2023). *Iterates of Blaschke Products and Peano Curves*, International Mathematics Research Notices, Volume 2023, Issue 8, April 2023, Pages 7140–7168, https://doi.org/10.1093/ imrn/rnac059

Gorbachev, D. & Ivanov, V. & Tikhonov, S (2023). *Logan's problem for Jacobi transforms*. Canadian Journal of Mathematics. 2024;76(3):915-945. doi:10.4153/S0008414X23000275

Shaimardan, S. & Persson, L-E. & Tokmagambetov, N. (2023). *Well-posedness of heat and wave equations generated by Rubin's q-difference operator in Sobolev spaces*. arXiv:2301.07381. doi: https://doi. org/10.48550/arXiv.2301.07381

Sánchez, D.C. & Kumar, V. Ruzhansky, M. & Tokmagambetov, N. (2023). *Global functional calculus, low-er/upper bounds and evolution equations on manifolds with boundary*. Adv. Oper. Theory 8, 50 (2023). https://doi.org/10.1007/s43036-023-00254-0.

Saucedo, M. (2023). *Hardy inequalities for p-weakly monotone functions*. Eurasian Math. J., 14:2 (2023), 94–106. doi: https://doi.org/10.32523/2077-9879-2023-14-2-94-106

Erneta, I.U. (2023). *Stable solutions to semilinear elliptic equations for operators with variable coefficients.* Communications on Pure and Applied Analysis, 2023, 22(2): 530–571. doi: https://doi. org/10.32523/2077-9879-2023-14-2-94-106

Audrito, A. & Felipe-Navarro, J-C. & Ros-Oton, X. (2023). *The Neumann problem for the fractional Laplacian: regularity up to the boundary*. Annali di Scienze. 2023: VOL. XXIV, ISSUE 2. doi: https://doi. org/10.2422/2036-2145.202105\_096

Cascante, C. & Fàbrega, J. & Pascuas, D. (2023). *Small Hankel operators on generalized weighted Fock spaces*. Proc. Amer. Math. Soc. 151 (2023), 4827-4839. DOI: https://doi.org/10.1090/proc/16534

Limani, A. & Nicolau, A. (2023). *Bloch functions and Bekolle-Bonami weights*. Indiana Univ. Math. J.Volume 72 (2), 381–-407. doi: http://dx.doi.org/10.1512/iumj.2023.72.9279

Cabré, X. & Csató, G. & Mas, A. (2023) *Existence and symmetry of periodic nonlocal-CMC surfaces via variational methods.* Journal für die reine und angewandte Mathematik (Crelles Journal), vol. 2023, no. 804, 2023, pp. 11-40. https://doi.org/10.1515/crelle-2023-0057.

Nicolau A. & Thomas PJ. (2023). *Invertibility Threshold for Nevanlinna Quotient Algebras.* Canadian Journal of Mathematics. 2023;75(1):225–244. doi:10.4153/S0008414X21000511

Mateu, J. & Mora, M.G. & Rondi, L. & Scardia, L. & Verdera, J. (2023). *Explicit minimisers for anisotropic Coulomb energies in 3D*. Advances in Mathematics. Volume 434, 1, 109333. doi: https://doi.org/10.1016/j.aim.2023.109333

Ros-Oton, X. & Torres-Latorre, C. (2023). *Optimal regularity for supercritical parabolic obstacle problems*. Comm. Pure Appl. Math., 77: 1724-1765. doi: https://doi.org/10.1002/cpa.22166 Oganesyan, K. Two-Dimensional Hardy-Littlewood Theorem for Functions with General Monotone Fourier Coefficients. J Fourier Anal Appl 29, 60 (2023). https://doi.org/10.1007/s00041-023-10039-x

Cantero, J.C. & Mateu, J. & Orobitg, J. & Verdera, J. (2023). The regularity of the boundary of vortex patches for some nonlinear transport equations. Vol. 16 (2023), No. 7, 1621–1650. DOI: 10.2140/ apde.2023.16.1621

Mateu, J. & Mora, M.G. & Rondi, L. & Scardia, L. & Verdera, J. (2023). Stability of Ellipsoids as the Energy Minimizers of Perturbed Coulomb Energies. SIAM Journal on Mathematical Analysis 2023 55:4, 3650-3676. doi: https://doi.org/10.1137/22M1479695

Ruzhansky, M. & Sebih, M.E. & Tokmagambetov, N. (2023) Schrödinger equation with singular position dependent mass. Z. Anal. Anwend. 42 (2023), no. 1/2, pp. 131–144 DOI: 10.4171/ZAA/1725

Cabré, X. & Erneta, I.U. & Felipe-Navarro, J.C. (2023) A Weierstrass extremal field theory for the fractional Laplacian. Advances in Calculus of Variations, 2023. https://doi.org/10.1515/acv-2022-0099

#### **DEFENDED THESES**

*On nonconvex special relativistic hydrodynamics* Marina Berbel Palomegue Supervisor: Susana Serna Defended at Universitat Autònoma de Barcelona

#### Energy and random point processes on two-point homogeneous manifolds

Víctor de la Torre Estévez Supervisor: Jordi Marzo Sánchez Defended at Universitat de Barcelona

#### Elliptic problems: regularity of stable solutions and a nonlocal Weierstrass extremal field theory

Iñigo Urtiaga Erneta Supervisor: Xavier Cabré Vilagut Defended at Universitat Politècnica de Barcelona

#### SCIENTIFIC ACTIVITIES

BARCELONA INTRODUCTION TO MATHEMATICAL RESEARCH 2023 SUMMER PROGRAM 03-28 July 2023 Universitat de Barcelona | Barcelona Courses hosted by: Natàlia Castellana (UAB-CRM) | Jezabel Curbelo (UPC-CRM) | Francesc Fité (UB-CRM) | Juanjo Rué (UPC-CRM) Organizers: Paloma Bengoechea (UB-CRM) | Gemma Huguet (UPC-CRM) | Xavier Ros-Oton (UB-CRM)

19TH SCHOOL ON INTERACTIONS BETWEEN DYNAMICAL SYSTEMS AND PARTIAL DIFFERENTIAL EQUATIONS (JISD2023)

03-07 July, 2023 Centre de Recerca Matemàtica | Barcelona Organizing Committee: Xavier Cabré (ICREA-UPC-CRM) | Gyula Csato (UB-CRM) | Amadeu Delshams (UPC-CRM) | Marcel Guàrdia (UB-CRM) | Tere M. Seara (UPC-CRM)

#### HARMONIC MEASURE AND FREE BOUNDARY PROBLEMS

November 07 - December 21, 2023 Universitat de Barcelona Organizers & Speakers: Xavier Ros-Oton (ICREA-UB-CRM) | Xavier Tolsa (ICREA-UAB-CRM) IMUB Colloquium Organizer: Xavier Ros-Oton

#### Analytic and algebraic methods in physics XX

28 – 31 August, 2023 Czech Technical University, Prague Co-organized by: Albert Mas Blesa (UPC-CRM)

#### Jornada Olga Ladyzhenskava: "Hopf, Caccioppoli and Schauder, reloaded"

26 April. 2023 Facultat de Matemàtiques i Estadística (UPC) Speaker: Xavier Cabré

#### Congreso Bienal de la RSME

22-26 January, 2024 UPNA Pamplona Scientific Committe: Joaquim Ortega Cerdà

Barcelona Math Days: Anàlisi i EDPs Session 2-3 November, 2023 Institut d'Estudis Catalans, Barcelona Organizer: Albert Clop

#### **OUTREACH**

#### Xavier Ros-Oton

- Public science talk. Real Academia de Ciencias, Madrid (January 2023)
- Round Table. Bienal Ciutat i Ciència. CCCB, Barcelona (February 2023)
- Public lecture for the "Cicle: Els grans interrogants de la ciència". Olot (March 2023)
- Interview for 'Dong-A Science Magazine', South Korea (April 2023)
- Inaugural Lecture for the 2023/24 'ESTALMAT' program, Madrid (September 2023)
- ICFO Colloquium, Institute of Photonic Sciences, Barcelona (December 2023)
- Interview for Centre de Recerca Matemàtica (November 2023)

#### JORNADA DE PORTES OBERTES AL CRM

13 November, 2023 Centre de Recerca Matemàtica | Barcelona Speakers: Jezabel Curbelo (UPC-CRM) | Xavier Jarque (UB-CRM) | David Romero (UAB) | Alex Roxin (CRM) | Sergey Tikhonov (ICREA-CRM)

#### Artur Nicolau

Analysis Seminar, Universidad Complutense de Madrid, "A Central Limit Theorem for iterates of an Inner Function", Madrid, 25/10/2023

Recent Advances in Function Spaces and their Operators "A Central Limit Theorem for iterates of an Inner Function", Marrakesh 10/05/2023

#### Sergey Tikhonov

Conference talk: International Conference on Multivariate Approximation, Schloss Rauischholzhausen, Germany

#### Xavier Cabré

Speaker at Séminaire d'Analyse Non Linéaire et EDP of ENS-PSL / Sorbonne Université / Université Paris Cité: "Stable solutions to semilinear elliptic equations are smooth up to dimension 9". January 17, 2023.

#### **OTHERS**

#### Xavier Ros-Oton

Premio Nacional de Investigación 2023 para Jóvenes investigadores en matemáticas y tecnologías de la información y las comunicaciones.

Frontiers of Science Awards 2023

Premi Ferran Sunyer i Balaguer 2023

#### Artur Nicolau

Postdoc mentored: Adem Limani (Lund University) (2022-2024)

#### Sergey Tikhonov

Member of Editorial Board:

- Rendiconti del Circolo Matematico di Palermo
- Advances in Operator Theory
- Journal of Fourier Analysis and Applications
- Jaen Journal on Approximation
- Analysis Mathematica
- Journal of Mathematical Analysis and Applications
- Demonstratio Mathematica

#### Xavier Cabré

Frontiers of Science Awards 2023 Research collaboration with Alessio Figalli and Joaquim Serra and attend "Conference in honour of Luigi Ambrosio's 60th birthday"", ETH Zurich (Switzerland)

# COMBINATORICS, LOGIC & ALGORITHMICS

#### DESCRIPTION

Discrete mathematics is a wide (and very active) area in mathematics which has become a central topic in modern research due to its deep interplay with theoretical computer science. The research of the combinatorics group exploits multiple connections of this area with many research disciplines including probability theory, number theory and group theory, among many others. Its interplay with logic and algorithimc plays also a strong line of research of our team.

More precisely, we aim to study several open problems inside the combinatorics framework, within the interplay between areas and in the interaction between different disciplines. In the first direction, we are interested in the study of random discrete structures, as random graphs and random sets, by the use of Erdös probabilistic method. The use of these probability techniques let us to study the typical behaviour of large random objects, as well as their limiting properties. Applications in real-world problems (as the comprehension of large networks) is also an important point addressed in this direction.

Concerning the interplay inside the research team, we are very interested on the role of pseudorandomness in computation. The hardness-vs-randomness trade-off of Nisan and Wigderson transformed the role of randomness in the design of algorithms. In this context, we investigate whether hardness for a model of symmetric computation could be enough to derandomize specific randomized constructions or algorithms. A celebrated example where the analysis of the randomness in a specific algorithm led to the breakthrough of the AKS algorithm, establishing that PRIMES is in P. another important line of research deals with the study of constrained classes of random graphs and logic limit laws: by using a combination of combinatorial, analytic, probabilistic and logical tools we are able to study the enumeration of planar graphs enriched with a global structure, and to determinine the set of limiting probabilities of graph properties in first-order logic for random graphs with given degree sequence; and analyzing the width of thresholds of random graph properties defined in suitable logical languages.

Finally, we are very much interested in the study of number theoretical problems (arising in abelian groups and in non-abelian groups) from a combinatorial perspective. This is the content of Arithmetic combinatorics: in the last years there has been a dramatic growth of the area due to its connections with Ergodic Theory, Functional Analysis and Extremal Combinatorics. We aim to make progress on this area by combining a wide variety of modern combinatorial techniques (regularity methods, hypergraph containers, and arithmetic removal lemmas) to get a better understanding of maximal densities of sets avoiding certain patterns in groups (finite or infinite); and guasirandomness properties of the associated Cayley graphs, including the stationary behavior of random walks on these structures.

#### **RESEARCH LINES**

#### Logic & Algorithmics

Since its inception, mathematical logic has both contributed to and has been motivated by the study of foundations of mathematics. Contemporary work in the foundations of mathematics often focuses on establishing which parts of mathematics can be formalized in particular formal systems. Algorithmics works in the description of the set of steps that can be used to solve a specific computation and is becoming more important in all mathematical fields

#### Combinatorics

Combinatorics is an area of mathematics concerned with the study of discrete objects, for example set systems, graphs, hypergraphs, integers, etc.. It is closely related to many other areas of mathematics and has many applications including logic, statistical physics and group theory, among others. Specially with theoretical computer science there is a rich interchange that had made this area a very active field of modern mathematics.

