

MEMÒRIA D'ACTIVITATS 2020















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Director's Foreword

Lluís Alsedà, Director of CRM

This report includes the research, training, transfer, and dissemination activities carried out at the Centre de Recerca Matemàtica during 2020. It provides a valuable snapshot of the centre and its performance during this year.

Unfortunately, 2020 has been a year dominated by the effects of the COVID-19 pandemic. The whole activities action line had to be postponed, tentatively to 2021 (one of the activities had to be suspended abruptly at the start of a workshop on March 13th). The remaining activities, including research, transfer, training, and administration, have been carried out remotely, with the difficulties involved with virtual communication systems.



An important action undertaken by the centre has been to improve our skills, hardware, and software to be ready for any kind of virtual and semi-present/semi-virtual activities. This will come to fruition in 2021.

www.crm.cat

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Lluís Alsedà, Director del CRM



Aquesta memòria inclou les activitats de recerca, formació, transferència i outreach dutes a terme al Centre de Recerca Matemàtica durant l'any 2020. Presenta una valuosa imatge del centre i de la seva evolució durant aquest any.

Malauradament, l'any 2020 ha estat un any dominat pels efectes de la pandèmia de la COVID-19. Tota la línia d'Activitats va haver de ser posposada, de manera provisional, al 2021 (una de les activitats es va suspendre de manera abrupta el 13 de març just al principi d'un workshop). La resta de les tasques, incloent-hi les de recerca, transferència, formació i administració, s'han dut a terme remotament amb les dificultats

inherents als sistemes de comunicació virtual.

De fet, una acció important empresa pel centre ha estat millorar les nostres destreses personals, hardware i software per estar preparats per qualsevol forma d'activitats, tant presencials com semipresencials/semivirtuals. Aquest esforç es veurà reflectit durant l'any 2021.

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1 The CRM

1.1 Mission and Statement

As stablished by its statutes, the CRM's aim is to foster research and advanced training in mathematics by collaborating with the universities and research institutions in Catalonia, in order to become an international reference in its field.

The CRM is a transversal center in the sense that its activities benefit the whole mathematical research community in Catalonia. The scientific policy of the CRM towards fulfilling its mission is structured around two main core concepts, quoted in the strategic plan within the contract-program with the Generalitat de Catalunya.

- To give support to research groups by organising activities with a size or nature that goes beyond the capabilities of the teams, achieving broad visibility and hosting visitors for joint collaborations.
- 2. To design and execute strategies aimed at addressing the weaknesses of the mathematical research activity in Catalonia as a whole, encouraging emergent areas and creating its own research groups in these areas.

1.2 Legal Status

The CRM was founded in 1984 as a research center under the Institut d'Estudis Catalans (IEC), the Catalan Academy. In the same year, an agreement was signed with the Universitat Autònoma de Barcelona (UAB), by virtue of which the CRM became established in the UAB Campus. In 1993, the CRM opened its own premises at the UAB's Science Faculty, thanks to the financial support from CIRIT. On that occasion, the CRM became associated with the UAB as one of its research institutes.

The Government of Catalonia approved on July 9th, 2002 (DOGC No. 3693, August 6th, 2002) the creation of the CRM Consortium, comprised by the Generalitat de Catalunya and the IEC. The CRM Consortium is a public body with its own legal status. In December 2013, the Universitat Autònoma de Barcelona joined the Consortium. The CRM is guided by its Governing Board and Director, and has a Scientific Advisory Board.

The CRM is one of the centers in the CERCA Institution of research centers sponsored by the Generalitat de Catalunya, and is a member of the Associació Catalana d'Entitats de Recerca (ACER). The CRM is a member of ERCOM, a committee of the European Mathematical Society (EMS).

CRM has started an ascription process of researchers from the universities with the aim of generating a collaborative multidisciplinary research framework. On November 5th, 2020, 24 distinguished researchers from UAB ascribed to CRM. The

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ascription process from researchers from UPC and UB is a working process that has been fruitful in 2021.

1.3 Governing Board

The Governing Board is the highest level of decision and management at the CRM. It consists of the following:



Due the COVID19 pandemic, the Governing Board met virtually on July 20th, 2020. In that meeting, the Generalitat de Catalunya was represented by Joan Gómez Pallarès, in his capacity of Director General de Recerca.

The IEC was represented by Joan Domènec Ros, who assumed the Chairmanship of the Board, and by Joan Solà-Morales and Josep Enric Llebot. Francisco Javier Lafuente, the vice-rector of Strategic Projects and Planning of the UAB, attended the meeting on behalf of the rector of the UAB. The CRM director, Lluís Alsedà, and the general manager, José Antonio Fuentes, also attended the meeting. CERCA was represented by Lluís Rovira. Josep María Alcoberro acted as Secretary.



1.4 Scientific Advisory Board

The Scientific Advisory Board (SAB) consists of prestigious personalities within the scientific scope of the Centre, appointed by the Governing Board after proposal by the Director. The SAB usually meets once a year before summer.



The composition of the Scientific Advisory Board (approved by the Governing Board on June 15th, 2018) is:

Due to the pandemic, the meeting to be held in 2020 was postponed to a virtual Meeting in January 2021.

1.5 Institutional Collaboration

The CRM participates in a variety of initiatives with other academic institutions.

BGSMath

Barcelona has an internationally recognized unit of excellence in mathematics research at the highest level. In the latest years, the number of foreign graduate students enrolled in master's and doctoral programs in Mathematics offered by Catalan universities has increased significantly. In this scenario, the Barcelona Graduate School of Mathematics (BGSMath) was created in 2013 with the aim of providing coordinated and high quality research PhD training with international projection. Another mission of the BGSMath is the enhancement of employment of mathematicians within the industry and in non-academic environment in general, and becoming a platform for all active agents in mathematical research towards the development of collaborative projects.

The promoting institutions of the BGSMath are:

- The Mathematics Faculty of the Universitat de Barcelona;
- The Mathematics Department of the Universitat Autònoma de Barcelona;
- The Faculty of Mathematics and Stadistics of the Universitat Politècnica

de Catalunya;

- Universitat Pompeu Fabra;
- Centre de Recerca Matemàtica;
- The Mathematics Institute of the Universitat de Barcelona also participates as a supporting entitiy.

In 2015 BGSMath was awarded a "Maria de Maeztu" grant by the Spanish Ministry of Economy and Competitiveness under its "Excellence Program", which concluded on June 30th, 2019. The award is aimed at Spanish research centers that are leaders in all areas of science and humanities. Grants provide funding for international PhD students and postdocs to complete stays in Barcelona.

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People funded by the BGSMath are listed at the Appendix of this report.