#### MEMBERS

Senior Researchers: Albert Atserias | Kolja Knauer | Marc Noy | Guillem Perarnau | Oriol Serra | Juan José Rué Postdoc: Tassio Naia PhD: Jordi Castellví

#### **PROJECTS**

PID2020-113082GB-100 Combinatoria: nuevas tendencias y aplicaciones IP: Guillem Perarnau, Simeon Ball Ministerio de Ciencia e Innovación (MICIN)

RED2022-134947-T Red de Matemática Discreta y Algorítmica

**IP: Guillem Perarnau** Ministerio de Ciencia e Innovación (MICIN)

PID2022-137283NB-C22 Algebraic combinatorics and its connections to geometry IP: Kolja Knauer Ministerio de Ciencia e Innovación (MICIN)

H2020-101007705-RandNET Randomness and learning in networks IP: Marc Nov European Comission

PID2019-109137GB-C22 Sistemas de prueba más allá de resolución: análisis teórico co-IP: Victor Dalmau (UPF), Albert Atserias (UPC) Ministerio de Ciencia e Innovación (MICIN)

#### PUBLICATIONS

Castellví, J. & Noy, M. & Requilé, C. (2023). Enumeration of chordal planar graphs and maps. Discrete Mathematics. Volume 346, Issue 1. 113163. doi: https://doi.org/10.1016/j.disc.2022.113163

Noy, M. & Requilé, C. & Rué, J. (2023). Enumeration of labelled 4-regular planar graphs II: Asymptotics. European Journal of Combinatorics. Volume 110, May 2023, 103661. doi: https://doi.org/10.1016/j. ejc.2022.103661

Coulson, M. & Perarnau, G. (2023). Largest component of subcritical random graphs with given degree sequence. Electronic Journal of Probability, 28(none) 1-28 2023. doi: https://doi.org/10.1214/23-EJP921

Cai, X.S. & Caputo, P. & Perarnau, G. & Quattropani, M. (2023). Rankings in directed configuration models with heavy tailed in-degrees. The Annals of Applied Probability, 33(6B) 5613-5667 December 2023. doi: https://doi.org/10.1214/23-AAP1955

#### **DEFENDED THESES**

First order logic of random sparse structures Lázaro Alberto Larrauri Borroto Supervisors: Marc Noy Serrano Defended at Univeristat Politècnica de Catalunya

#### **SCIENTIFIC ACTIVITIES**

#### BARCELONA INTRODUCTION TO MATHEMATICAL RESEARCH 2023 SUMMER PROGRAM

03-28 July 2023 Universitat de Barcelona | Barcelona Courses hosted by: Natàlia Castellana (UAB-CRM) | Jezabel Curbelo (UPC-CRM) | Francesc Fité (UB-CRM) | Juanjo Rué (UPC-CRM) Organizers: Paloma Bengoechea (UB-CRM) | Gemma Huguet (UPC-CRM) | Xavier Ros-Oton (UB-CRM)

#### DISCRETE PROBABILITY DAYS

16-18 October, 2023 Centre de Recerca Matemàtica | Barcelona Speaker: Guillem Perarnau (UPC-CRM)

#### Barcelona Math Days: Discrete Math Session

2-3 November, 2023 Institut d'Estudis Catalans, Barcelona Organizer: Kolja Knauer

"Three Talks in Combinatorics". Combinatorics seminar series at Universitat de Barcelona: "Beyond Symmetry in Generalized Petersen graphs" 24 October, 2023 Organizer and Speaker: Kolja Knauer

#### **OUTREACH ACTIVITIES**

#### Juan José Rué

Conferences:

- "L'home que només estimava els nombres". Llotja del Cànem (Castelló), January 2023
- "L'home que només estimava els nombres". L'Hospitalet ciència, March 2023

Opening talk of the Societat Catalana de Matemàtiques, September 2023

#### **OTHER**

Juan José Rué Albert Dou Award of the Societat Catalana de Matemàtiques

Kolja Knauer Editor in Chief: Annals of Combinatorics

# ALGEBRA, GEOMETRY, NUMBER THEORY &TOPOLOGY

#### DESCRIPTION

This area/group covers a broad spectrum of research fields: number theory, algebraic and arithmetic geometry, operator algebras, algebraic topology, differential and symplectic geometry. Research in those fields interact between them as well as with other areas of the CRM, like dynamics or analysis and PDEs.

Among the precise research subjects, we point out category theory and homotopy structures (algebraic topology), C\* algebras (operators algebras), integral geometry (differential geoemtry), Weinstein conjecture and Navier Stokes equations (symplectic geometry), cohomology of arithmetic manifolds (number theory) or continuous rank functions (algebraic geometry).

#### **RESEARCH LINES**

#### Algebra

Our research group focuses on classification aspects of C\*-algebras, C\*-dynamical systems, and Leavitt path algebras. One of the key tools we use in our investigations is the Cuntz semigroup (also in its dynamical form), a powerful technical device constructed akin to the Murray-von Neuman projection monoid. We use this object in order to develop the correct notion of Z-stability in the dynamical context and to explore regularity conditions of dynamical systems that yield classifiable crossed products. Our study of Leavitt path algebras focuses, among others, on Hazrat's conjecture, for which the use of K-theory proves to be essential.

#### Geometry

The research of the group covers several aspects of differential geometry: symplectic, algebraic, integral, and complex geometry. In symplectic geometry, besides singularities our team has made a contribution in fluid dynamics, in Tao's approach on disproving the Navier-Stokes conjecture. In algebraic geometry we have worked on the classification of irregular varieties and the interaction with physics. In integral geometry we obtain kinematic formulas and consider questions of convexity and measures, including Alesker valuation theory. On the complex side, we have worked on moduli spaces of foliations and related geometric structures as webs.

#### Number Theory

Number theory is devoted to the study of questions concerned with integers and, more generally, with rings and fields of arithmetic nature: additive and multiplicative properties of integer numbers, integral solutions of equations with integral coefficients and integer-valued functions. This branch of mathematics bears strong and deep connections with real, complex and non-archimedean analysis, commutative algebra, algebraic geometry, topology and logics. The Number Theory research group in Barcelona works on a wide range of problems in Galois theory, the Langlands program, abelian varieties, Shimura varieties and L-functions.

#### Topology

While traditionally algebraic topology uses discrete, algebraic methods to tackle topological problems, we are as much concerned with the applications of homotopy methods to understand combinatorial and algebraic structures. We explore applications to posets, decomposition spaces, incidence algebras, finite groups, representations, and other structures.

#### MEMBERS

Senior Researchers: Josep Àlvarez | Jaume Amorós | Carlos Antonio d'Andrea | Ramon Antoine | Pere Ara | Miguel Ángel Barja | Laura Costa | Dolors Herbera | Martí Lahoz | Simone Marchesi | David Marín | Eva Miranda | Rosa M. Miró | Ignasi Mundet | Francesc Perera | Joan Carles Naranjo | Joan Porti | Gil Solanes | Martín Sombra | Luis Dieulefait | Francesc Fité | Xavier Guitart | Marc Masdeu | Víctor Rotger | Carles Broto | Natàlia Castellana | Joana Cirici | Imma Gálvez | Javier J. Gutiérrez | Joachim Kock | Albert Ruiz

Postdoctoral Researchers: Michele Fornea | Alfonso Garmendia | Irene Spelta PhD Students: Soren Dhyr, Javier Guillán, Pablo Nicolás

#### PROJECTS

PID2019-103849GB-100 Geometría, Álgebra, Topología y aplicaciones multidisciplinares (GATA-TECH) IP's: Eva Miranda and Josep Alvarez Funded by Agencia Estatal de Investigación

PID2020-117971GB-C22

Homotopical methods in geometry Pl's: Joana Cirici and Javier Gutiérrez Funded by Agencia Estatal de Investigación

2021 SGR 00697

Geometry and topology at Universitat de Barcelona (GiT-UB) Coordinator: Joana Cirici Funded by Generalitat de Catalunya (AGAUR)

H2020-MSCA-ITN-2019 learninG, pRocessing, And oPtimising shapES (GRAPES) IP: Carlos D'Andrea Funded by European Comission

PID2019-104047GB-100 Geometría algebraica, lineal y diferencial. Teoría y aplicaciones (GALATEA) IPs Carlos D'Andrea and Martí Lahoz Funded by Agencia Estatal de Investigación

PID2022-137605NB-100 *Abelian Varieties, L-functions and rational points* IP: Francesc Fité Funded by Ministerio de Ciencia e Innovación

PID2020-116542GB-100 IP: Marc Masdeu Funded by Ministerio de Ciencia e Innovación

2021 SGR 01015 (2022--2025) *Laboratori d'Interaccions entre Geometria, Àlgebra i Topologia* IP: **Dolors Herbera** Funded by AGAUR

FCT 21-16863 *Estalmat* IP: Dolors Herbera Spanish Foundation for Science and Technology (Fecyt)

EIC21-1-72 Computational, dynamical and geometrical compleixty in fluid dynamics. IP: Eva Miranda BBVA Foundation

PID2020-113047GB-100 *Anillos, módulos, C\*-álgebras, y dinámica: clasificación, estructura fina y regularidad* IPs: Pere Ara and Francesc Perera Funded by Ministerio de Ciencia e Innovación

PDI2020-116481GB-100. *Teoría de homotopía de estructuras combinatorias y algebraicas.* Ministerio de Ciencia e Innovación. IP: Joachim Kock and Wolfgang Pitsch

PID2019-107297GB-100 Modularidad de representaciones de Galois y ecuaciones diofánticas de tlpo Fermat, conjetura de Sato-Tate, problema 12 de Hilbert IP: Luis Dieulefait Funded by Agencia Estatal de Investigación

PID2020-113674GB-100 *Fibrados Vectoriales en Geometría Algebraica, II* IP: Rosa Maria Miro Roig Funded by Agencia Estatal de Investigación

PID2021-125625NB-100 *Estructuras y desigualdades geométricas universales* PIs: Gil Solanes and Florent Balacheff Funded by Ministerio de Ciencia e Innovación

#### PUBLICATIONS

Braddell, R. & Kiesenhofer, A. & Miranda, E. (2023). *A b-symplectic slice theorem*. Bull. London Math. Soc., 55: 90–112. doi: https://doi.org/10.1112/blms.12713

Coquinot, B. & Mir, P. & Miranda, E. (2023). *Singular cotangent models in fluids with dissipation. Physica D*: Nonlinear Phenomena. Volume 446, April 2023, 133655. doi: https://doi.org/10.1016/j. physd.2023.133655

Cardona, R. & Miranda, E. & Peralta-Salas, D. (2023). *Computability and Beltrami fields in Euclidean space.* Journal de Mathématiques Pures et Appliquées. Volume 169, January 2023, Pages 50-81

Cortadellas-Benítez, T. & D'Andrea, C. & Montoro, E. (2023). *Bounds for degrees of syzygies of polynomials defining a grade two ideal.* Journal of Symbolic Computation. Volume 115, March–April 2023, Pages 124–141. doi: https://doi.org/10.1016/j.jsc.2022.08.004

Marchesi, S. & Vallès, J. (2023). *On invariant rank two vector bundles on P2*. Publicacions Matemàtiques, UAB. Volume 67, Issue 1 (2023) pp. 259–275. DOI: 10.5565/PUBLMAT6712306

Brugués, J. & Hohloch, S. & Mir, P. & Miranda, E. (2023); *Constructions of b-semitoric systems*. J. Math. Phys. 28 July 2023; 64 (7): 072703. doi: https://doi.org/10.1063/5.0152551

Miranda, E. & Oms, C. (2023). *Contact structures with singularities: From local to global*. Journal of Geometry and Physics. Volume 192, October 2023, 104957. doi: https://doi.org/10.1016/j.geom-phys.2023.104957

Fontana-McNally, J. & Miranda, E. & Oms, C. & Peralta-Salas, D. (2023). *From 2N to Infinitely Many Escape Orbits*. Regul. Chaot. Dyn. 28, 498–511 (2023). doi: https://doi.org/10.1134/S1560354723520039

Ara, P. (2023). *Leavitt path algebras of weighted and separated graphs.* Journal of the Australian Mathematical Society. 2023;115(1):1-25. doi:10.1017/S1446788722000155

Garmendia, A. & Paycha, S. (2023). *Principal bundle groupoids, their gauge group and their nerve*. Journal of Geometry and Physics. Volume 191, September 2023, 104865. doi: https://doi.org/10.1016/j. geomphys.2023.104865

Matveeva, A. & Miranda, E. (2023). *Reduction theory for singular symplectic manifolds and singular forms on moduli spaces*. Advances in Mathematics. Volume 428, 1 September 2023, 109161. doi: https://doi.org/10.1016/j.aim.2023.109161

Cox, D.A. & D'Andrea, C. (2023). *Subresultants and the Shape Lemma.* Math. Comp. 92 (2023), 2355–2379. doi: http://dx.doi.org/10.1090/mcom/3840

Cardona, R. & Miranda, E. & Peralta-Salas, D. & Presas, F. (2023). *Universality of Euler flows and flexibility of Reeb embeddings*. Advances in Mathematics. Volume 428, 1 September 2023, 109142. doi: https://doi.org/10.1016/j.aim.2023.109142

D'Andrea, C. & Jeronimo, G. & Sombra, M. *The Canny–Emiris Conjecture for the Sparse Resultant*. Found Comput Math 23, 741–801 (2023). https://doi.org/10.1007/s10208-021-09547-3.

Corrêa, M. & Jardim, M. & Marchesi, S. (2023). *Classification of the invariants of foliations by curves of low degree on the three-dimensional projective space*. Rev. Mat. Iberoam. 39 (2023), no. 5, pp. 1641–1680

Mir, P. & Miranda, E. & Weitsman, J. (2023). Bohr-Sommerfeld quantization of b-symplectic toric manifolds. Pure and Applied Mathematics Quarterly. Volume 19 (2023). Number 4 Pages: 2169 – 2194. DOI: https://dx.doi.org/10.4310/PAMQ.2023.v19.n4.a15

Broto, C. & Møller, J.M. & Oliver, B. & Ruiz, A. (2023). Realizability and tameness of fusion systems. Proc. London Math. Soc., 127: 1816-1864. https://doi.org/10.1112/plms.12571

Huh, S. & Marchesi, S. & Pons-Llopis, J. & Vallès, J. Generalized Logarithmic Sheaf on Smooth Projective Surfaces, International Mathematics Research Notices, Volume 2023, Issue 21, November 2023, Pages 18387–18442, https://doi.org/10.1093/imrn/rnad029

Belmont, E. & Castellana, N. & Lesh, K. (2023). Subgroup collections controlling the homotopy type of a p -local compact group. Journal of Pure and Applied Algebra. Volume 227, Issue 11, November 2023, 107387. doi: https://doi.org/10.1016/j.jpaa.2023.107387

#### DEFENDED THESES

Higher limits via homotopical algebra Guille Carrión Santiago Supervisors: Natàlia Castellana and Antonio Díaz. Defended at Universitat Autònoma de Barcelona

Directed hereditary species and decomposition spaces of intervals. Wilson Javier Forero Baquero Supervisor: Joachim Kock Defended at Universitat Autònoma de Barcelona

Robotic manipulation of cloth: mechanical modeling and perception Franco Coltraro Ianniello Supervisors: Jaume Amorós Torrent and Maria Alberich Carramiñana Defended at Universitat Politècnica de Catalunya

Theta correspondences and arithmetic intersections Armando Gutiérrez Terradillos Supervisors: Victor Rotger Cerdà and Gerard Freixas i Montplet Defended at Universitat Politècnica de Catalunya

Robotic manipulation of cloth: mechanical modeling and perception Franco Coltraro Ianniello Supervisors: Jaume Amorós Torrent and Maria Alberich Carramiñana Defended at Universitat Politècnica de Catalunya

Theta correspondences and arithmetic intersections Armando Gutiérrez Terradillos Supervisors: Victor Rotger Cerdà and Gerard Freixas i Montplet Defended at Universitat Politècnica de Catalunya

#### SCIENTIFIC ACTIVITIES

3RD BARCELONA WEEKEND ON OPERATOR ALGEBRAS 27-28, January 2023 Centre de Recerca Matemàtica | Barcelona Co-organizers: Ramon Antoine and Francesc Perera

**OPERADIC METHODS IN GEOMETRY** 

22-24 November, 2023 University of Barcelona, Barcelona Organizer: Joana Cirici (UB-CRM)

SMGA: Seminari Mediterrani de Geometria Algebraica 16-17 November, 2023 University of Barcelona, Barcelona Scientific Committee: Martí Lahoz (UB-CRM) Organizing Committee: Carlos D'Andrea (UB-CRM) | Martí Lahoz (UB-CRM) | Joan Carles Naranjo (UB-CRM) | Irene Spelta (CRM)

Workshop Geometry of Polynomial System Solving 16-20 October, 2023 Institut Henri Poincaré, Paris Organizer: Carlos D'Andrea (UB-CRM)

Learning Week II: Industrial skills and advanced topics in ML 4-8 September, 2023 Universitat de Barcelona, Barcelona Organizer: Carlos D'Andrea (UB-CRM)

SIJIMAT Seminar Organizers: Lucía Arancibia, Juan Arellano, Giovanni Dalmasso, Gerard Farré, Alfonso Garmendia, Dídac Gil. Roser Homs

Number Theory in Montserrat 2023 27-29 June, 2023 Montserrat. Catalonia Organizers: Francesc Fité (UB-CRM) | Marc Masdeu (UAB-CRM)

Trends in Representation Theory and Related Topics. 12-16 September, 2023. Universitatea Babes-Bolyai, Cluj-Napoca (Romania) Invited speaker: **Dolors Herbera** (UAB-CRM)

BARCELONA INTRODUCTION TO MATHEMATICAL RESEARCH 2023 SUMMER PROGRAM

03-28 July 2023 Universitat de Barcelona | Barcelona Courses hosted by: Natàlia Castellana (UAB-CRM) | Jezabel Curbelo (UPC-CRM) | Francesc Fité (UB-CRM) | Juanjo Rué (UPC-CRM) Organizers: Paloma Bengoechea (UB-CRM) | Gemma Huguet (UPC-CRM) | Xavier Ros-Oton (UB-CRM)

#### Eva Miranda as a Speaker:

Infinite dimensional Geometry and Fluids: "Navigating Uncharted Waters: Bridging Geometry and Fluid Dvnamics" 5-10 Novembre, 2023 The Banff International Research Station, Canada

Computation in Dynamical Systems Octobre 9-13, 2023. Obergurgl resort

Groups in action: from representations and harmonic analysis on Lie groups to index theory 4-9 Septembre, 2023 Paris (France)

GSI'23 "Geometric Science of Information" August 30 - Septembre 1, 2023 Saint-Mal'o (France)

Quantization in Geometry July 24-28, 2023 Cologne (Germany)

Dynamische Systeme Oberwolfach 2023

#### Hardy Lecturer June 30, 2023 LMS, London

The many interactions of symplectic and Poisson geometry: A conference in honour of Alan Weinstein's 80th birthday. IHP, June 2023.

FoCM 2023 (Foundations of Computational Mathematics) July, 2023 Paris

#### **OUTREACH ACTIVITIES**

Josep Álvarez Montaner

Fundació Sunyer i Balagué talks:

- DITMAE Figueres (4 February, 2023)

- DIMAT La Seu d'Urgell (15 April, 2023)

#### Joan Porti Piqué

Dissabtes de les Matemàtiques: Conference and worhsop "Per què les bombolles són rodones". 11 March, 2023. Universitat Autònoma de Barcelona. Workshop at MAMBO: MAtemàtiques aMb BOmbolles de Sabó: "Superfícies mínimes i bombolles de sabó", at Centre de Recursos Pedagògics Específics de Suport a la Innovació i a la Recerca Educativa. April 15, 2023. Universitat Autònoma de Barcelona

#### Francesc Fité

Jury for the "Mathematics Competition for University Students 2023" at UPC Marc Masdeu Talk at XIII Jornades "Les matemàtiques entre la secundària i la universitat": "Ensenyant formalització a través de LEAN". Also a participant at the round table "La intel·ligència artificial a l'aula, problema o oportunitat?" Summer Course, Programa Argó: "Poden els ordinadors entendre les matemàtiques? De la geometria axiomàtica als theorem provers".

Participant at the workshop "Lean for the Curious Mathematician 2023" (Düsseldorf) as a tutor.

#### Dolors Herbera

Mentor at the program #steMatEsElla organized by Real Sociedad Matemática Española and Asociación Española de Ejecutiv@ s y Consejer@s (EJE&CON), in collaboration with Basque Center for Applied Mathematics (BCAM) and Instituto de Ciencias Matemáticas (ICMAT).

#### Eva Miranda

Interview for Centre de Recerca Matemàtica on 11F. "La bellesa de les matemàtiques consisteix en captar l'essència de les coses" Interview for ARA with Toni Pou, May 2023.

"La investigación es una montaña rusa llena de emociones". La Vanguardia, November 2023.

#### OTHER

Joan Porti Piqué

Vicepresident of the Societat Catalana de Matemàtiques

#### **Dolors Herbera**

Member of the Editorial Board of: Journal of Algebra and its Applications, and of Communications in Algebra.

Secretary of the Comité Español de Matemáticas (Spanish Adhering Organization to IMU) Involved in the evaluation of Postdoctoral Grans for AGAUR (Generalitat de Catalunya, Spain), PhD Grants (INPHiNit program) for La Caixa Foundation (Spain) and evaluation reports for positions for the Czech Academy of Sciences and for Yamouk University (Jordan).

#### Eva Miranda

London Mathematical Society Hardy Lecturer Invited to give a lecture "Singular Symplectic Manifolds" in the Nachdiplom series at ETH Zurich for the fall of 2025.

# DYNAMICAL SYSTEMS

#### DESCRIPTION

Dynamical systems theory looks for the milestones that organize dynamics, essentially their invariant objects and their connections. In this ambitious goal, the group has a recognized track record and a leading role, addressing it through, among others, analytical, geometrical, topological, or numerical tools, which, complemented, also contribute to a deeper understanding of the dynamics of a system. The dynamics of the systems studied, which are real or complex, can be both discrete and continuous, their dimensions are low or high, depending very much on the specific applications.

In low-dimensional systems, the search for periodic orbits and their repercussions on global dynamics is of paramount importance, especially as a result of the associated symbolic, topological, and combinatorial dynamics. The computational and numerical implementation for looking the phase portraits and bifurcation diagrams is also widely used in modelization and other applications.

In high-dimensional systems, the search for invariant tori and their disposition into normally hyperbolic invariant objects is studied especially to describe the skeleton from which emanates global dynamics, such as KAM theory, Arnold diffusion, and associated exponentially small phenomena, with special attention to applications in Celestial Mechanics, Astrodynamics, Neuroscience, and Chemistry.

#### **MEMBERS**

Senior Researchers: Lluís Alsedà | Immaculada Baldomà | Amadeu Delshams | Núria Fagella | Ernest Fontich | Armengol Gasull | Marcel Guardia | Alejandro Haro | Xavier Jargue | Àngel Jorba | Tomás Lazaro | Pau Martín de la Torre | Tere Martínez-Seara | Josep Masdemont | Mercè Ollé | Joan Torregrossa | Arturo Vieiro

Postdoctoral Researchers: | Marc Jorba | Gustavo Rodrigues Ferreira | Frank Trujillo PhD Students: Dídac Gil

#### PROJECTS

PID2021-122954NB-100 Invariant Manifolds, Hamiltonian systems and dynamics in Neuroscience, Epidemiology and Atmosphere (IMNHEA).

PIs: Tere Martinez-Seara and Inmaculada Baldoma

funded by MCIN/AEI/10.13039/501100011033/ and ERDF A way of making Europe

LE022-2-1819 Detectando Estructuras Lagrangianas Coherentes en flujos geofísicos IP: Jezabel Curbelo Funded by Fundación BBVA

PID2021-125535NB-100 Métodos analíticos y computacionales en sistemas dinámicos Pls: Angel Jorba and Alejandro Haro Funded by Ministerio de Ciencia, Innovación y Universidades

PID2020-118281GB-C32 Estabilidad y caos en iteración holomorfa PI: Núria Fagella Funded by Ministerio de Ciencia e Innovación

PID2021-123968NB-100 Métodos modernos en mecánica celeste y aplicaciones PIs: Josep Masdemont and Pau Martín de la Torre Funded by Ministerio de Ciencia e Innovación

PID2022-136613NB-100 Continuous and Discrete Dynamical Systems: Bifurcations, periodic orbits, integrability and applications PI: Joan Torregrosa Funded by Ministerio de Ciencia e Innovación

RED2022-134273-T Dinamica, atractores, No linealidad, Caos y estabilidad PI: Joan Torregrosa Funded by Ministerio de Ciéncia e Innovación

PID2019-104851GB-100 Problemas analíticos y computacionales en sistemas dinamicos y aplicaciones Pls: Ernest Fontich and Arturo Vieiro Funded by Ministerio de Ciencia, Innovación y Universidades

PGC2018-098676-B-I00. Dinámica Asociada a Conexiones entre Objetos Invariantes con Aplicaciones a la Neurociencia y la Mecánica (DACOBIANEM). Pls: Gemma Huguet and Tere Martinez-Seara. Funded by Agencia Estatal de Investigación.

PID2019-104658GB-100 Estudio de los sistemas dinàmicos continuos y discretos con énfasis en sus bifurcaciones, órbitas periòdicas e integrabilidad PI: Joan Torregrosa Funded by Ministerio de Ciéncia e Innovación

2021SGR00113 Dynamical Systems: Theory, mathematical modelization and applications PI: Joan Torregrosa Funded by Generalitat de Catalunya

PID2020-118281GB-C31 Sistemas dinámicos discretos y continuos orientados a la modelización y las aplicaciones PI: Lluís Alsedà Funded by Ministerio de Ciéncia e Innovación

PID2019-104658GB-100 Estudio de los sistemas dinàmicos continuos y discretos con énfasis en sus bifurcaciones, órbitas periòdicas e integrabilidad PI: Joan Torregrosa Funded by Ministerio de Ciéncia e Innovación

H2020-MSCA-RISE-2017-777911 Contributions to codimension k bifurcations in dynamical systems theory - Dynamics PI: Joan Torregrosa Funded by European Community Project

#### PUBLICATIONS

Baldomá, I. & Capiński, M.J. & Guardia, M. & Seara, T.M. (2023). *Breakdown of Heteroclinic Connections in the Analytic Hopf-Zero Singularity: Rigorous Computation of the Stokes Constant*. J Nonlinear Sci 33, 28 (2023). https://doi.org/10.1007/s00332-022-09882-x

Bonet, C. & Jeffrey, M.R. & Martín, P. & Olm, J.M. (2023). *Novel slow-fast behaviour in an oscillator driven by a frequency-switching force.* Communications in Nonlinear Science and Numerical Simulation. Volume 118, April 2023, 107032. doi: https://doi.org/10.1016/j.cnsns.2022.107032

Gimeno, J. & Jorba, À. & Jorba-Cuscó, M. & Miguel, N. & Zou, M. (2023). *Numerical integration of high-order variational equations of ODEs.* Applied Mathematics and Computation. Volume 442, 1 April 2023, 127743. doi: https://doi.org/10.1016/j.amc.2022.127743

Ferragut, A. & Gasull, A. & Zhang, X. (2023). *Meromorphic first integrals of analytic diffeomorphisms.* Journal of Mathematical Analysis and Applications. Volume 519, Issue 1, 1 March 2023, 126796. doi: https://doi.org/10.1016/j.jmaa.2022.126796

Fontich, E. & Vieiro, A. (2023). *Dynamics near the invariant manifolds after a Hamiltonian-Hopf bifurcation*. Communications in Nonlinear Science and Numerical Simulation. Volume 117, February 2023, 106971. doi: https://doi.org/10.1016/j.cnsns.2022.106971

Álvarez, M.J. & Gasull, A. & Prohens, R. (2023). *Uniqueness of the limit cycles for complex differential equations with two monomials.* Journal of Mathematical Analysis and Applications. Volume 518, Issue 1, 1 February 2023, 126663. doi: https://doi.org/10.1016/j.jmaa.2022.126663

Clarke, A. & Fejoz, J. & Guàrdia, M. (2023). *Topological shadowing methods in arnold diffusion: weak torsion and multiple time scales.* Nonlinearity 36 426. DOI 10.1088/1361-6544/aca5df

Canela, J. & Evdoridou, V. & Garijo, A. & Jarque, X. (2023) *On the basins of attraction of a onedimensional family of root finding algorithms: from Newton to Traub.* Math. Z. 303, 55 (2023). https:// doi.org/10.1007/s00209-023-03215-8

Fagella, N. & Jové, A. (2023) *A model for boundary dynamics of Baker domains.* Math. Z. 303, 95 (2023). https://doi.org/10.1007/s00209-023-03245-2

Rosales, J.J. & Jorba, À. & Jorba-Cuscó, M. (2023) *Invariant manifolds near L1 and L2 in the quasi-bicircular problem*. Celest Mech Dyn Astron 135, 15 (2023). https://doi.org/10.1007/s10569-023-10129-4

Lázaro, T.J. & Alarcón, T. & Garay, C.P. & Sardanyés, J. (2023) *Semiclassical theory predicts stochastic ghosts.* scalingProc. R. Soc. A.47920220621. http://doi.org/10.1098/rspa.2022.0621

Baldomá, I. & Giralt, M. & Guàrdia, M. (2023). *Breakdown of homoclinic orbits to L3 in the RPC3BP (II). An asymptotic formula*. Advances in Mathematics. Volume 430, 1 October 2023, 109218. doi: https://doi. org/10.1016/j.aim.2023.109218

Bastos, J.L.R. & Buzzi, C.A. & Torregrosa, J. (2023) *Cyclicity Near Infinity in Piecewise Linear Vector Fields Having a Nonregular Switching Line.* Qual. Theory Dyn. Syst. 22, 125 (2023). https://doi. org/10.1007/s12346-023-00817-9

Gasull, A. & Zhao, Y. (2023) *Existence of at most two limit cycles for some non-autonomous differential equations.* Communications on Pure and Applied Analysis, 2023, 22(3): 970–982. doi: 10.3934/ cpaa.2023016

Coll, B. & Gasull, A. & Prohens, R. (2023) *Probability of existence of limit cycles for a family of planar systems.* Journal of Differential Equations. Volume 373, 15 November 2023, Pages 152–175. dol: https://doi.org/10.1016/j.jde.2023.07.015

Gasull, A. & Luca, F. & Varona, J.L. (2023) *Indagationes Mathematicae*. Volume 34, Issue 6, November 2023, Pages 1373-1396. doi: https://doi.org/10.1016/j.indag.2023.07.002

Cima, A. & Gasull, A. & Mañosa, V. & Mañosas, F. (2023). *On some rational piecewise linear rotations.* Journal of Difference Equations and Applications, 1–13. https://doi.org/10.1080/10236198.2023.2260898

Reyner-Parra, D. & Bonet, C. & Seara, T.M. & Huguet, G. (2023) *Traveling waves in a model for cortical spreading depolarization with slow-fast dynamics.* Chaos 1 August 2023; 33 (8): 083154. https://doi.org/10.1063/5.0160509

Akingbade, S.W. & Gidea, M. & M-Seara, T. *Arnold Diffusion in a Model of Dissipative System.* SIAM Journal on Applied Dynamical Systems. Volume 22 (3), 1983–2023. doi: https://doi.org/10.1137/22M1525508