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. Only centers for which the number of visiting staff substantially exceeds the number of permanent and long-term staff, and which cover mathematical sciences broadly, are eligible for representation in ERCOM. The CRM has been a member of ERCOM since its foundation in 1997.

The annual meeting of ERCOM in 2020 was supposed to be held on March 26th and 27th, at the BCAM-Basque Center for Applied Mathematics (Spain). However, due to the COVID19 pandemic a short virtual meeting was held on 4th June 2020 and the official ERCOM meeting was finally postponed to 24th and 25 March 2021.



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. Current ICREA Research Professors based at the CRM are Sergey Tikhonov (since 2012) and Tomás Alarcón (since 2015).



Red Estratégica de Matemáticas

The Red Estratégica de Matemáticas (REM) was created in 2017 and its primary

goal is to gather innovations to create a strategy that will improve the international position and foster synergies between the mathematical scientific community and the socio-economic impact of the Spanish research in mathematics. It encourages the dissemination and transfer of mathematical technology, orienting R & D to the needs of companies, industries, and public institutions. Its applications in the productive sector

provide a vital added value to economic life, as well as being a very important part in technological advancement and the improvement of living conditions. Its objectives are:

- Structure the mathematics research community and to position it at the vanguard both nationally and internationally.
- · Boost transversal actions of Mathematical Technology Transfer, in particular through the Spanish mathematics-industry network (Math-in).
- Study the socio-economic impact of research and transfer of mathematical

technology in Spain.

- · Disseminate the activity and results of mathematical research in Spain to improve the public perception of this science.
- Promote the presence of Spanish mathematics in the world by participating in the activities of international organizations.
- · Promote funding provision for research and transfer in mathematics.

REM editions:

- 1. From September 2017 to September 2019, coordinated by Dr. Tomás Chacón from the Institute of Mathematics of the Universidad de Sevilla (IMUS).
- 2. It is currently coordinated by Dr. Luis Vega, from the Basque Center for Applied Mathematics (BCAM).

Both the Centre de Recerca Matemàtica and the Barcelona Graduate School of Mathematics are active members of the REM. Activities promoted by the REM:

1. Presentation of the Study of the economic impact of Mathematics in Spain by Diego Vizcaino Delgado, coordinator of the study (AFI), was to take place on October 29th, 2019 but due to the political issues and administrative blockade caused by the application of 155 article of the Spanish constitution, had to be delayed until January 8th, 2020.

Comité Español de Matemáticas

The Comité Español de Matemáticas (CEMat) was created in 2004 as a restructuring and extension of the Spanish Committee for the International Mathematical Union which was reconstituted on April 17th, 1998 as a joint initiative by the Real Sociedad Matemática Española (RSME), the Societat Catalana de Matemàtiques (SCM), the Sociedad Española of Matemática Aplicada (SEMa) and the Sociedad de Estadística e Investigación Operativa (SEIO). On July 20th 2020, the Governing Board of the CRM approves the incorporation of the CRM into the CEMat as a Federated Entity in its own right and appoints Dr. Lluís Alsedà i Soler, in his capacity as director, as its representative.

Presently, the CEMat is in a process of refoundation to become a federation and to work on behalf of the entire Spanish mathematical community before the political and academic authorities.

Its objectives are:

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- Coordinate the Spanish mathematical activities of international nature related to the IMU and the CEISC (the Spanish Commission for the ISC: the International Science Council), reinforcing the Spanish presence in the commissions of these entities.
- Channel the initiatives of IMU and CEISC within Spain and, in general, when necessary, to advise and report to the corresponding ministries.
- Collectively, represent the Federated Entities interests before the public and private organisms, collaborating with them for the benefit of mathematics.
- Assist with achieving a greater awareness on the part of the scientific community, the Administration, companies and society in general, regarding the importance of Mathematics in today's world.

It is worth saying CEMat shares the purposes of its federated entities and will collaborate in achieving them, as well as all those that are not available to the federated entities, when approved by the executive committee.



Fundació Jaume Bofill

Since the 2018, the Centre de Recerca Matemàtica participates in the program "Magnet, aliances per a l'èxit educatiu", promoted by the Jaume Bofill Foundation, Diputació de Barcelona, el Consorci d'Educació de Barcelona and UAB's Institut de Ciències de l'Educació.

The main goal of the Magnet program is to address scholar segregation by developing a collaboration between an educational institution and a research institution.

Joaquim Blume school, based in Sabadell, is one of the selected schools to develop, during the forthcoming 4 years, this innovation project. With the motto "Al Blume, tots hi comptem. Suma-t'hi!", Joaquim Blume school has started a collaboration with Centre de Recerca Matemàtica which will allow to develop an educational innovation project by using mathematics as a cornerstone.

On March 13th 2019, the Magnet team of the CRM organized a twinning activity with the teaching team at the Joaquim Blume school in Sabadell. With this activity, the CRM initiated an accompaniment project at this school for a 4 years period, within the framework of the aforesaid program. The meeting of the Monitoring Committee was held on 10th July 2020 at the Joaquim Blume school.

During this year 2020, marked by the COVID19 pandemic, an exhibition and a video "premièrie" have been the Magnet activities carried out. It is worth noting that the Joaquim Blume school celebrated its 40th aniversary during 2020 and one of the events was an exhibition in which the alliance between CRM and the school is highlighted. Also, a video was released where the work performed by the students, in collaboration with CRM researchers, is shown at youtu.be/jHtHInwiT3Y

1.6. SPONSORSHIPS



1.6 Sponsorships

In recent years, the CRM has made a considerable effort to attract funding from a variety of private and public entities. Fortunately, the efforts of the center to attract the interest of sponsors sensitive to mathematical research has had some success along 2020. The CRM is deeply grateful to the institutions listed below since their contributions can maintain and increase the quality of some of the activities consolidated at the center.

"la Caixa" Foundation

"la Caixa" Foundation is an institution committed to society through Welfare Projects, human rights, peace, justice, and people's dignity. The foundation also works in collaboration with research institutions to generate new scientific knowledge by opening up research horizons. The main focus for action of "la Caixa" Foundation in sponsoring science is giving research institutions more security when planning their research and facilitating the generation of synergies among different centers. At the end of 2013, "la Caixa" Foundation, within the framework of the agreement with the Catalan Government, approved funding for the training program on Collaborative Mathematics presented by the CRM. See

www.crm.cat/funding-programs

The aim of the program is to encourage interdisciplinary and collaborative mathematical research. Within the framework of this program, collaborative research means "*mathematical research located in an interface which purpose is the development, analysis and simulation of contextualized models, with interest beyond mathematics, contrasted by interacting with experimentalists*".

The funding of this program by "la Caixa" allows the CRM to support a number of doctoral students and postdoctoral fellows, starting January 2014. Our fellowship students receive 3-year contracts linked to a training project on a specific topic defined jointly by a researcher in mathematics as director and a co-director from another discipline.

This program has been terminated by "la Caixa" during the year 2020.



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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. During 2020, the EMS support has allowed to enhance the economic conditions of lecturers and the possibility to offer several grants for young researchers.



www.euro-math-soc.eu

Centre International de Mathématiques Pures et Appliquées

The Centre International de Mathématiques Pures et Appliquées (CIMPA), founded in France in 1978, is a nonprofit organisation that promotes research in Mathematics in developing countries. The CIMPA has an agreement with the CRM in order to fund and encourage the participation of young mathematicians from developing countries in short-term thematic international programs. This collaboration aims to offer these young researchers the opportunity to work together with other mathematicians from around the world, in an ideal environment to exchange and share experience. The CIMPA has also a similar agreement with the Centre International de Rencontres Mathématiques (CIRM) and with the Institut Henri Poincaré (IHP).



www.cimpa.info

1.7 Structure

Directing Team

The Governing Board elects a Director, at the proposal of the Chairman, to serve for a period of four years. The current Director is Lluís Alsedà, who was elected for the period from 2016 to 2019 in the Meeting of the Governing Board on December on December 1st, 2015.

At the Meeting of the Governing Board on July 20, 2020, it was decided to renew the agreement for the appointment of Lluís Alsedà as the CRM Director for an additional period of four years, starting on July 20, 2020.

The Executive Commission of the CRM, which meets regularly to discuss routine or urgent affairs is formed by

- The Director.
- The assistant director; represented by the principal investigator Tomás Alarcón.
- The Manager.

- A representative of the researchers; represented by the principal investigator Tim Myers.
- The general scientific manager.

1.8 Equipment

The CRM facilities are located in an adjoining wing to the UAB Faculty of Sciences with a total floor space of $2,125 \text{ m}^2$, after the completion of the extension of the CRM premises in October 2010, made possible by the funding provided by the Generalitat and FEDER. The facilities include management offices with capacity for up to 60 researcher places, three meeting rooms, three lecture rooms with capacity for 95 people and an auditorium with capacity for 100 people.

Accommodation for visiting researchers is provided by Vila Universitària at Bellaterra.

The CRM computer equipment is based on a LAN Ethernet net of, approximately, eighty workstations, equipped both with Microsoft and Linux operating systems, and structured under a Windows domain. Among other services, the network includes a printing server, a file server and a *Firewall/Router* that linked it to the UAB infrastructure by means of a 1 Gb connection. The CRM network is endowed with systems that allow remote access (via SSH) to computing servers and a secure system through VPN allowing access to the rest of the center's services.

Facilities also include wifi internet connection, seven projectors and recording systems for all the meeting rooms, resources for videoconferencing, digital control systems for the meeting rooms, a tactile CRM presentation screen and the infrastructure for live broadcasting and streaming. Moreover, the CRM has opened a broadcast channel where you can find videos of lectures held at the center



www.youtube.com/user/CRMatematica

During 2020, a renewal of the IT administration equipment has been done. Some of them to laptops, to have a better mobility for the people and enhance the connection from home. Also we have acquired multimedia devices and videoconferencing licenses to use it on remote activities. Finally, we acquired Office 365 educational licensing and we are Planning to migrate our email service to Microsoft to integrate all the products in only one. We activated the new website and the intranet integrated with our new Accounting program.

2 Research Groups

2.1 Introduction

As mentioned in Section 1.1, the scientific policy of the CRM has two main axes. The second one encourages the creation of research groups covering underdeveloped areas in Catalonia, by supporting its own research groups in such areas. It is worth to say that the aforesaid support includes Research Training. By investing in training programmes, the CRM fosters creativity and expertise in mathematics, promotes collaboration, encourages the exchange of ideas among research groups, networking, stimulates discussion, and promotes career development.

Nowadays, CRM has 7 research groups. Despite the COVID19 pandemic, several scientific achievements have been released and some COVID19 oriented works have been done. The following table provides a snapshot of their scientific activities during 2020.



The research lines of each group and the main activities that they have carried out during 2020 are outlined along the following pages. The reader will also find the main tasks and duties performed by the Knowledge and Technology Transfer Unit.







Research Groups

Cancer Modelling Group

Tomás Alarcón

Most phenomena studied by the Natural Sciences, from Material Sciences to Astrophysics, are multi-scale processes, i.e. they involve the coupling of multiple different processes characterized by widely ranging time and length scales, with the macroscopic behaviour emerging from the complex interactions between them. Whilst considerable progress has been done in dealing with such problems in the Physical Sciences, the success achieved so far in the Biological Sciences is rather more limited. This is partly due to the fact that the individual components of biological systems (e.g. cells) are much more complex than their counterparts in physical systems and, therefore, new methods and models are needed to analyse multi-scale processes in Biology. Such is the remit of the Cancer Modelling Group at CRM: To propose new models relevant to experimental biologists and clinicians and develop the analytical and computational tools necessary for their analysis. We pay special attention to problems with clinical relevance, in particular those related to cancer.

The research activity of our group is developed along the following lines:

- Multiscale modelling of tumour growth and tumour-induced angiogenesis.
- Hybrid methods for multiscale models.
- Epigenetics and ageing.
- Stochastic models in population dynamics.
- Theoretical biophysics: modelling of complex fluids microfluidics.

Collaborators

- Javier Ménendez, ICO IDIBGI
- Rafael Barrio, UNAM México
- Helen M. Byrne, University of Oxford
- Juan Calvo, Universidad de Granada
- Pilar Guerrero, Universdad Carlos III
- Philip K. Maini, University of Oxford
- Miguel Bernabeu, Institute for Medical Informatics, Edinburgh, UK

2020 Activities

Co-organiser (jointly with Santiago F. Elena, Institute for Integrative Systems Biology, Valencia, and Josep Sardanyés, Centre de Recerca Matemàtica, Barcelona) of the Intensive Research Programme Dynamical Systems meet Systems and Synthetic Biology, Centre de Recerca Matemàtica, Barcelona, Spain. Postponed to 2021 due to the COVID19 pandemic

Talks

- T. Alarcon. Quantitative characterisation of epigenetic landscapes in cell reprogramming, ICO-ProCure, IDIBELL, Barcelona, Spain, February 2020. Seminar
- T. Alarcon. Mathematical modelling of large-scale transitions in chromatin structure, First Retreat of the Research Unit on Dynamical Systems and Computational Virology, Canfranc