Gasull, A. & Guillamon, A. & Mañosa, V. (2023). *Counting configurations of limit cycles and centers.* Buletinul Academiei de Stiinte A republicii Moldova. Matematica. Number 1(101), 2023, Pages 78–96 ISSN 1024–7696, E-ISSN 2587–4322. doi: https://doi.org/10.56415/basm.y2023.i1.p78

M-Seara, T. & Ollé, M. & Rodríguez, Ó. & Soler, J. (2023) *Generalized Analytical Results on n-Ejection-Collision Orbits in the RTBP.* Analysis of Bifurcations. J Nonlinear Sci 33, 17 (2023). https://doi.org/10.1007/ s00332-022-09873-y

Curbelo, J., & Rypina, I. I. (2023). *A three dimensional Lagrangian analysis of the smoke plume from the 2019/2020 Australian wildfire event*. Journal of Geophysical Research: Atmospheres, 128, e2023JD039773. https://doi.org/10.1029/2023JD039773

Alsedà, L. & Juher, D. & Los, J. & Mañosas, F. (2023) *On Families of Bowen – Series–Like Maps for Sur-face Groups.* Regul. Chaot. Dyn. 28, 659–667 (2023). https://doi.org/10.1134/S1560354723040093

Fejoz, J. & Guàrdia, M. *A Remark on the Onset of Resonance Overlap.* Regul. Chaot. Dyn. 28, 578–584 (2023). https://doi.org/10.1134/S1560354723040056

Giuliani, F. & Guàrdia, M. (2023), *Arnold diffusion in Hamiltonian systems on infinite lattices*. Comm. Pure Appl. Math.. https://doi.org/10.1002/cpa.22191

#### **DEFENDED THESES**

Contributions to the study of periodic orbits and invariant manifolds in dynamical systems Clara Cufí Cabré Supervisors: Ernest Fontich Julià and Jaume Llibre Defended at Universitat Autònoma de Barcelona

About the connectivity of Fatou components for some families of rational maps Dan Alexandru Paraschiv Supervisors: Xavier Jarque Ribera and Jordi Canela Sánchez

Defended at Universitat de Barcelona

#### Degenerate invariant tori in KAM theory

Juan Pello García Supervisors: Àlex Haro Provinciale and Ernest Fontich Julià Defended at Universitat de Barcelona

Unstable motions in the Three Body Problem Jaime Paradela Díaz Supervisors: Marcel Guàrdia Munarriz and Teresa Martínez-Seara Alonso Defended at Universitat Politècnica de Catalunya

#### **SCIENTIFIC ACTIVITIES**

13TH INTERNATIONAL CONFERENCE ON NONLINEAR MATHEMATICS AND PHYSICS I NOLINEAL 2023 26-28 June 2023 Centre de Recerca Matemàtica | Barcelona Josep J. Masdemont (UPC-CRM), Angel Jorba (UB-CRM) as part of the Scientific Committee Inma Baldomà (UPC-CRM), Jezabel Curbelo (UPC-CRM), Pau Martín (UPC-CRM), Mercè Ollé (UPC-CRM) as part of the Organizing Committee Speakers: Tomás Alarcón (ICREA\_CRM) | Amadeu Delshams (UPC-CRM) | Marc Jorba-Cuscó (UPC-CRM)| Gemma Huguet (UPC-CRM)

#### BARCELONA INTRODUCTION TO MATHEMATICAL RESEARCH 2023 SUMMER PROGRAM

03-28 July 2023 Universitat de Barcelona | Barcelona Courses hosted by: Natàlia Castellana (UAB-CRM) | Jezabel Curbelo (UPC-CRM) | Francesc Fité (UB-CRM) | Juanio Rué (UPC-CRM) Organizers: Paloma Bengoechea (UB-CRM) | Gemma Huguet (UPC-CRM) | Xavier Ros-Oton (UB-CRM)

#### 19TH SCHOOL ON INTERACTIONS BETWEEN DYNAMICAL SYSTEMS AND PARTIAL DIFFERENTIAL EQUATIONS (JISD2023)

03-07 July, 2023 Centre de Recerca Matemàtica | Barcelona Organizing Committee: Xavier Cabré (ICREA-UPC-CRM) | Gyula Csato (UB-CRM) | Amadeu Delshams (UPC-CRM) | Marcel Guàrdia (UB-CRM) | Tere M. Seara (UPC-CRM)

#### FITTING DATA WITH DYNAMICAL MODELS: TEN LESSONS ON MATHEMATICAL FIELD WORK

October 24 - December 05, 2023 Centre de Recerca Matemàtica | Onlien Speakers: Lluís Alsedà (UAB-CRM) | Marc Jorba-Cuscó (UPC-CRM) | Josep Sardanyés (CRM)

#### ICM-CRM MEETING: NEW BRIDGES BETWEEN MARINE SCIENCES AND MATHEMATICS

02-10 November, 2023 Institut de Ciències del Mar (CRM) | Centre de Recerca Matemàtica (CRM) Speakers: Lluís Alsedà (UAB-CRM) | Álvaro Corral (UAB) | Jezabel Curbelo (UPC-CRM) | Filip Ivancic (CRM) | Àngel Jorba (UB-CRM) | Marc Jorba-Cuscó (UPC-CRM) | Pere Puig (UAB-CRM) | Josep Sardanyés (CRM) Organizer: David Romero (CRM)

#### JORNADA DE PORTES OBERTES AL CRM

13 November, 2023 Centre de Recerca Matemàtica | Barcelona Speakers: Jezabel Curbelo (UPC-CRM) | Xavier Jarque (UB-CRM) | David Romero (UAB) | Alex Roxin (CRM) | Sergey Tikhonov (ICREA-CRM)

#### 6A JORNADA DE SISTEMES DINÀMICS DE CATALUNYA

11 October, 2023 Institut d'Estudis Catalans, Barcelona Organizer: Ernest Fontich Julià (UB-CRM) Speaker: Arturo Vieiro Yanes (UB-CRM)

LSC-RETREAT 4.0 ON MATHEMATICAL MODELLING IN BIOLOGY 24-26 January, 2023. Laboratorio Subterráneo de Canfranc (LSC)

#### SCHOOL ON CONFORMAL SYMPLECTIC DYNAMICS AND RELATED FIELDS

8-12 May. 2023 Centre International de Rencontres Mathématiques (CIRM) Marsella Scientific committee: Tere M. Seara (UPC-CRM)

#### EMS SUMMER SCHOOL: TOPICS IN COMPLEX DYNAMICS 2023

19-23 June. 2023 Institute of Mathematics at the Universitat de Barcelona Scientific Committee: Núria Fagella (UB-CRM) Organizing Committee: Núria Fagella (UB-CRM) | Xavier Jargue (UB-CRM) | Kostya Drach (UB-CRM)

#### MODERN HOLOMORPHIC DYNAMICS AND RELATED FIELDS

March 1 - June 30, 2023. University of Warsaw Invited Speaker: Núria Fagella (UB-CRM)

September 4-8, 2023. University of Lodz Programme Committee: Núria Fagella (UB-CRM) Speaker: Núria Fagella (UB-CRM)

#### BARCELONA MATHEMATICAL DAYS: SESSION "SISTEMES DINÀMICS"

2-3 November, 2023 Institut d'Estudis Catalans, Barcelona Organizers and Speakers: Inma Baldomà (UPC-CRM)

REPTES EN MATEMÀTIQUES I EL SEU IMPACTE SOCIAL 12 Desember, 2023 Madrid Round Table: Núria Fagella (UB-CRM)

SPANISH-POLISH MATHEMATICAL MEETING. SPECIAL SESSION IN DISCRETE DYNAMICAL SYSTEMS

#### **OUTREACH ACTIVITIES**

SIJIMAT: Portes Obertes al CRM 16, November, 2023 Centre de Recerca Matemàtica | Barcelona Speakers: Lucía Arancibia (CRM) | Giovanni Dalmaso (CRM) | Dídac Gil (CRM) | Roser Homs (CRM)

#### Núria Fagella

Round Table: Retos en matemáticas y su impacto social. Fundación Ramón Areces. Madrid, December 13, 2023. Talk-Workshop: "Fractals: Models matemàtics de la natura": - DITMAE 2023. Figueres, Febrer 2023. - DITMAE 2023. La Seu d'Urgell. Abril 2023. Talk: "Do's and Don'ts about giving math talks". Learning Week I: Academic skills and advanced topics in CAD, 2021, BGSMath 2023. Interview for Centre de Recerca Matemàtica on 11F.

**Tere M- Seara** Interview for Centre de Recerca Matemàtica on 11F.

Kostiantyn Drach Special lecture within Kharkiv-Vienna Summer School

#### OTHER

Tere M. Seara

Editorial boards:

 $\cdot$  Journal of Dynamics and Differential equations (JDDE).

• Nonlinearity.

• Nonlinear Differential Equations and Applications (NoDEA).

# CLIMATE CHANGE AND NATURAL HAZARDS

#### DESCRIPTION

Our goal is to use mathematical and statistical techniques to deal with natural hazards and tackle environmental challenges, including issues from the forecasting of extreme weather events to carbon capture. Extreme natural hazards are a great societal problem, not only in underdeveloped countries, and are negatively affected by climate change. Their physics is poorly understood, and a lack of reliable statistics hinders risk assessment or identification of signatures of climate change. We will address the study of atmospheric and oceanic phenomena enhancing sub-seasonal predictability of weather events, and in particular their extremes. In a broader context, we will perform different statistical analysis of natural-hazard occurrence.

Tackling environmental challenges is this generation's defining task (EC Green Deal 2020). One such challenge, holding global warming to 2°C, can only be achieved through the extraction of greenhouse gases and emission reductions, among others. A toxic free environment requires the removal of a multitude of contaminants. We will focus on topics related to the elimination of pollutants, including the removal of environmental contaminants such as C02, volatile organic compounds and pharmaceuticals via adsorption techniques, the role of green roofs and also the use of direct absorption solar cells.

#### **RESEARCH LINES**

#### **Complex Systems**

At the CRM Complex Systems Group, we focus on two major lines of research: one, natural disasters and meteorological phenomena, resulting from the complex activity of the Earth's system, and the other, the structure of information in human communication, produced by the areas of the brain responsible for this and the relationship between the communicating agents. Regarding natural hazards, we study the occurrence patterns of earthquakes, forest fires, hurricanes, rainfall, etc., with the idea that the statistical properties of these phenomena contain key information for their understanding, modelling and forecasting. In relation

#### Industrial Mathematics

The Industrial Mathematics group is currently contributing, in terms of research, primarily in the application of mathematics to the environment and nanotechnology. More traditional IM activities are not forgotten through the group's involvement in international Study Groups. As well as publishing journal articles group members produced a book on practical applications of mathematics (Eds. F. Font, T. Myers) and the group leader submitted a book to CUP on novel moving boundary problems. The

primary research topics dealt with by group members in 2021 included: column sorption, phase change, lensless imaging of nanoparticles, nanocrystal growth, nanoscale heat flow and other topics such as green roofs, clutch manufacture, spontaneous combustion, mask design and trade in rhino horn.to human communication, we concentrate both in both natural language and music. Again, we study occurrence patterns, this time of the symbols that constitute the texts or the musical composition, in order to better understand how these unique human characteristics work, and also to investigate whether machines could reproduce them.

#### **Probability & Statistics**

Our group conducts internationally recognised research in methodological and substantive applications, the most of which are concerned with the effects of climate change and/or natural hazards. The group's goal is to use stochastic and statistical modelling tools to analyse and solve practical multidisciplinary problems, and to apply the ideas and results from the theoretical investigation to problems in epidemiology, phage dynamics, queuing networks, criminology, extreme events, syndromic surveillance, and biological dosimetry. Important challenges in these applied fields provide a rich stream of research subjects for the group, leading to publications in high impact journals like the Journal of the American Statistical Association, Statistics in Medicine, Radiation Research, etc. As a recent example of our work, we used our models to calculate the probability of a Carrington-like geomagnetic storm occurring. We also used a new model to analyse and predict the underreported covid cases during the previous pandemic. Several PhD students contribute significantly to some of our research projects. Our group is highly involved in the training of young researchers, with two postdoctoral researchers who have been awarded public competitive funds (Juan

#### MEMBERS

Senior Researchers: Álvaro Corral | Tim Myers | Pere Puig Postdoctoral Researchers: Lucy Auton | Cristina Crespo | Álvaro González PhD Students: Mónica Minjares

#### PROJECTS

H2020-MSCA-ITN, *Climate Advanced Forecasting of sub-seasonal Extremes (CAFE)* IP: Álvaro Corral Funded by the European Commission

PID2021-1259790B-100 Aplicaciones de la ciencia de sistemas complejos a los desastres naturales, epidemias y patrones de población. IP: Álvaro Corral Funded by Ministerio de Ciencia e Innovación

PID2020-115023RB-100 *Aplicaciones mediambientales de difusión con una forntera móvil* PI: Tim Myers Funded by Ministerio de Ciencia e Innovación

PDC2021-121088-100 La explotación de las matemáticas para ayudar en el diseño de columnas de adsorción (MathCol) PI: Tim Myers Funded by Ministerio de Ciencia e Innovación

#### PUBLICATIONS

Weiß, C. H. & Puig, P. & Aleksandrov, B. (2023). Optimal Stein-type goodness-of-fit tests for count data. Biometrical Journal, 65, 2200073. https://doi.org/10.1002/bimj.202200073

Myers, T.G. & Cabrera-Codony, A. & Valverde, A. (2023). On the development of a consistent mathematical model for adsorption in a packed column (and why standard models fail). International Journal of Heat and Mass Transfer. Volume 202, March 2023, 123660. doi: https://doi.org/10.1016/j. ijheatmasstransfer.2022.123660

Aquareles, M. & Calvo-Schwarzwalder, M. & Font, F. & Myers, T.G. (2023). A mathematical model for the energy stored in green roofs. Applied Mathematical Modelling. Volume 115, March 2023, Pages 513-540. doi: https://doi.org/10.1016/j.apm.2022.10.042

Moriña, D. & Fernández-Fontelo, A. & Cabaña, A. & Arratia, A. & Puig, P. (2023) Estimated Covid-19 burden in Spain: ARCH underreported non-stationary time series. BMC Med Res Methodol 23, 75 (2023). https://doi.org/10.1186/s12874-023-01894-9

del Castillo, J. & Puig, P. (2023) Distinguishing between a power law and a Pareto distribution. Phys. Rev. E 107, 064113. DOI:https://doi.org/10.1103/PhysRevE.107.064113

Mitchell, S.L. & Myers, T.G. (2023). On the safe storage of bagasse. The ANZIAM Journal. 2023;65(1-2):79-92. doi:10.1017/S1446181123000044

Badiella, L. & del Castillo, J. & Puig, P. (2023) Ultra log-concavity of discrete order statistics. Statistics & Probability Letters. Volume 201, October 2023, 109900. doi: https://doi.org/10.1016/j.spl.2023.109900

Puig, P., & Valero, J. & Fernández-Fontelo, A. (2023). Some mechanisms leading to underdispersion: Old and new proposals. Scand J Statist, 51(1), 245–267. https://doi.org/10.1111/sjos.12677

Corral, Á. & Minjares, M. & Barreiro, M. (2023) Increased extinction probability of the Madden-Julian oscillation after about 27 days. Phys. Rev. E 108, 054214. DOI:https://doi.org/10.1103/PhysRevE.108.054214

#### **DEFENDED THESES**

Models per a dades de recompte amb mesures repetides i errors de mesura Llorenc Badiella Busquets Supervisor: Pere Puig Defended at Universitat Autònoma de Barcelona

#### **SCIENTIFIC ACTIVITIES**

#### ICM-CRM MEETING: NEW BRIDGES BETWEEN MARINE SCIENCES AND MATHEMATICS

02-10 November, 2023 Institut de Ciències del Mar (CRM) | Centre de Recerca Matemàtica (CRM) Speakers: Lluís Alsedà (UAB-CRM) | Álvaro Corral (UAB) | Jezabel Curbelo (UPC-CRM) | Filip Ivancic (CRM) | Àngel Jorba (UB-CRM) | Marc Jorba-Cuscó (UPC-CRM) | Pere Puig (UAB-CRM) | Josep Sardanyés (CRM) Organizers: David Romero (CRM) | Josep Sardanyés (CRM)

#### XI GEFENOL SUMMER SCHOOL ON STATISTICAL PHYSICS OF COMPLEX SYSTEMS

17-28 July, 2023 University of Barcelona, Faculty of Physics Scientific and organizing committee: Álvaro Corral (CRM)

#### X COMPLEXITAT DAY

21 June, 2023 La Lleialtat Sansenca Barcelona. Scientific Committee: Álvaro Corral Speakers: Josep Sardanyés (CRM-UAB) | Giovanni Dalmasso (CRM-UAB)

#### **OUTREACH ACTIVITIES**

#### Alvaro Corral

- Article for the CAFE Project blog: M. Minjares and A. Corral, "Sudden deactivation of the Madden-Julian Oscillation".