Members:

Tomás Alarcón (team leader)
Aurora
Hernández-Machado (scientific collaborator)
Daria Stepanova (PhD student)
Stefano Pedarra (PhD student)
Lourdes
Méndez-Moral (Industrial Doctorate)



Current Projects:

 RTI2018098322-B-I00.
 The mathematical underpinnings of integrative systems biology, 2019-2021,
 Co-PIs: Tomás Alarcón & Josep Sardanyés

Subterranean Laboratory (LSC), Canfranc, Spain, March 2020. Invited Talk

• D.Stepanova. Multiscale modelling of

complex cell behavior in early angiogenesis, Canfranc Underground Laboratory, Canfranc, Spain, October 20, 2020. Invited talk

Publications

- 1. J. Sardanyés, C. Raich, and T. Alarcón. Noise-induced stabilization of saddle-node ghosts. *New Journal of Physics*, 22(9), 2020
- E. Cuyàs, S. Verdura, B. Martin-Castillo, T. Alarcón, R. Lupu, J. Bosch-Barrera, and J.A. Menendez. Tumor cell-intrinsic immunometabolism and precision nutrition in cancer immunotherapy. *Cancers*, 12(7):1–27, 2020
- E. Cuyàs, J. Gumuzio, S. Verdura, J. Brunet, J. Bosch-Barrera, B. Martin-Castillo, T. Alarcón, J.A. Encinar, Á.G. Martin, and J.A. Menendez. The lsd1 inhibitor iadademstat (ory-1001) targets sox2-driven breast cancer stem cells: A potential epigenetic therapy in luminal-b and her2-positive breast cancer subtypes. *Aging*, 12(6):4794–4814, 2020
- 4. R.A. Barrio, T. Alarcon, and A. Hernandez-Machado. The dynamics of shapes of vesicle membranes with time dependent spontaneous curvature. *PLoS ONE*, 15(1), 2020







Research Groups

Complex Systems

Álvaro Corral

We can consider complex systems to be those composed by a large number of strongly interacting elements. As a result, many of mankind's greatest challenges come from trying to unravel the behaviour of these systems, such as climate, economy, society, the brain, biological development, etc. Contrary to this, the hydrogen atom, the solar system or an ideal gas would be simple systems, despite the fact that in order to study them we need to use in-depth physics concepts and sophisticated mathematics. However, if everything that is complex is a complex system, what does the new science of complexity bring to the table? Can such wide-ranging systems be tackled with in a single perspective? One of the key ideas in complexity studies is that structures appear in these types of systems at all levels, including levels far in excess from those achieved by the interaction between components; in addition to this, the structures also show surprising statistical regularities.

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 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 compositions, in order to better understand how these unique characteristics of humans work, and also to investigate whether machines could reproduce them.

Remarkably, during 2020 Mónica Minjares joined the group as the second earlystage researcher of the ITN project CAFE. The CRM CAFE team was completed and, in addition to the standard research work, the team participated in the Second CAFE School, taking place in part in Freiberg (Germany), and in part online, due to the COVID pandemic, and also in the First CAFE Workshop (taking part online as well). In addition, the whole group (Baró, Corral, González, Minjares, Rieger, Serra) participated very actively in the EGU General Assembly (also online). In fact, A. González was co-organizer of one session of the Assembly. Baró, González and Serra organized an important virtual Workshop on Micro-Mechanics, Statistics and Hazards of Mechanical Failure, which was the culmination of Baró's AXA Fellowship. Also remarkable was that Víctor Navas-Portella successfully defended his PhD thesis in Mathematics (Universitat de Barcelona). Also, Daniel López defended his Master thesis and Eder Rodríguez, Aina Cornellà, Guillem Castellano, and Joaquim Rico presented their Bachelor theses. The group has continued its usual lines of research, publishing articles in earthquakes, linguistics, statistical tools, and performance of multiprocessors, and has culminated the introduction of a new line of research with a paper in the science of cities. Ironically, the tragic pandemic situation has opened the scientific horizons of the group, leading to the publication of three preprints about the statistics of epidemic outbreaks (available on the arXiv).

Members:

 Álvaro Corral (team leader) Isabel Serra (associated researcher) Jordi Baró (AXA post-doctoral researcher) Álvaro González (Juan de la Cierva post-doctoral researcher) Mónica Minjares (MSCA PhD student) · Víctor Navas (FPI PhD student) Niclas Rieger (MSCA PhD student) Patrícia Paredes (Ecuador government Phd student)



Current Projects:

 2017-SGB-01735 AGAUR. CRM research group in Collaborative Mathematics. PI: Á. Corral PGC-FIS2018-099629 BI00, Herramientas probabilistas y estadísticas para los sistemas complejos, Ministerio de Ciencia v Universidades. 2019-2021. PI: Á. Corral. • 813844-CAFE-H2020MSCA-ITN-2018 Climate Advanced Forecasting of Subseasonal Extremes, **Besearch Executive** Agency, EU, 2019-2023. PI: Á. Corral. RheMechFail. Stochastic rheology models of mechanical failure to monitor the resilience of structures under severe conditions. AXA Research Fund, 2018-2020. PI: J. Baró.

Activities

- Climate Advanced Forecasting of sub-seasonal Extremes: CAFE ITN Project, Álvaro Corral et al., May 4, 2020, online, EGU General Assembly
- Probability estimation of a Carrington-like geomagnetic storm, Isabel Serra et al., May 4-8, 2020, online, EGU General Assembly
- Topology and properties of aftershock clusters in a viscoelastic model of quasi-brittle failure, Jordi Baró, May 4-8, 2020, online, EGU General Assembly
- Seismic Hazard due to Fluid Injections, Jordi Baró, May 4-8, 2020, online, EGU General Assembly
- The global statistical distribution of time intervals between consecutive earthquakes, Álvaro González et al.,
- Víctor Navas Portella, PhD thesis, Mathematics PhD Program, UB, supervised by Álvaro Corral and Eduard Vives
- Session: "Statistics and pattern recognition applied to the spatio-temporal properties of seismicity", May 4-8, 2020, online, European Geosciences Union General Assembly, co-organized by Álvaro González, https: //meetingorganizer.copernicus.
- Estadística y Física de los Desastres Naturales, Álvaro Corral, February 29, 2020, UAB, outreach talk at Dissabtes de la Física
- Los Extremos del Clima, Niclas Rieger,

May 4-8, 2020, online, EGU General Assembly

- Characterisation of seismogenic zones and gas hydrates accumulation regions in the South Caribbean margin using 3D lithospheric-scale thermal and rheological models, Ángela María Gómez-García, Álvaro González et al., May 4-8, 2020, online, EGU General Assembly
- Criticality of Geophysical Processes and Estimation Procedures, Álvaro Corral, September 21, 22, 23, 2020, online, CAFE 2nd School
- Complex Canonical Correlation Analysis: a Method to Detect Lagged Correlations Between Variables, Niclas Rieger et al., November 18, 2020, online, Earth Observation for Water Cycle Science (EO4Water)

Defended theses

 Daniel López, Master thesis, Modelling for Science and Engineering, UAB, supervised by Jordi Baró

Scientific Activities

org/EGU2020/session/34890

 Virtual Workshop on Micro-Mechanics, Statistics and Hazards of Mechanical Failure, organized by Jordi Baró, October 19-22, 2020, CRM/online, Barcelona, Spain, http://fail.crm.cat/

Outreach Activities

et al., November 27, 2020, Uruguay / Spain / France / online, European Researchers' Night, https://www.crowdcast.io/e/ los-extremos-del-clima/

2.1. INTRODUCTION

 Distribuciones tamaño-frecuencia de fenómenos naturales peligrosos, Álvaro González, talk at Máster de Recursos Minerales y Riesgos Geológicos, December 16, 2020, UB-UAB

Other Activities

- Selected as Outstanding Referee of the American Physical Society, Álvaro Corral, February 2020
- Participation in the evaluation committee of the PhD thesis of Pouye Yazdi, Álvaro González, March 2020, Universidad Politécnica de Madrid

Publications

- 1. V. Navas-Portella, A. Jiménez, and Á. Corral. No significant effect of coulomb stress on the gutenberg-richter law after the landers earthquake. *Scientific Reports*, 10(1), 2020
- 2. Á. Corral, F. Udina, and E. Arcaute. Truncated lognormal distributions and scaling in the size of naturally defined population clusters. *Physical Review E*, 101(4), 2020
- 3. Á. Corral and I. Serra. The brevity law as a scaling law, and a possible origin of zipf's law for word frequencies. *Entropy*, 22(2), 2020
- 4. A. Corral and M.G. del Muro. From boltzmann to zipf through shannon and jaynes. *Entropy*, 22(2), 2020
- 5. Á. Corral, I. Serra, and R. Ferrer-I-Cancho. Distinct flavors of zipf's law and its maximum likelihood fitting: Rank-size and size-distribution representations. *Physical Review E*, 102(5), 2020
- S. Vilardell, I. Serra, R. Santalla, E. Mezzetti, J. Abella, and F.J. Cazorla. Hrm: Merging hardware event monitors for improved timing analysis of complex mpsocs. *IEEE Transactions on Computer-Aided Design of Integrated Circuits* and Systems, 39(11):3662–3673, 2020







Research Groups

Computational Neuroscience

ALEX ROXIN, KLAUS WIMMER, ALEXANDRE HYAFIL

The computational neuroscience unit at the CRM was founded in 2012 and is made up of three Principal Investigators (Alex Roxin, Klaus Wimmer and Alex Hyafil) and their groups. The unit is an active member of a larger, Barcelona-wide Neuroscience community which includes theoretical, experimental and clinical groups located in a variety of university departments and research centers (www.barccsyn.org). 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. Here's a short description of the groups more specific research interests:

The research focus in the group of Alex Roxin is on dynamical and network mechanisms in systems neuroscience. We model cognitive processes such as long-term memory formation and decision making, but also study the dynamical repertoire of neuronal networks more generally.

Research in the group of Klaus Wimmer focuses on the neural network dynamics underlying perceptual decision making and working memory, with the general aim of understanding the neural mechanisms underlying elementary cognitive functions.

Finally, the group led by Alex Hyafil has started in 2019, with an interest in understanding the core computations that underlie perception, decision-making and cognitive control in humans and mammals in general.

Collaborators

- Jonathan Pillow, Princeton University
 - Tobias Donner, UKE Hamburg
 - Yingxue Wang, Max Planck Florida Institute for Neuroscience
 - Jerôme Epzstein, INSERM at INMED
 - Jennifer Luebke, Boston Univ
 - Ernest Montbrió, UPF
 - Yaniv Ziv, Weizmann Institute of Science

2020 Activities

School, Kavli Moen Gard, Norway (and online), July 23 – Aug 4 2020.

• JM. Esnaola. Bump attractor dynamics

Members:

· Alex Roxin (team leader) · Klaus Wimmer (team leader) · Alexandre Hyafil (team leader) Federico Devalle (postdoc) · Emma Roscow (postdoc) • Pan Ye (PhD Student) Dmitrii Todorov (postdoc) José Mari Esnaola (postdoc) Nicolás Pollán (PhD student) Citlalli Vivar (PhD student) Travis Steward (PhD) Student) • Pau Blanco i Arnau (research assistant)



Current Projects: • MINECO, BFU2017-86026-R,

1/1/2018-31/12/2020 MINECO, RTI2018-097570-B-I00, 01/01/2019-31/12/2021 • MINECO, PID2019-111629GB-I00, 01/07/202-30/06/2023 · MINECO, RYC2017-23231 · MINECO, RYC2015-17236 • FI2019_FI_B1289, AGAUR • MINECO, PRE2018-083963 • MINECO, RED2018-102491-T -CLISYNE, 1/1/2020-31/12/2021 • AGAUR, 2017 SGR 1565. 1/1/2017-31/12/2020

• Nicolas Baumard, ENS Paris

- Rubén Moreno Bote, UPF
- Albert Compte, IDIBAPS
- C. Constantinidis, Wake Forest Univ
- Tatiana Pasternak, University of Rochester
- Adam Snyder, University of Rochester
- Rosa Cossart, INSERM at INMED
- Bijan Pesaran, NYU
- Jaime de la Rocha, IDIBAPS

Delivered Talks

 Long-term turnover in hippocampal circuits. Mathematical Methods in Computational Neuroscience Summer

• Normely, July 25 – Aug 4 2020.

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explain temporal weighting of evidence in estimation and categorization tasks. Neuromatch 2.0. [online], May 25 2020.

evidence integration and action initiation occur in parallel during perceptual decisions. Neuromatch conference 2.0. [online], May 20 2020.