-"The (abnormal) Mathematics of Natural Hazards": Talk at the Cicle Contemporalia Ciència, "Cercant la certesa en un món incert". Casa de Cultura Girona, October 19, 2023

- Outreach through Twitter.

- "La Laura i en Joan fan recerca a tota potència": book series. General Directorate of Research.

#### Mónica Miniares

- "La Laura i en Joan fan recerca a tota potència": book series. General Directorate of Research.

#### Pere Puig

- "Veient l'invisible: un repte per a la modelització estadística": Talk at the Cicle Contemporàlia Ciència,
- "Cercant la certesa en un món incert". Casa de Cultura Girona. October 19. 2023

#### Álvaro González

Charity breakfast and conference on Turkish earthquakes. March 3, 2023. Centre de Recerca Matemàtica.

#### **OTHER**

Álvaro Corral

- Vocal and member of the scientific committee of the Catalan Network for the Study of Complex Systems

- Host of the visit of Scott Hottovy to CRM, through the CRM Program Research in Pairs



One of the cornerstones of the CRM, explicitly stated in its statutes, is the transfer of the research carried out within the center. It is considered important to disseminate both the knowledge obtained and the methodologies used, seeking to maximize their social impact. To this end, the CRM works together with other research institutions, companies, and industries. The Knowledge Transfer Unit (KTU) is the main link for companies and industries with the CRM to foster collaborations. In particular, the KTU develops ad hoc research to solve challenges with social impact, in which designed mathematical solutions are developed, either for original projects of the center or focused on the challenges posed by other institutions. This research takes benefit from the synergy of the KTU with the research groups in the center.

The actions involved in putting knowledge to practical use is a major concern for the CRM, the CERCA institutions and their researchers. There are many opportunities to apply CRM research findings in society and participate in its development. The KTU identifies viable results, connects researchers with companies, and offers consulting services.

Because we are at CRM, the KTU:

. Knows (mainly) mathematical tools and, moreover, collaborates with people that know cutting-edge mathematical tools that can be transferred to practical challenges. We are not "blind" developers: before developing a software, we have a look and mince . the problem.

- To tackle the industrial and applied research challenges we:
- Take advantage of being a mathematical hub.
- Conduct practical research.
- Act as a training unit.

#### The projects

The projects in which the KTU is active on are:

**AIMCOOK**: For this project, the KTU is exploring and improving a mathematical model for cooking a wide range of foods using a new device. The unit is also creating an interface for the program to provide a more user-friendly experience.

**DYSEDAS** (Data shrinking method enabled by Dynamical Systems for resources saving) aims to develop a lossless data compression method, that increases compression rates well beyond the current stateof-the-art. This project is a collaboration between the CRM - KTU and the ALBA Synchrotron, who will be the final user of the developed data compression method.

LICSAI: This project focuses on cybersecurity. The KTU developed a model to quantify the uncertainty of an artificial intelligence algorithm developed by I2Cat to determine the risk of an individual being a victim of a phishing attack.

**HEMOCOVID** is a multi-center, international clinical research project coordinated by the Medical Photonics group at the Institut de Ciències Fotòniques (ICFO) and Hospital Parc Taulí Sabadell. The role of CRM - KTU in this project is to perform a statistical analysis of the data collected from different centers. The objective is to identify discrepancies that cannot be explained by the measured data, but rather by issues with the devices or incorrect experimental protocols.

TIPSAVIR (Therapeutic Interfering ParticleS as AntiVIRal therapy): In this project we simulate the infection of a virus on a tissue at the level of RNA replication. This enables us to study different aspects of virus evolution in silico in low computation time. The goal of the project is to find the correct RNA sequence (generated by replication of the wild-type virus) that can stop the infection.

#### Members and training

This 2023, the Unit has added three new Scientific Program Developers and one Research Technician, one of them from Investigo programs (SEPE and AGAUR).

#### Members:

Scientific Software Developer: Clara Cufí | Axel Masó | Pau Reig | Andrea Suárez Impact Officer: Albert Escolà Research Technician: Sandra Hidalgo Director: David Romero

A doctoral thesis, one master theses and one final degree project have been co-directed from the KTU, with the aim that encompasses the whole CRM of reaching towards powerful interdisciplinary research.

The doctoral thesis is currently being written by Antonio Jesús Ortiz García. It is co-directed by David Romero (CRM), Toni Guillamon (UPC-CRM) and Jesús Giraldo (INc). The thesis topic is on computational methods and modelization of the behavior of specific reactions inside pharmacology.

Degree thesis: Ricard Sierra. Foot-MoneyBall: anàlisi d'equips i jugadors, i predicció de rendiments.

Master thesis: (co-directed with Sergio Villamyor Tomás from ICTA) Rut Blanco Prieto. Modelling the Impact of CLimate Change and depopulation in rural areas of l aRioja, Spain. A cellular automaton approach.

Besides that, 4 interns have stayed on different periods in the KTU, as well as the awardees of a Premi Extraordinari de Batxillerat (Baccalaureate Extraordinary Prize).

#### Scientific Activities

#### TRB Conference 8-12 January, 2023 Washington, USA

Transfiere 15-17 February, 2023 Málaga

EBRT2023 Kickoff 2-3 February, 2023 Brussels, Belgium

Binding Kinetics and Mechanistic PK/PD modeling in early Drug Discovery 27-28 March, 2023 Cambdrige

EBRT2023 follow-up 20-22 November, 2023 Rimini, Italy

**Co-organization of ICM meetings** 2-10 November, 2023 Barcelona

#### **Outreach Activities**

Talk: "Matemàtiques per la sostenibilitat: dels ecosistemes a la intel·ligència artificial" at "Dilluns de Ciència. Desafiaments i reptes del Canvi Global" by Residència d'Investigadors 20 March. 2023 Speakers: David Romero (KTU), Josep Sardanyés (CRM)

Talk: "Fem un got de ciència" at Nit de la Ciència (Vic) 28 September, 2023 Speaker: Axel Masó

#### Publications and Posters

#### Publications:

Díaz, Ó. & Martín, V. & Renault, P. & Romero, D. & Guillamon, A. & Giraldo, J. Allosteric binding cooperativity in a kinetic context (2023). Drug Discovery Today. Volume 28, Issue 2, February 2023, 103441. doi: https://doi.org/10.1016/j.drudis.2022.103441

#### Posters:

Poster at Washington: A Digital Twin for Local Transport Service Comparison Poster at Cambridge Modeling and study of the heterodimerization process of G Protein- Coupled Receptors (GPCRs): towards combined drug therapies

#### Participations and Collaborations

David Romero from the KTU is a member of the Severo Ochoa Maria de Maeztu (SOMMA) Workgroup 'Narrative and Impact'. Its objective is to broaden and renew the definition of transference in accordance with the international context and focused on the social impact. The second objective is to work on a new set of indicators more fit to all research disciplines and a broader variety of outcomes to measure the impact.

The KTU is also an active member in Math-In network. Lately it has been involved in projects involving the logistic sector and creating synergies with other centers such as Galician Centre for Mathematical Research and Technology (CITMAGA).

Furthermore, the KTU participes in the CERCA meetings.



## **3RD BARCELONA** WEEKEND ON **OPERATOR ALGEBRAS**

JANUARY 27 - 28, 2023

#### DESCRIPTION

The theory of C\*-algebras, after the major breakthrough in the classification programme, is now at a game changing point, where the quest for large classes of examples that satisfy the main assumptions to fall into the classifiable class has begun. Many of these examples are found within topological dynamical systems and their noncommutative counterpart, the C\*-dynamical systems. Another important line of research consists of, on the one hand, deciding whether certain assumptions in the current classification theorems are redundant and, on the other hand, using finer invariants and their intrinsic theory to find broader classes of C\*-algebras that are amenable to be understood. Also a consequence of the recent achievements in classification is the idea to aim at larger families of C\*-algebras: new milestones in this direction are set on removing the restrictions of simplicity and Z-stability, and for both cases the need for a larger and finer invariant is naturally required. It has been known for a long time that the Cuntz semigroup, an ordered abelian semigroup generalizing K-theory, should play a key role.

#### ORGANIZERS

Ramon Antoine | UAB/CRM Joan Bosa | Universidad de Zaragoza Francesc Perera | UAB/CRM







#### **INVITED SPEAKERS**

Francesca Arici | Universiteit Leiden Kristin Courtney | University of Münster (WWU) Jamie Gabe | University of Southern Denmark **Eusebio Gardella** | Chalmers University of Technology Antonio Peralta | Universidad de Granada Karen Strung | Czech Academy of Sciences Hannes Thiel | Kiel University Alessandro Vignati | Université de Paris Eduard Vilalta | Universitat Autònoma de Barcelona

#### GENDER BALANCE



MALE FEMALE PREFER NOT TO SAY

#### GEOGRAPHIC DISTRIBUTION



NATIONAL EUROPE **REST OF THE WORLD** 

## BARCCSYN 2023

Barcelona Computational, Cognitive and Systems Neuroscience Meeting

MAY 25 - 26, 2023

#### DESCRIPTION

The annual Barcelona Computational, Cognitive and Systems Neuroscience (BARCCSYN) meeting is about bringing together researchers from computational, systems and cognitive neuroscience. Our goal is to provide a forum for lively discussion and promote active collaboration between Barcelona-based research groups, especially between theorists and experimentalists.

This is the 11th annual Barccsyn conference. The conference will be held on May 25 and 26, 2023, at the Institut d'Estudis Catalans. Each day we will have 8-10 brief oral presentations from local researchers, a poster session and two longer keynote lectures from two renowned researchers from abroad.

BARCCSYN 2023 is the first edition organised by the section Neurociència computacional i de sistemes that belongs to the Societat Catalana de Biologia and Societat Catalana de Matemàtiques.

#### ORGANIZERS

Gemma Huguet | Universitat Politècnica de Catalunya – CRM Chiara Mastrogiuseppe | Universitat Pompeu Fabra Adrián Ponce Álvarez | Universitat Politècnica de Catalunya Klaus Wimmer | CRM



#### INVITED SPEAKERS

Julijana Gjorgjieva | Technische Universität München Maurizio Mattia | Italian National Institute of Health (ISS)

#### GENDER BALANCE



#### GEOGRAPHIC DISTRIBUTION



## HYPATIA 2023

#### JUNE 5 - 8, 2023

#### DESCRIPTION

This summer school series aims at training their participants in key strategic problems in mathematics and their applications, with the core idea that theory and applications strengthen each other. The school is focused in training of young researchers whilst opening new fields for senior ones.

The Hypatia Graduate Summer School will consist in two keynote courses on subjects of exceptional promise and scientific importance delivered by highly distinguished speakers in the area plus a high-level colloquium on a complementary subject.

The Hypatia Graduate Summer School will be developed in an informal atmosphere based on discussions, exchange of ideas and critical analysis of results. Moreover, to honour its namesake, it is committed to work under a friendly gender perspective that highlights the role of women in mathematics and encourages and helps the participation and promotion of young female researchers at a professional level.

#### LECTURERS

Eva Miranda | UPC - CRM Daniel Peralta | ICMAT Susanna Terracini | Università di Torino Cristopher Moore | Santa Fe Institute





#### GENDER BALANCE

7	
10	2
	10

NATIONAL EUROPE REST OF THE WORLD

#### BIOMAT 2023: MULTISCALE METHODS AT THE FRONTIER BETWEEN DATA AND MATHEMATICAL MODELS

#### JUNE 12 - 16, 2023

#### DESCRIPTION

The eighteenth edition of the Biomat International Summer School is based on the relationship between Biochemistry and Biomechanics, and their possible applications in neuroscience. The determination of the chemical interactions that govern the genesis, growth and renewal of different types of tissues is an emerging research problem in which advances have begun to be made with important implications. To some extent, it may be surprising to understand that the mechanical interactions that take place during the mentioned processes can also condition the functioning of a whole series of chemical reactions that take place in the tissue itself. The proper understanding of this type of relationship requires approaches that combine physical-mathematical foundations, analysis of experimental data, and computational simulation of models.

That is why the lines of teaching and research that this summer school addresses are found at the interface between Physics, Mathematics, Biology, Computer Science and the aforementioned Life Sciences and Social Sciences. The speakers have extensive experience in multidisciplinary research, which, from the point of view of training young scientists, will allow them to integrate various research sensibilities: mathematical modeling from micro to macro, complexity, data analysis, developmental biology , biomechanics, tumor dynamics, cell mechanics, social dynamics, numerical simulation, Deep learning... In turn, students will be able to make contact with the new frontiers of knowledge that are opening up as a result of the combination of the mentioned aspects, allowing them to acquire a privileged position to address cutting-edge lines of research with wide repercussions on society.

It is a fact that these types of topics are framed in an international context that is increasingly conducive to collaborations between scientists and specialists from different disciplines. For the reasons mentioned, this type of multidisciplinary school is growing.



#### MNat CRM



Biomat2023, June 12-16, 2023 Multiscale Methods at the Frontier Between Data and Mathematical Models

Katie Bentley, Francis Crick Institute & King's College, London Dagmar Iber, ETH Zurich Jean-François Joanny, College de France, Paris Giovanni Petri, CENTAI Institute, Italy Bernadette Stolz-Pretzer, École Polytechnique Fédérale de Lausanne Keynote speakers Marino Arroyo, Universitat Politècnica de Catalunya Ana Paula Millán, Universitat Politècnica de Catalunya Ana Paula Millán, Universitad de Granada Xavier Trepat, IBEC, Barcelona Alfonso Valencia, Centro Nacional de Supercomputación de Barcelon



#### ORGANIZERS

Tomás Alarcon | ICREA-CRM Juan Calvo | Universidad de Granada David Poyato | Universidad de Granada Juan Soler | Universidad de Granada

#### LECTURERS

Dagmar Iber | ETH Zurich Jean-François Joanny | College de France Giovanni Petri | CENTAI Institute Bernadette Stolz-Pretzer | École Polytechnique Fédérale de Lausanne

#### LECTURERS

Marino Arroyo | Universitat Politécnica de Catalunya Ana Paula Millán | Universidad de Granada Xavier Trepat | Institute for Bioengineering of Catalonia Alfonso Valencia | Centro Nacional de Supercomputación de Barcelona



#### GENDER BALANCE

29	11	11

MALE FEMALE PREFER NOT TO SAY

#### GEOGRAPHIC DISTRIBUTION



NATIONAL EUROPE REST OF THE WORLD

#### NoLineal 2023 13TH INTERNATIONAL CONFERENCE ON NONLINEAR MATHEMATICS AND PHYSICS

#### JUNE 26-28, 2023

#### DESCRIPTION

The International Conference on Nonlinear Mathematics and Physics series started in 1997 as a bi-annual conference. It aims to offer senior and young researchers of different areas of nonlinear sciences, such as Physics, Mathematics, Biology, Economics, Social Sciences, among others, the possibility to disseminate their latest results in an interdisciplinary meeting.

The conference will consist on the following thematic sessions: Dynamical Systems, PDEs and applications, Biology, Chemistry, Machine learning, Numerical Dynamical Systems, Applications of Nonlinear Dynamics, Astrodynamics, Numerical methods in Engineering, Fluid Mechanics, Oceans and Atmosphere, Neuroscience.

#### SCIENTIFIC COMMITTEE

Francisco Balibrea Gallego | Universidad de Murcia Ricardo Chacón | Universidad de Extremadura Faustino Palmero Acebedo | Universidad de Sevilla Avadh B. Saxena | Los Alamos National Laboratory Josep J. Masdemont | Universitat Politècnica de Catalunya



Gustavo Deco | Universitat Pompeu Fabra Àngel Jorba | Universitat de Barcelona Ignacio J. Turias | Universidad de Cádiz Laura Rebollo-Neira | University of Aston Ricardo Carretero | San Diego State University Humberto Michinel | Universidad de Vigo Ma. Ángeles Rodríguez Bellido | Universidad de Sevilla Patricia Yanguas | Universidad Públida de Navarra Rosa Ma. Benito Zafrilla | Universidad Politécnica de Madrid Henar Herrero | Universidad de Castilla La Mancha

#### **ORGANIZING COMMITTEE**

Inma Baldomà | CRM i Universitat Politècnica de Catalunya Esther Barrabés | Universitat de Girona Jezabel Curbelo | Universitat Politècnica de Catalunya Pau Martín | CRM i Universitat Politècnica de Catalunya Mercé Ollé | CRM i Universitat Politècnica de Catalunya Òscar Rodríguez | Universitat Politècnica de Catalunya

#### LECTURERS

Elisa Maria Alessi | IMATI-CNR Juan M. Lopez | Arizona State University Carmen Núñez | Universidad de Valladolid Daniel Peralta-Salas | ICMAT Victor Pérez García | Universidad Castilla La Mancha Peregrina Quintela | Universidade de Santiago de Compostela

#### SPEAKERS

Maria Aguareles | Universitat de Girona Tomás Alarcón | ICREA-CRM Florentino Borondo | Universidad Autónoma de Madrid Javier Borondo | Universidad Pontificia Comillas Fernando Casas Pérez | Universitat Jaume | Manuel J. Castro Díaz | Universidad de Málaga Amadeu Delshams | UPC-CRM Elena Fantino | Khalifa University Joan Gimeno | UB/Georgia Tech Emilio Hernández García | UiB-CSIC Gemma Huguet | UPC-CRM Santiago Ibáñez | Universidad Oviedo Marc Jorba-Cusco | CRM Estrella Olmedo | CSIC Luis Rández | Universidad de Zaragoza Fabio Revuelta | Universidad Politécnica de Madrid Joan Sanchez-Umbria | UPC Toni Susín | UPC

#### GENDER BALANCE



#### GEOGRAPHIC DISTRIBUTION



REST OF THE WORLD





#### BIMR 2023 BARCELONA INTRODUCTION TO MATHEMATICAL RESEARCH 2023 SUMMER PROGRAM

#### JULY 3 - 28, 2023

#### DESCRIPTION

This new edition of the 'Barcelona Introduction to Mathematical Research' Summer School, now under the BGSMath aims to attract students in Mathematics (mainly in their 3rd or 4th year), from any University (in Barcelona or elsewhere).

The students will participate in the following activities:

- Working on a research project in Mathematics during the month of July. This will be done under the supervision of an Advisor/Tutor, and may consist of reading one or a few research papers (or book chapters), or working on a small open problem.

- Attendance to the Minicourses on Introduction to Research that will take pace during the weeks of July 3-7 and 10-14. Attendance to the Round Table: 'Academic career in mathematical research: what to do and when' and a General - Public talk (topic still to decide), that will take place during the afternoon in mid-July.

- Participation in weekly social events (coffee breaks during the minicourses, and one social pizza evening for each week of July).

#### ORGANIZERS

Paloma Bengoechea | Universitat de BarcelonaGemma Huguet | Universitat Politècnica de CatalunyaWolfgang Pitsch | Universitat Autònoma de BarcelonaXavier Ros Oton | Universitat de Barcelona

www.crm.cat/ bimr2023/
BIMR 2023 Barcelona Introduction to Mathematical Research
July 2023 Oliversitat de Barcelona (Facultat de Matemàtiques i Informàtica)
This Summer Program aims to attract students in Mathematics (mainly in their 3rd or 4th year), from any University.
<ul> <li>The students will participate in the following activities:</li> <li>Working on a research project in Mathematics during the month of July. This will be done under the supervision of an Advisor/Tutor.</li> <li>Attendance to the Minicourses on Introduction to Research.</li> <li>Attendance to the Round Table: 'Academic career in mathematical research: what to do and when' and a General Public talk (topic still to decide).</li> <li>Participation in weekly social events.</li> </ul>
MINICOURSES The students will participate in four courses on Introduction to Research, nives by
Natàlia Castellana" (UAB, Algebraic Topology)     Jezabel Curbelo (UPC, Simulation and Modelling of Fluids)     Francesc Fité (UB, Number Theory)     Juanjo Rué (UPC, Discrete Mathematics)
GRANTS There will be Accommodation fellowships for the month of July for students who live outside the Barcelona metropolitan area.
CRM9 Contractor UNIVERSITAT: BARCELONA UNIVERSITAT: UN

#### LECTURERS

Natàlia Castellana | UAB, Algebraic Topology Jezabel Curbelo | UPC, Applied Mathematics Francesc Fité | UB, Number Theory Juanjo Rué | UPC, Discrete Mathematics

#### GENDER BALANCE



PREFER NOT TO SAY

#### GEOGRAPHIC DISTRIBUTION





#### JISD 2023 19TH SCHOOL ON INTERACTIONS BETWEEN DYNAMICAL SYSTEMS AND PARTIAL DIFFERENTIAL EQUATIONS

#### JULY 3 - 7, 2023

#### DESCRIPTION

The School on Interactions between Dynamical Systems and Partial Differential Equations (JISD) is an international summer school that takes place at the School of Mathematics and Statistics of the Universitat Politècnica de Catalunya (UPC) since 2002. The last four editions have been held at the Centre de Recerca Matemàtica (CRM).

The JISD is an annual meeting between experts and young researchers in Dynamical Systems and Partial Differential Equations (PDEs). It is designed to encourage and enhance exchange of knowledge and methods, with the goal of advancing the study of cutting edge problems in the aforesaid fields of mathematics and with the aim of fostering the interaction among the participants. The symposium is aimed at local researchers, as well as scientists from the rest of Spain and foreign countries. It is organized into four advanced courses of about 7 hours and complemented by a poster session by young researchers. Throughout the latest editions the attendance numbers have ranged between 60 and 100 participants, mostly internationals.

A primary objective of the JISD is to attract talented young researchers who can present a poster to put them in condition to benefit from the exposure to world-leading experts, and help them establish working relationships that could prove critical for their short and long term success. An especially strong effort has been devoted in past years to encourage the participation of undergraduates, PhDs and postdocs from developing countries and, more generally, young researchers who may encounter difficulties in accessing an adequate financial support.

#### ORGANIZERS

Xavier Cabré | ICREA-Universitat Politècnica de Catalunya-CRM
Gyula Csato | Universitat de Barcelona-CRM
Amadeu Delshams | Universitat Politècnica de Catalunya-CRM
Marcel Guàrdia | Universitat de Barcelona-CRM
Tere M. Seara | Universitat Politècnica de Catalunya-CRM

#### SCIENTIFIC COMMITTEE

Scott Armstrong | Courant Institute, New York University Jean Pierre Eckmann | Université de Genève Jean-Michel Roquejoffre | Paul Sabatier University Susanna Terracini | Università de Torino



#### LECTURERS

Viviane Baladi (CNRS, France) Guido de Philippis (Courant Institute, US) Jacopo de Simoi (University of Toronto, Canada) Joaquim Serra (ETH Zürich, Switzerland)

#### GENDER BALANCE



#### GEOGRAPHIC DISTRIBUTION



#### BAMB! 2023 BARCELONA SUMMER SCHOOL FOR ADVANCED MODELING OF BEHAVIOUR

July 19 - 27, 2023

#### DESCRIPTION

BAMB! teaches advanced techniques in model-based analysis of behavior (humans and other species) to cognitive and computational neuroscientists at PhD and early career levels. This will be achieved through structured lectures, talks, hands-on tutorials and group project aimed at making knowledge obtained directly applicable to the participants' own research. We want the trainees to acquire both the conceptual bases and the technical skills that will enable them to pursue a full modelling approach on their own when they come back to their lab.

The course is intended for PhD students and postdocs in cognitive and computational neuroscience with solid background in computational/quantitative analysis to benefit maximally from the advanced training offered by the course. Proficiency in either Python or Matlab is also required. We will seek a nice blend of experimentalists (cognitive psychology / neuroscience) and theoreticians (with or without experience in cognitive modeling). Scientists from underrepresented groups and countries are especially encouraged to apply.



#### ORGANIZERS

Alex Hyafil | CRM, Barcelona Marion Rouault | Paris Brain Institute Heike Stein | ENS Paris Chris Summerfield | Oxford / Deepmind Klaus Wimmer | CRM, Barcelona



#### GENDER BALANCE



EUROPE REST OF THE WORLD

## CRM COLLOQUIUM 2023

#### SEPTEMBER 4, 2023

#### ABSTRACT

In this lecture I will describe the progress made in the last 15 years, in our understanding of the long-time behavior of large solutions to the energy critical focusing nonlinear wave equation. In the last part of the lecture, I will concentrate on progress (with Collot, Duyckaerts, Martel and Merle) on the asymptotic simplification for large time, into sums of modulated static solutions plus a linear term, in all dimensions, in the radial case.



#### GENDER BALANCE

#### 35 11 MALE FEMALE PREFER NOT TO SAY

#### GEOGRAPHIC DISTRIBUTION





## MINI-COURSE ON GEOMETRIC RANDOM GRAPH MODELS

OCTOBER 10-11, 2023

#### DESCRIPTION

In order to prepare for the Discrete Probability Days workshop the week afterwards, this mini-course starts with an introduction to random geometric graphs in Euclidean space, a discussion of some of their properties and their link to percolation. Then we move on to explain hyperbolic random graphs, and finally we define more general spatial random graph models. Time permitting, we also discuss dynamic models of these graph models.

#### ORGANISER

Dieter Mitsche | Pontificia Universidad Católica de Chile

#### GENDER BALANCE



#### GEOGRAPHIC DISTRIBUTION



#### INVITED SPEAKER Carlos Kenig | University of Chicago



## DISCRETE PROBABILITY DAYS

-

#### OCTOBER 16-20, 2023

#### DESCRIPTION

The goal of this workshop is to bring together researchers in the broad field of discrete probability, In more detail, the workshop will deal with the following topics: different random graph models, random walks, percolation, and stochastic geometry.

The workshop is also part of the ANR GrHyDy project that brings together researchers in the field of dynamic geometric models.

#### ORGANISER

Dieter Mitsche Pontificia | Universidad Católica de Chile

#### SCIENTIFIC COMMITTEE

Pierre Calka | Université de Rouen Elisabetta Candellero | Università di Roma 3 David Coupier | Institut Mines Télécom Nord Europe Júlia Komjáthy | TU Delft Dieter Mitsche | Pontificia Universidad Católica de Chile

#### **SPEAKERS**

Luisa Andreis | Politecnico Milano Marian Boguñá | Univ. de Barcelona Raimundo Briceño | Pontificia Universidad Católica de Chile David Coupier | Institut Mines Telecom Lille Douai Ernesto Estrada | Univ. de les Illes Balears Geoffrey Grimmett | Univ. Cambridge Renan Gross | Tel Aviv University Ivailo Hartarsky | TU Wien Markus Heydenreich | Univ. Augsburg Joost Jorritsma | TU Eindhoven Julia Komjathy | TU Delft Matthew Kwan | IST Austria Jean-Francois Le Gall | Univ. Paris-Saclay Lyuben Lichev | Univ. Jean Monnet Bas Lodewijks | Univ. Jean Monnet Colin McDiarmid | Univ. Oxford Patrick Morris | Univ. Politecnica Catalunya Tobias Müller | Univ. Groningen Guillem Perarnau | Univ. Politecnica Catalunya Xavier Perez Gimenez | Univ. Nebraska Gábor Pete | Alfréd Rényi Institute of Mathematics Balázs Ráth | Alfréd Rényi Institute of Mathematics Matthias Reitzner | Univ. Osnabrück Bruno Schapira | Univ. Aix-Marseille



Augusto Teixeira | IMPA Rio Patrick Thiran | EPFL Lausanne Daniel Valesin | Univ. Warwick Joseph Yukich | LeHigh Univ.