• Ll. Hernández Navarro. Sensory

Scientific Activities

- Weekly computational and systems neuroscience webinar, co-organized by K. Wimmer (https://barccsyn.org/webinar)
- Executive committee member, Chair of

Other Activities

• K. Wimmer and A. Hyafil were faculty mentors at the Neuromatch Academy

Region & Language Committee for Neuromatch Academy and Day-Chief at Neuromatch Academy (3-week online summer school, 1700+ students, https:

 $//{\tt www.neuromatchacademy.org}/)$

Summer School, [online], July 13 – 31, www.neuromatchacademy.org

Publications

- 1. A. Hyafil and D. Moriña. Analysis of the impact of lockdown on the reproduction number of the sars-cov-2 in spain [análisis del impacto del confinamiento en el número de reproducción del sars-cov-2 en españa]. *Gaceta Sanitaria*, 2020
- A. Hermoso-Mendizabal, A. Hyafil, P.E. Rueda-Orozco, S. Jaramillo, D. Robbe, and J. de la Rocha. Response outcomes gate the impact of expectations on perceptual decisions. *Nature Communications*, 11(1), 2020







 $T = m(o, X_T)$ **Research** Groups

Harmonic Analysis and Approximation Theory

Sergey Tikhonov

Harmonic analysis studies the representation of functions or signals as the superposition of basic waves. It is currently one of the most applicable fields of modern mathematics. Among its many applications are signal processing/image transmission, various electrical and computer engineering applications, physics, probability theory and many fields of pure and applied mathematics.

Approximation theory considers the problem of how best approximating general and possibly complicated functions by simpler and more easily calculated ones. Concepts such as "best", "simpler" and "easily calculated" depend on the specific applications. Although approximation theory is a well-established area of mathematics, it is currently experiencing a significant rise due to its wide applications both in mathematics (e.g., numerical, wavelet analysis) and in computer science, signal processing, biomedical optics and geographic information systems. Recent developments in nonlinear approximation theory are aimed at carrying out fundamental mathematical (compress, denoise,...) and algorithmic study to increase our ability to process large data sets.

Visiting Positions

• September. Invited Researcher, IHES,

Bures-sur-Yvette, France

Conferences and programs organized

 02/08 – 08/08. Co-organizer (together with Feng Dai, Ronald DeVore, Vladimir Temlyakov) of the Banff-CMO workshop "Applied

Functional Analysis", Oaxaca, Mexico, (cancelled due to COVID- 19 pandemic)

Conference Talks

- 20/09. Russian–Kazakh mathematical symposium, online
- 16/01 18/01. MATA2020 Multivariate Approximation: Theory and Applications, Perugia, Italy.

Seminar Talks

- December. Approximation Theory, Harmonic Analysis and related topics, online.
- April. Analysis Seminar, UB, UAB, CRM, Barcelona, online.

Members:

Sergey Tikhonov (Team Leader)
Kristina Oganesyan (PhD student)

Gend	er	ratio F:M		
Open Access Pubs.				

Current Projects: • MTM2017-87409-P. Teoría De La Aproximación Y Análisis Harmónico: Métodos y Aplicaciones, 2018-2020. PI: S. Tikhonov. • Grup de teoría de funcions de la UAB/UB, 2017-2019. PI: S. Tikhonov

Publications

- M. Dyachenko, A. Mukanov, and S. Tikhonov. Hardy–littlewood theorems for trigonometric series with general monotone coefficients. *Studia Mathematica*, 250(3):217–234, 2020
- Ó. Domínguez, D.D. Haroske, and S. Tikhonov. Embeddings and characterizations of lipschitz spaces. *Journal des Mathematiques Pures et Appliquees*, 144:69–105, 2020
- D.V. Gorbachev, V.I. Ivanov, and S.Y. Tikhonov. Sharp approximation theorems and fourier inequalities in the dunkl setting. *Journal of Approximation Theory*, 258, 2020
- 4. S. Tikhonov and P. Yuditskii. Sharp remez inequality. *Constructive Approximation*, 52(2):233–246, 2020
- D. Gorbachev, V. Ivanov, and S. Tikhonov. Uncertainty principles for eventually constant sign bandlimited functions. *SIAM Journal on Mathematical Analysis*, 47(3):4751–4782, 2020
- 6. Y. Kolomoitsev and S. Tikhonov. Properties of moduli of smoothness in lp(rd). *Journal of Approximation Theory*, 257, 2020
- 7. E. Nursultanov and S. Tikhonov. Weighted fourier inequalities in lebesgue and lorentz spaces. *Journal of Fourier Analysis and Applications*, 26(4), 2020
- L. De Carli, D. Gorbachev, and S. Tikhonov. Weighted gradient inequalities and unique continuation problems. *Calculus of Variations and Partial Differential Equations*, 59(3), 2020
- 9. F. Dai, D. Gorbachev, and S. Tikhonov. Nikolskii constants for polynomials on the unit sphere. *Journal d'Analyse Mathematique*, 140(1):161–185, 2020
- E. Nursultanov and S. Tikhonov. Wiener-beurling spaces and their properties. Bulletin des Sciences Mathematiques, 159, 2020
- 11. D.V. Gorbachev, V.I. Ivanov, and S.Y. Tikhonov. Riesz potential and maximal function for dunkl transform. *Potential Analysis*, 2020
- F. Dai, D. Gorbachev, and S. Tikhonov. Nikolskii inequality for lacunary spherical polynomials. *Proceedings of the American Mathematical Society*, 148(3):1169–1174, 2020
- M. Dyachenko, A. Mukanov, and S. Tikhonov. Hardy–littlewood theorems for trigonometric series with general monotone coefficients. *Studia Mathematica*, 250(3):217–234, 2020









Industrial Mathematics

TIMOTHY G. MYERS

Industrial mathematics can be defined as the application of mathematics to real-world problems. The field appears to be gaining in popularity throughout the world. In Europe the European Consortium for Mathematics in Industry has been promoting the subject for over 25 years, they have now been joined by EU-Math-In and between 2014-2019 the EU COST Network MI-Net.

The Industrial Mathematics group at the CRM 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 Study Groups.

In this year of restricted travel, the PI took the opportunity to write two books, the first on Optics at the nanoscale was co-authored with a French collaborator, the second was a single author book on phase change and was submitted for the Ferran Sunyer prize.

The primary research topics dealt with by group members in 2020 included:

- Column sorption: the focus of this project is on modelling contaminant removal by passing a fluid through a column packed with an adsorbent porous media. Initial work has dealt with the removal of small amounts of a single contaminant, see Myers et al, Applied Energy 278, Int. J. Heat Mass Trans. 163, 2020. (Note, Applied Energy is ranked 1st out of 174 journals in the category Building and Construction, see SCOPUS, IJHMT is also 1st Decile, 3rd/83).
- Phase change: this work has included developing new models for melting at the nanoscale; approximate solution techniques; energy conserving one-phase reductions; solidification of supercooled melts, resulting in 10 ISI publications since 2015. The nanoscale models are particularly exciting, given that they provide novel equations not yet seen in the literature as well as explaining experimentally observed physical phenomena. Of particular interest are Myers et al Int. J. Heat Mass Trans. 149, 2020 which is the culmination of the previous work and provides the theoretical framework for phase change with size dependent thermophysical properties and also the

book, see below, which unites Prof. Myers work on moving boundary problems.

- Lensless imaging of nanoparticles: an ongoing collaboration with an experimental group at the Center for Materials Elaboration and Structural Studies (CEMES), a CNRS research centre in Toulouse, France, to identify the position of nanoparticles on a surface via a standard laser and then analysing interference patterns. See Bacsa, Bacsa & Myers, Optics Near Surfaces and at the Nanometer Scale, Springer 2020.
- Nanocrystal growth: this is a recent research line motivated by the experimental work of the Inorganics Nanoparticle Group at the Institut Català de Nanociència i Nanotecnologia with the aim of efficiently growing monodisperse nanocrystals. See Myers & Fanelli, J. Colloid Interf. Sci. 536, 2019; Fanelli et al Int. J. Heat Mass Trans. 165, 2021 (both 1st Decile journals).
- Nanoscale heat flow: a collaboration with the Physics department at UAB.
 We have developed models to describe heat flow at the nanoscale, using this to determine an accurate expression for

Members:

Tim Myers (Team Leader)
Francesc Font (post-doctoral researcher)
Claudia Fanelli (PhD Student)

Gender ratio F:M				
Open Access Pubs.				

Current Projects: • MTM2017-82317-P. Mathematics in Nanotechnology and Industry, 2017–2019. PI: T. Myers.

the variation of thermal conductivity with size which shows excellent agreement with experimental results. Four papers have so far been published; this also feeds in to the nanoscale phase change work. • General industrial mathematics: the group is also involved in IM activities, recently publishing work on green roofs, clutch manufacture, spontaneous combustion and trade in rhino horn.

Due to COVID restrictions group members attended only two meetings in 2020, both were study groups, held in South Africa and CRM. They worked on green roof modelling and the manufacture of clutch components.

The final group PhD student, Claudia Fanelli, graduated Cum Laude in June.

Collaborators

- Maria Aguareles, University of Girona
- Sarah Mitchell, University of Limerick
- Brian Wetton, University of British Columbia
- Matt Hennessy, University of Oxford
- Vincent Cregan, Munster Technological University
- Xavier Alvares, Universitat Autònoma de Barcelona
- Wolfgang Bacsa, Centre d'Elaboration de Matériaux et d'Etudes Structurales

The PI and Dr. Font were main organisers for the 158th European Study Group with Industry, held at CRM Jan. 2020. The PI was also a main organiser for the webinar, Mathematics of the COVID19 crisis – In the eye of the storm, April 2020; a member of the Scientific Committee for the 2020 ECMI conference (postponed to 2021) and gave talks (online) in the series Bojos per les matematiques (to high school students), to an undergraduate class at UPC and a research talk for Cardiff University Maths Dept.

Grant applications included MICINN Retos programme (TM); La Caixa Junior Leader (FF); Marie Curie Individual Fellowship (for a new post-doc, not awarded but the score of 89.4% gives a Seal of Excellence, the grant has been resubmitted to Beatriu de Pinos). Also, TM as part of a team for a French Research Council grant - €350K, Dec. 2020, Optical Lensless Imaging of Nanoparticles on surfaces, PI Prof. W. Bacsa.

Remarkable achievements

2020.

- Optics near surfaces and at the nanoscale, W. Bacsa, R. Bacsa, T. Myers, see https://www.springer. com/gp/book/9783030589820
- Theoretical and practical Stefan problems, T. Myers, submitted for Ferran Sunyer i Balaguer prize, Nov.
- Multidisciplinary Mathematical Modelling: Applications of Mathematics to the Real World, F. Font, T. Myers (Eds.), ISBN 978-3-030-64271-6, Springer 2021.

Coordinator of all European Study Groups with Industry (ESGI), 2016 - present.

Publications

1. T.G. Myers and F. Font. Mass transfer from a fluid flowing through a porous media. *International Journal of Heat and Mass Transfer*, 163, 2020
- H. Ribera, B.T.R. Wetton, and T. Myers. Cellular automaton model for substitutional binary diffusion in solids. *Journal of Mathematical Modeling*, 8(1):91–104, 2020
- A. Beardo, M.G. Hennessy, L. Sendra, J. Camacho, T.G. Myers, J. Bafaluy, and F.X. Alvarez. Phonon hydrodynamics in frequency-domain thermoreflectance experiments. *Physical Review B*, 101(7), 2020
- 4. T.G. Myers, M.G. Hennessy, and M. Calvo-Schwarzwälder. The stefan problem with variable thermophysical properties and phase change temperature. *International Journal of Heat and Mass Transfer*, 149, 2020
- V. Cregan, J. Williams, and T.G. Myers. Contact melting of a rectangular block with temperature-dependent properties. *International Journal of Thermal Sciences*, 150, 2020
- 6. M. Calvo-Schwarzwälder, T.G. Myers, and M.G. Hennessy. The one-dimensional stefan problem with non-fourier heat conduction. *International Journal of Thermal Sciences*, 150, 2020
- 7. T.G. Myers, F. Font, and M.G. Hennessy. Mathematical modelling of carbon capture in a packed column by adsorption. *Applied Energy*, 278, 2020
- S. Flemming, F. Font, S. Alonso, and C. Beta. How cortical waves drive fission of motile cells. *Proceedings of the National Academy of Sciences of the United States of America*, 117(12):6330–6338, 2020
- E. Moreno, S. Flemming, F. Font, M. Holschneider, C. Beta, and S. Alonso. Modeling cell crawling strategies with a bistable model: From amoeboid to fan-shaped cell motion. *Physica D: Nonlinear Phenomena*, 412, 2020







Research Groups

Mathematics of development and evolution

ISAAC SALAZAR CIUDAD

Our group is focused in understanding the mathematical bases of evolution.

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. In the case of multicellular organisms, such as us, the questions are:

- How does a fertilized egg transform itself into a complex adult organism? Can we understand the mathematics of such a dramatic pattern formation process?
- How did this complexity arose by a gradual process of evolution by natural selection. This implies explaining also the evolution of the development that

produces such complexity in each generation.

3. Are there some logical or mathematical requirements or principles that gene networks need to fulfil in order to be able to produce complex morphologies during development? If so, can we approach question 1 and 2 above from understanding these principles?

Understanding question 1 is highly non-trivial: something very complex, e.g. our body, is produced from something much simpler and small, a simple cell, in a relatively short time.