#### GENDER BALANCE



MALE FEMALE PREFER NOT TO SAY

#### GEOGRAPHIC DISTRIBUTION



## ICM-CRM MEETING

NOVEMBER 2,3, 9 and 10, 2023

#### DESCRIPTION

The Centre de Recerca Matemàtica (CRM) and the Institut de Ciències del Mar (ICM) want to explore potential ways of collaboration. On one side, the ICM is dedicated to marine research. Under the motto "Ocean Science for a Healthy Planet", the ICM conducts frontier research and fosters both knowledge and technology transfer on topics related to ocean and climate interactions, conservation and sustainable use of marine life and ecosystems, and impact mitigation of natural and anthropogenic hazards. In-depth knowledge, determined action, and coordinated management are essential to confronting these global challenges, thereby driving the sustainable development of humankind.

On the other side, the remit of the CRM is to be a resource of excellence in mathematical research and training at an international level. Its specific aims are high-quality research of international standing in mathematics (including a special emphasis on real-world applications carried out in a collaborative or interdisciplinary context), knowledge transfer based on validated mathematical research (with special emphasis on concrete implementations of justified models that address emergent problems with societal impact), advanced training in the field of mathematics, through collaboration and synergies with other research institutions and dissemination of the advances in mathematics within both the wider academic community and society in general.

To explore possible scientific cooperation, it was agreed to hold two two-day meetings where, first at the headquarters of the ICM and then at the headquarters of the CRM they will expose and discuss the research that is done at the ICM and how the CRM can help/collaborate with them. In this meeting(s), leaving aside the protocol acts, the goal is to promote the exchange of ideas, techniques and problems to facilitate the possibilities of matchmaking.

#### TALKS BY

Lluís Alsedà | CRM Pere Puig | UAB-CRM Álvaro Corral | CRM Jezabel Curbelo | UPC-CRM Josep Sardanyés & Filip Ivancic | CRM Àngel Jorba (UB-CRM) & Marc Jorba-Cuscó | CRM Ramiro Logares & Francesc Piferrer | ICM Eugenia Makarova | ICM Manuel Arias | ICM Jonas Ruh – Roger Urgeles – Savitri Galiana & Xavier Garcia | ICM Ivan Masmitja (UPC-ICM) & Joan Navarro | ICM Fran Ramírez | ICM Manuel Arias | ICM Estela Jimenez | ICM







## **BGSMATH MISSION**

The Barcelona Graduate School of Mathematics (BGSMath) was created in 2014 as a collaborative initiative of the research groups in mathematics of four main universities, and an international research centre located in the Barcelona area:

- University of Barcelona (UB)
- Autonomous University of Barcelona (UAB)
- Pompeu Fabra University (UPF)
- Catalan Polytechnic University (UPC)
- Mathematical Research Centre (CRM)

up

Its primary objective is to provide doctoral and postdoctoral training at the highest level in an international environment.

In 2015, BGSMath was awarded a "Unit of Excellence Maria de Maeztu" distinction by the Spanish Government. These recognitions are meant to fund "highly competitive strategic research programmes in the frontiers of knowledge" that "are among the best in the world in their respective scientific areas". The financial support over 4 years was for a total of 2,000,000€. During that period, BGSMath was the only unit in mathematics in Spain holding this distinction.

With the completion of the Maria de Maeztu programme in 2019, the BGSMath became a delegated committee of the Centre de Recerca Matemàtica (CRM).

UAB Universitat Autônoma de Barcelona



**CRM ANNUAL REPORT 2023** 

#### GRADUATE COURSE **STALLINGS AUTOMATA** AND APPLICATIONS

**JANUARY 17 - FEBRUARY 16, 2023** 

#### GRADUATE COURSE FITTING DATA WITH DYNAMICAL MODELS: TEN LESSONS ON MATHEMATICAL FIELD WORK

OCTOBER 24 - DECEMBER 05. 2023

#### DESCRIPTION

both classical results (like membership problem or Nielsen-Schreier theorem) and more recent advancements, including methods for counting Stallings graphs and extending the theory to more complex groups.

The course is accessible with a basic In this course, given a time series of observed data, background in algebra and graph theory, and also an active research area with many recent publications.

#### **ORGANISER**

Enric Ventura | UPC

#### LECTURERS

Enric Ventura | UPC Jordi Delgado | UPC Pascal Weil | Université Bordeaux

#### DESCRIPTION

Stallings automata offer a modern and Mathematical models are essential for understanding powerful approach to studying subgroups and predicting the behaviour of dynamical processes of free groups. This theory provides a in a wide range of fields, from physics and engineering visual (geometric) representation of these to biology and social sciences. A mathematical model subgroups and allows for efficient algorithms is a set of equations that describe the evolution of to solve many problems related to them. a system over time, based on certain assumptions and simplifications. By formulating a mathematical The course aims to introduce students to this model, scientists can gain insight into the underlying technique and its applications. It will cover mechanisms of a dynamical process and test hypotheses that would be difficult or impossible to investigate experimentally. Moreover, mathematical models allow scientists to make predictions about the behaviour of a system under different conditions and to design interventions that optimize its performance.

we will model their time evolution using dynamical it emphasizes the computational aspects by systems theory with the objective of determining providing algorithms for solving problems. It's the possible sets of parameters such that the time trajectories generated by the model fit the time series of the observed data. To do so, we will provide different modelling approaches based on mathematical and/or computational models and a variety of different tools for data fitting. In summary, we aim to design models that describe observed data and validate them.

#### **ORGANIZERS**

Lluís Alsedà | UAB - CRM Josep Sardanyés | CRM

LECTURERS

Lluís Alsedà | UAB - CRM Josep Sardanyés | CRM Marc Jorba | UPC

**GRADUATE COURSE** HARMONIC MEASURE AND FREE BOUNDARY **PROBLEMS** 

#### NOVEMBER 07 - DECEMBER 21, 2023

#### DESCRIPTION

Harmonic measure and free boundary problems are classical topics in Analysis and PDE which have seen enormous development in recent years. While the motivation and origin of these two topics of research are guite different, there have been important connections between them, and the development we have seen in the last years would not have been possible without such deep connections. Both topics have been strongly influenced by Geometric Measure Theory, and are still objects of intensive research.

#### ORGANISER

Xavier Ros Oton | ICREA-UB-CRM Xavier Tolsa | ICREA-UAB-CRM

#### LECTURERS

Xavier Ros Oton | ICREA-UB-CRM Xavier Tolsa | ICREA-UAB-CRM

#### TRAINING FOR PHD CANDIDATES WRITING SCIENTIFIC ARTICLES

MARCH 21, 2023

DESCRIPTION

#### ORGANIZING AND STRUCTURING A SCIENTIFIC ARTICLE

In this talk we will discuss about writing and publishing mathematical articles: from the initial steps of designing an article to considerations on submitting the final paper.

LECTURER

Marc Noy | UPC - CRM

#### MASTERCLASS OUTREACH HOW TO SPEAK ABOUT MATHEMATICS TO BROAD **AUDIENCES**

MARCH 06, 2023

MARCH 16, 2023

#### DESCRIPTION

means being able to connect a certain content to a certain audience. We will explore some In this talk we will give some practical advice on giving general techniques to stablish this connection in different ways. We will give practical advice, study some examples and address the main issues one faces when trying to communicate important activities in our profession. science or math.

This talk is aimed at PhD and Postdoctoral LATEX: TIPS AND TRICKS researchers.

#### **SPEAKER**

Eduardo Saénz de Cabezón | U. de La Rioja

#### DESCRIPTION

#### To speak about science to broad audience DO'S AND DON'T'S ABOUT GIVING MATH TALKS

TRAINING FOR PHD CANDIDATES

**SPEECH & SLIDES** 

TRICKS ON PRESENTATIONS:

talks about mathematics. We will address content. form and performance, in an attempt to review what we do right and what we do wrong in one of the most

LaTeX is a software system for document preparation wich encourages authors not to worry too much about the appearance of their contents but to concentrate on getting the right content. In this talk we will see some particularities of this system, including the typesetting of formulas, tables, graphics and the Beamer class for presentations.

#### LECTURERS

Núria Fagella | UB - CRM Albert Ruiz | UAB - CRM

## **UAB MASTER'S DEGREE IN** MATHEMATICS FOR FINANCE

#### EDICIÓ Nº26



#### ABOUT

The master's degree in Mathematics for Financial Instruments arose in response to the growing demand from the financial sector for persons with a solid grounding in mathematics.

This programme is open to graduates in Mathematics, Physics, Business Studies, Economics, Statistics, or related subject areas, and its objective is to train up quantitative analysts in the field of finance, with a deep, critical understanding of the models and methods used in the sector.

Classes are taught by instructors from the academic world (UAB, UB, UPC, CRM) and the world of professional practice (CaixaBank, Banc de Sabadell, Catalana Occidente, Barcelona Stock Exchange), which creates important contact opportunities for future interactions.

Our collaborating organisations provide us with the necessary on-the-job learning component by offering grants for placements. This establishes a direct line of collaboration between the academic and professional worlds, enabling us, on the one hand, to develop and teach ground-breaking techniques for the valuation of derivative financial products, for calculating their coverage strategies, and for assessing and controlling risks and, on the other hand, to introduce our students to this employment market, thus enriching their professional experience.

This master's degree offers excellent career prospects for our graduates in all areas where a combination of mathematical skills and financial knowledge is required.

The CRM's mission includes the integration of its mathematical research into the society by improving the scientific culture of citizens through communication and outreach. We understand the Communication as a transversal aspect to research. It is needed not just for transparency but also to engage diferent societal groups to it and increase the general scientific culture for further and better collaborations. It is also needed to give tools to researchers to communicate their research: for better research, to promote collaborations with colleagues and to make the sharing of knowledge better.

Traditional outreach at the CRM has been directed through the education system, often with programs to talented students. The CRM aims to open the outreach perspective to broader general public, improving the efficiency of the actions directed to education, reaching more students and overall achieving a higher impact on more society groups.

The CRM is committed to raising awareness among students, teachers, researchers and the general public about the capital role that mathematics plays in the development and progress of the Catalan society at large.

M M (

The main goal of the CRM's outreach team is to give an insight into what a career in mathematics could be like and support young students in current curriculum activities. These include talks, school visits, workshops and exhibitions at science festivals. Whatever the medium, we work to show people that mathematics can be a wonderful, tasteful and imaginative subject that is involved in many aspects of our everyday lives.



#### FESTA DE LA CIÈNCIA 2023

The CRM participated in Barcelona's 16th Science Festival with two workshops. On Saturday, Dani Ramos and Pau Varela led a session on chaos and fractals, helping attendees understand complex mathematical patterns through interactive activities. On Sunday, the Computational Neuroscience group collaborated with IDIBAPS to conduct a workshop on brain function, discussing neural signals and mathematical modeling.

The event, which drew nearly 16,000 visitors, was a notable success, showcasing CRM's efforts to make advanced scientific concepts accessible to the public. The workshops offered hands-on experiences, fostering a deeper appreciation for mathematics among participants of all ages.



### THE KNOWLEDGE TRANSFER UNIT HOSTS TWO HIGH SCHOOL AND FIRST-YEAR UNIVERSITY STUDENTS.

The CRM Knowledge Transfer Unit hosted Irina Espasa and Aran Terrades, two outstanding students. Under the mentorship of David Romero and Pau Reig, the students engaged in mathematical research activities, contributing to ongoing projects and gaining practical experience.

This initiative aims to inspire young talents by providing them with a glimpse into scientific research and careers in mathematics. The program underscores CRM's commitment to fostering the next generation of mathematicians and enhancing students' understanding and appreciation of the field.



#### **EUROPEAN RESEARCHERS' NIGHT**

The CRM participated in the European Researchers' Night, aiming to make science and research accessible to all ages. Axel Masó and Giovanni Dalmasso demonstrated how mathematics is crucial in areas like healthcare, transport, and biology. Masó discussed projects on disease detection, optimizing Barcelona's bus network, and preventing phishing attacks. He also shared insights on using mathematical models to improve cooking techniques.

Giovanni Dalmasso presented at CosmoCaixa, explaining how mathematical modeling helps understand biological processes during human development, specifically the formation and disappearance of blood vessels in limbs during gestation. These talks underscored the vital role of mathematics in solving real-world problems and enhancing everyday life.

#### THE CRM CELEBRATES II DAY

The CRM celebrated Pi Day on March 14 by printing and displaying digits of  $\pi$  on the walls of the Faculty of Sciences at the Universitat Autònoma de Barcelona. We also created a website features a tool to search for sequences within  $\pi$ , encouraging users to find and mark these digits on the walls. This event promotes the understanding of  $\pi$ 's properties and engages the public with interactive activities like searching for birth dates or notable sequences within  $\pi$ 's infinite expansion.







#### **HIGHLIGHTING WOMEN IN MATHEMATICS: INTERVIEWS WITH CRM RESEARCHERS**

The Centre de Recerca Matemàtica (CRM) featured interviews with four female researchers: Marta Casanellas, Núria Fagella, Eva Miranda, and Tere M-Seara. These interviews aimed to highlight their contributions and perspectives in mathematics, aligned with the International Day of Women and Girls in Science, addressing gender diversity in the field.

The researchers discussed their interdisciplinary work, the challenges they faced as women in mathematics, and their views on the importance of gender diversity in scientific research. This initiative aims to inspire and encourage more women to pursue careers in mathematics and science.

#### **CRM PARTICIPATES IN MAMBO:** MATHEMATICS WITH BUBBLES EVENT

The CRM participated in the MAMBO event held and SCM. This event focused on the educational and outreach applications of soap bubbles, Joan Porti and Daniel Ramos, who discussed geometric properties of bubbles and minimal surfaces, respectively.

The event aimed to explore innovative ways to teach and popularize mathematics.

#### **INTERVIEW WITH ARIADNA FARRÉS:** MATHEMATICIAN AND HYPATIA CREW MEMBER

Ariadna Farrés, a mathematician at NASA's Goddard on April 15, organized by CREAMAT, FEEMCAT, Space Flight Center, is part of the all-female Hypatia crew at the Mars Desert Research Station in Utah. Her work involves trajectory calculations and space featuring contributions from CRM members navigation. Inspired by "The Martian," she designs experiments for satellite coverage on Mars.

> The Hypatia mission aims to explore diverse scientific fields, inspire future generations, and promote scientific vocations among women, showcasing the importance of women's roles in STEM.













The Human Resources Strategy for Researchers (HRS4R), launched in 2008, supports institutions in implementing The European Charter for Researchers and The Code of Conduct for Recruitment. This strategy aims to enhance the relationship between researchers and employers, fostering successful knowledge generation, transfer, and career development.

The HR Excellence in Research award recognizes institutions aligning their HR policies with the Charter & Code principles, signifying a commitment to fair and transparent recruitment and appraisal. The European Commission (EC) has outlined a five-step process for this:

- I. Conduct a Gap Analysis.
- II. Publish the institution's strategy (Action Plan) online.
- III. Seek EC evaluation and approval.
- IV. Continuously apply and self-assess.
- V. Undergo an external evaluation by the EC after five years.

The Centre de Recerca Matemàtica (CRM) committed to the Charter & Code in February 2014 and conducted a Gap Analysis in May 2014. Since July 2015, CRM has held the HR Excellence in Research award, working to improve professional welfare, skills, and career development.

In 2017, a stricter application process was introduced, emphasizing Open, Transparent, Merit-based Recruitment (OTM-R). CRM's interim assessment in 2018 showed robust implementation of its Action Plan, confirmed by the EC. In March 2023, CRM hosted an onsite EC assessment, resulting in the renewal of the HRS4R award.

CRM's commitment to these standards demonstrates its dedication to creating a supportive, transparent, and progressive research environment, contributing to the European Research Area.



CRM ANNUAL REPORT 2023

## AURA FOUNDATION

Aura Foundation, created in October 1989, is a non-profit organization initially formed as an association and that since 2004 has operated as a private foundation. It pioneered the «Supported Employment» program in Spain by implementing and developing its' methodology. Aura aims to improve the quality of life of people with intellectual disability by helping to integrate them into society and find them employment.

The CRM collaborates with the Aura Foundation since the year 2006 through the hiring of Mari Paz Valero as Administrative Assistant in our center.



## PEOPLE

#### Senior Researchers

ALARCÓN COR, TOMÁS	CRM-ICREA
ÁLVAREZ, JOSEP	UPC-CRM
AMORÓS, JAUME	UPC-CRM
ANTOINE, RAMON	UAB-CRM
ARA, PERE	UAB-CRM
ATSERIAS, ALBERT	UPC-CRM
BALDOMÁ, INMACULADA	UPC-CRM
BARJA, MIGUEL ANGEL	UPC-CRM
BENGOECHEA, PALOMA	UB-CRM
BROTO, CARLES	UAB-CRM
CABRÉ, XAVIER	UPC-ICREA-CRM
CALSINA, ÀNGEL	UAB-CRM
CASANELLAS, MARTA	UPC-CRM
CASCANTE, CARME	UB-CRM
CASTELLANA, NATÀLIA	UAB-CRM
CIRICI, JOANA	UB-CRM
CLOP, ALBERT	UB-CRM
CORRAL CANO, ÁLVARO	CRM
COSTA, LAURA	UB-CRM
CSATO, GYULA	UB-CRM
CURBELO, JEZABEL	UPC-CRM
D'ANDREA, CARLOS	UB-CRM
DELSHAMS, AMADEU	UPC-CRM
DIEULEFAIT, LUIS	UB-CRM

Mathematical & Computational Biology
Algebra, Geometry, Number Theory & Topology
Combinatorics, Logic & Algorithmics
Dynamical Systems
Algebra, Geometry, Number Theory & Topology
Algebra, Geometry, Number Theory & Topology
Algebra, Geometry, Number Theory & Topology
Analysis & Partial Differential Equations
Analysis & Partial Differential Equations
BIO-GEOMAP
Analysis & Partial Differential Equations
Algebra, Geometry, Number Theory & Topology
Algebra, Geometry, Number Theory & Topology
Analysis & Partial Differential Equations
Climate Change & Natural Hazards
Algebra, Geometry, Number Theory & Topology
Analysis & Partial Differential Equations
Dynamical Systems
Algebra, Geometry, Number Theory & Topology
Dynamical Systems
Algebra, Geometry, Number Theory & Topology

DONAIRE, JUAN JESÚS UAB-CRM DRACH, KOSTIANTYN UB-CRM FAGELLA, NÚRIA UB-CRM FERNÁNDEZ, JESÚS UPC-CRM FITÉ, FRANCESC UB-CRM FONTICH, ERNEST UB-CRM UPC-CRM GÁLVEZ, IMMACULADA GASULL, ARMENGOL UAB-CRM **GUÀRDIA, MARCEL** UB-CRM **GUILLAMON, ANTONI** UPC-CRM **GUITART, XAVIER** UB-CRM GUTIÉRREZ, JAVIER J. UB-CRM HARO, ALEJANDRO UB-CRM UAB-CRM HERBERA, DOLORS UPC-CRM HUGUET, GEMMA HYAFIL. ALEXANDRE CRM JARQUE, XAVIER UB-CRM JORBA, ÀNGEL UB-CRM KNAUER, KOLJA UB-CRM LAHOZ. MARTÍ UB-CRM LÁZARO, JOSÉ TOMÁS UPC-CRM MARCHESI, SIMONE UB-CRM MARÍN, DAVID UAB-CRM MARTIN, PAU UPC-CRM MARTÍNEZ-SEARA, TERESA UPC-CRM MARZO, JORDI UB-CRM MAS, ALBERT UPC-CRM UPC-CRM MASDEMONT, JOSEP UAB-CRM MASDEU, MARC UAB-CRM MATEU, JOAN E. MIRANDA, EVA UPC-CRM MIRÓ, ROSA MARIA UB-CRM MUNDET, IGNASI UB-CRM CRM MYERS, TIMOTHY G. UB-CRM NARANJO, JOAN CARLES UAB-CRM NICOLAU, ARTUR NOY, MARC UPC-CRM OLLE, MERCÈ UPC-CRM OROBITG, JOAN UAB-CRM ORTEGA, JOAQUIM UB-CRM PADROL, ARNAU UB-CRM UB-CRM PAU. JORDI

Analysis & Partial Differential Equations Dynamical Systems Dynamical Systems **BIO-GEOMAP** Algebra, Geometry, Number Theory & Topology Dynamical Systems Algebra, Geometry, Number Theory & Topology Dynamical Systems Dynamical Systems Neuroscience Algebra, Geometry, Number Theory & Topology Algebra, Geometry, Number Theory & Topology Dynamical Systems Algebra, Geometry, Number Theory & Topology Neuroscience Neuroscience Dynamical Systems **Dynamical Systems** Combinatorics, Logic & Algorithmics Algebra, Geometry, Number Theory & Topology Dynamical Systems Algebra, Geometry, Number Theory & Topology Algebra, Geometry, Number Theory & Topology Dynamical Systems Dynamical Systems Analysis & Partial Differential Equations Analysis & Partial Differential Equations Dynamical Systems Algebra, Geometry, Number Theory & Topology Analysis & Partial Differential Equations Algebra, Geometry, Number Theory & Topology Algebra, Geometry, Number Theory & Topology Algebra, Geometry, Number Theory & Topology Climate Change & Natural Hazards Algebra, Geometry, Number Theory & Topology Analysis & Partial Differential Equations Combinatorics, Logic & Algorithmics Dynamical Systems Analysis & Partial Differential Equations Analysis & Partial Differential Equations Combinatorics, Logic & Algorithmics Analysis & Partial Differential Equations

PERARNAU, GUILLEM PERERA, FRANCESC PORTI, JOAN PRAT, LAURA PRATS, MARTÍ PUIG, PERE **ROS-OTON, XAVIER** ROTGER, VÍCTOR ROXIN, ALEX RUÉ, JUAN JOSÉ RUIZ, ALBERT SAARI, OLLI SALAZAR CIUDAD, ISAAC SARDANYÉS, JOSEP SERNA, SUSANA SERRA, ORIOL SOLANES, GIL SOMBRA, MARTÍN TIKHONOV, SERGEY TOLSA, XAVIER TORREGROSA, JOAN VIEIRO, ARTURO WIMMER. KLAUS

**UPC-CRM** 

**UAB-CRM** 

**UAB-CRM** 

**UAB-CRM** 

**UAB-CRM** 

**UAB-CRM** 

UPC-CRM

UPC-CRM

UAB-CRM

UPC-CRM

UAB-CRM

UPC-CRM

**UAB-CRM** 

**CRM-ICREA** 

**UAB-CRM** 

**UB-CRM** 

CRM

**UB-ICREA-CRM** 

UAB-ICREA-CRM

CRM

CRM

CRM

**UB-ICREA-CRM** 

#### **Postdoctoral Researchers**

AUTON. LUCY CHARLOTTE **CECCHINI, GLORIA** CLOETE, IELYAAS DA FONSECA, MARIA DALMASSO, GIOVANNI FORNEA, MICHELE GARMENDIA, ALFONSO GONZALEZ GOMEZ, ALVARO HOMS PONS, ROSER IBAÑEZ SOLAS. SARA **IVANCIC, FILIP** JORBA CUSCO, MARC KALOU, AIKATERNI KOSOV, EGOR MAIONE, ALBERTO MOLANO MAZON, MANUEL NAIA DOS SANTOS, TÁSSIO **RODRIGUES FERREIRA, GUSTAVO**  Combinatorics, Logic & Algorithmics Algebra, Geometry, Number Theory & Topology Algebra, Geometry, Number Theory & Topology Analysis & Partial Differential Equations Analysis & Partial Differential Equations Climate Change & Natural Hazards Analysis & Partial Differential Equations Algebra, Geometry, Number Theory & Topology Neuroscience Combinatorics, Logic & Algorithmics Algebra, Geometry, Number Theory & Topology Analysis & Partial Differential Equations Mathematical & Computational Biology Mathematical & Computational Biology Analysis & Partial Differential Equations Combinatorics, Logic & Algorithmics Algebra, Geometry, Number Theory & Topology Algebra, Geometry, Number Theory & Topology Analysis & Partial Differential Equations Analysis & Partial Differential Equations Dynamical Systems Dynamical Systems Neuroscience

Climate Change & Natural Hazards **Computational Neuroscience** Mathematical and Computational Biology **Computational Neuroscience** Mathematical and Computational Biology Algebra, Geometry, Number Theory & Topology Algebra, Geometry, Number Theory & Topology Climate Change & Natural Hazards **Bio-Geomap** Computational Neuroscience Mathematical and Computational Biology Climate Change & Natural Hazards Computational Neuroscience Analysis & Partial Differential Equations Analysis & Partial Differential Equations Computational Neuroscience Combinatorics, logic & algorithmics **Dynamical Systems** 

SPELTA. IRENE STEPANOVA, DARIA TOKMAGAMBETOV, NIYAZ TORRES BUSTOS, ANGELICA TRUJILLO AMEZQUITA, FRANK

#### Predoctoral Researchers

ARELLANO TINTO, JUAN CASTELLVI FOGUET, JORDI DE ARANCIBIA CASILLAS, LUCIA GARCIA-DURAN, ALEXANDRE GIL RAMS, DIDAC **GUILLAN RIAL, JAVIER** DYHR. SOREN ISTVAN ADORJAN LLOPIS ALMELA, ORIOL MARTINEZ AÑON. KEVIN MINJARES GONZALEZ, MONICA NICOLAS MARTINEZ, PABLO PEDARRA, STEFANO POLLAN HAUER, NICOLAS SALAT MOLTO, MARTÍ SAUCEDO CUESTA, MIQUEL URTIAGA ERNETA, IÑIGO VIELBA TRILLO, AMAIA VIVAR ABURTO, CITLALLI YE, PAN

#### **Research Assistant**

DONDERIS DE VICENTE. MIGUEL ORRIT VIÑETS, LAURA POU AMENGUAL. NEUS WILSON GANZABAL, ANNA

#### Knowledge Transfer Unit

CRM ANNUAL REPORT 2023

CUFI CABRE, CLARA ESCOLÀ SOLES, ALBERT HIDLAGO VAZQUEZ. SANDRA MASÓ PUIGDELLOSAS, AXEL **REIG LLUNELL, PAU** ROMERO SANCHEZ, DAVID

Algebra, Geometry, Number Theory & Topology Mathematical and Computational Biology Analysis & Partial Differential Equations Bio-Geomap Dynamical Systems

**Dynamical Systems** 

**Computational Neuroscience** Mathematical and Computational Biology **Computational Neuroscience Computational Neuroscience** 

Impact Officer Researcher Responsable KTU

- Mathematical and Computational Biology
- Combinatorics, logic & algorithmics
- Computational Neuroscience
- Computational Neuroscience
- Algebra, Geometry, Number Theory & Topology
- Algebra, Geometry, Number Theory & Topology
- Mathematical and Computational Biology
- Mathematical and Computational Biology
- Climate Change & Natural Hazards
- Algebra, Geometry, Number Theory & Topology
- Mathematical and Computational Biology
- Computational Neuroscience
- Mathematical and Computational Biology
- Analysis & Partial Differential Equations
- Analysis & Partial Differential Equations
- Mathematical and Computational Biology
- Computational Neuroscience
- Computational Neuroscience

- Scientific Software Developer
- Scientific Software Developer
- Scientific Software Developer

#### Research Support Staff

ALVES BLANCO, PATRICIA CAÑAMERO RODRIGO, IVAN COSTA SORIANO, PAU CUNI DOLS, JORDI DROU ROGET, ANNA FUCHO RIUS, MARIONA GUTH, BASILE GUTIÉRREZ ARBONÉS, ARIADNA **GUTIERREZ ARBONES, GERARD** HERNANDEZ MARTIN, NURIA MANCERO ALVARADO, ERICK MARTINCIC, MARKUS MARTINEZ BARRERA, GEMMA MULLOR TENAS, JORDI RAMIREZ GARCIA, VANESSA ROCA GUILLÉN, CONSOL SÁNCHEZ PIRELA, VANESSA SANZ GARCIA, ARANZAZU VALERO NAVAZO, MARIA PAZ VARELA RODRIGUEZ, PAU

Accountant IT Technician Scientific Activities Technician HR Officer Communication and Dissemination Manager Communications Technician Impact Officer Data Steward Data Steward Scientific Activities Coordinator IT Technician Project Manager Manager IT Manager Scientific Activities Technician Management Assistant HR Manager Head of Strategy Administration Assistant Communications Technician



# 08 FUNDING



The following charts portray the expenditure and income that the CRM has carried out during the 2020-2023 period.

To begin with, in 2023 the CRM continues with the trend to balance external funds (competitive funding and other revenue) with funds contributed by the trustees (non-competitive funding and subversion of capital).



Figure 1: External vs. Trustees funding from 2020 to 2023.

More clearly, the funding comes from the following kind of sources:



Figure 2: Sources of the funding 2023.

A 39,87% of the funds come from the Generalitat de Catalunya (Non-competitive Funding), of which 49,25% was used for the operation of the center.



55,22% of the resources are obtained through competitive calls and of these, 78,96% come from the Spanish State through the Spanish Research Agency (I+D National Programme), 16,30% from autonomous bodies of the Generalitat de Catalunya, mainly the AGAUR (Regional Funding), and 4,74% from the European Union (EU Funding).



Of all these revenues, the vast majority are allocated to Personnel Expenses (73,93%), and a 19,64% to Operating Expenses (material, cleaning, telephone, maintenance, subsistence allowances and travel and training, among others).

Figure 3: Competitive funding distribution.





ANNUAL REPORT 2023

Campus de Bellaterra Edifici C 08193 Bellaterra Barcelona Tel +34 93 581 1081 Fax +34 93 581 2202 crm@crm.cat