This process cannot be understood by looking at single genes. Embryonic development involves the interaction between huge numbers of genes and cells. Thus, for example, to understand which morphological changes will occur from specific mutations in a gene, we need to understand how that gene is embedded in a gene network and how that affects the dynamics of signalling and mechanical interactions between cells and tissues. In other words, we have a huge number of heavily interacting elements at different levels (e.g. genes, cells, tissues) that lead to the arising and variation of a macroscopic pattern, the body's.

To address these questions, 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 (cell growth, cell contraction, cell division, etc?). 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. Genes affect the mechanical properties and behaviours of the cells in which they are expressed. As a result, cells move and rearrange themselves in space. In their turn, cell affect back gene expression by differentially affecting, through cell-cell signalling, where genes get expressed.

The research activity of our group is developed along the following lines:

- Multiscale modelling of pattern formation and morphogenesis in embryonic development.
- Modelling of evolution in biologic and non-biologic systems.
- Statistical developmental biology.
- Combining and contrasting developmental biology and quantitative genetics approaches to the genotype-phenotype map and evolution.

Members:

- Isaac Salazar (Team Leader)
- Tazzlo Tissot (PhD
- Student)
- Kevin Martinez Anon (PhD Student)

Gender ratio F:M

Open Access Pubs.	

Current Projects: • MINECO,

PGC2018-096802-B-100,Comprension de la relacion entre el desarrollo embrionario, la variacion genetica additiva, la variacion ambiental y el mapa genotipo-fenotipo **PI** I. Salazar.

CHAPTER 2. RESEARCH GROUPS

Collaborators

- Jukka Jernvall, University of Helsinki
- Osamu Shimmi, University of Helsinki
- Antonio Barbadilla, Universitat Autònoma de Barcelona
- David Houle, Florida State University
- Stuart A. Newman, New York Medical College

2020 Activities

During 2020 we have had two main approaches and results. In the first one (Hagolani et al., 2021) we build a huge ensemble of random developmental mechanisms, e.g. gene networks coupled with cell behaviours and mechanical properties, and simulated them to explore which ones can lead to morphogenesis (e.g. the transformation of a simple morphology into a more complex one). We found there is an intrinsic asymmetry in complexity: mutations leading to a decrease in morphological complexity are more frequent than the mutations leading to an increase in complexity. In addition, the former tend to have a more complex relationship between genetic and morphological variation. This happens in all gene networks that can lead to the development of a morphology. This leads us to suggest that there is a general trend in the evolution of complexity according to which complexity, in those lineages where it does. In addition, we also published (Salazar-Ciudad, 2021) a theoretical discussion on why the concept of developmental constraints and biases mis-represents the role of development in evolution.

Publications

1. L. Milocco and I. Salazar-Ciudad. Is evolution predictable? quantitative genetics under complex genotype-phenotype maps. *Evolution*, 74(2):230–244, 2020









Nonlinear Dynamics and Evolution Lab

Josep Sardanyés Cayuela

Our laboratory seeks to understand nonlinear dynamical phenomena. Our research is focused on biological processes at different scales, from virus dynamics and evolution to cancer and ecosystems. To do so we use the qualitative theory of dynamical systems and computer simulations (stochastic dynamics and spatially extended systems using cellular automata models). We investigate the dynamical evolution of nonlinear systems, paying special attention to the bifurcations and phase transitions separating relevant dynamical phenomena.

Our investigations have the ultimate goal to identify potential useful dynamical scenarios such as ecosystems' recovery or tumor cell extinctions.

Also, we are doing research in general topics of nonlinear dynamical systems such as bifurcations, universality phenomena, scaling, and transients.

https://sites.google.com/site/nonlineardynamicsevolutionlab

Collaborators

- Tomás Alarcón, ICREA CRM UAB
- Santiago F. Elena, Instituto de Biología Integrativa de Sistemas, I2SysBio and The Santa Fe Institute
- Álvaro Corral, CRM UAB
- Javier A. Menendez (Cancer Metabolism Lab, Catalan Institute for Oncology)
- Núria Fagella, UB
- Ricard Solé, ICREA Complex Systems Lab, UPF and The Santa Fe Institute
- Lluís Alsedà, CRM UAB

- Sergi Valverde, Institut de Biologia Evolutiva - CSIC
- Carlos Peña, Instituto de Biología Integrativa de Sistemas, I2SysBio; Laboratorio Subterráneo de Canfranc
- Daniel Oro, Centre d'Estudis Avançats de Blanes – CSIC
- Frederic Bartumeus, ICREA Centre d'Estudis Avançats de Blanes – CSIC – TheeLab
- David Alonso, Centre d'Estudis Avançats de Blanes – CSIC – TheeLab
- Nuno Martins, Instituo Superior Técnico de Lisboa

2020 Activities

Along 2020, the NoDE lab has been doing research on dynamical systems applied to different biological subjects: cancer, origins of life, cancer and virus evolution. The lab has supervised 1 MSc thesis and 2 BsC thesis. The lab has incorporated a PhD student (Marc Plana). We have published 6 research articles in 2020.

We have started long-term collaborations with three research centers:

- 1. Cancer Metabolism Lab, Catalan Institute for Oncology (Girona)
- 2. Gene therapy and cancer (IDIBAPS, Hospital Clínic de Barcelona)
- 3. Laboratorio Subterráneo de Canfranc (Huesca)

Members:

 Josep Sardanyés (Team Leader) Marc Plana (PhD Student) • Blai Vidiella Rocamora (PhD Student) **External members:** Cristina Januário (ISEL) • Ernest Fontich (UB) Antoni Guillamon (UPC) · Jorge Duarte (ISEL -IST) · J. Tomás Lázaro (UPC)

Gender ratio F:M
Open Access Pubs.

Current Projects • Los puntales matemáticos de la biología integrativa de sistemas PI T. Alarcón & J. Sardanyés.

CHAPTER 2. RESEARCH GROUPS

Scientific talks

- "Social copying drives non-linear population collapse in a colonial bird". Fostering Complex Systems in Ecology, Epidemiology, and Systems Biology. "Laboratorio Subterráneo de Canfranc" LSC 2.0 Conferences. 19-21st October 2020.
- "Dynamics of cooperation: from origins of life to ecosystems". The 12th European Conference on Mathematical and Theoretical Biology - eSMTB. Virtual Conference: Mini-Symposium Eco-evolutionary dynamics across scales of organisation 18th August 2020.

Publications

- J. Sardanyés, C. Raich, and T. Alarcón. Noise-induced stabilization of saddle-node ghosts. *New Journal of Physics*, 22(9), 2020
- B. Vidiella, J. Sardanyés, and R.V. Solé. Synthetic soil crusts against green-desert transitions: A spatial model: Synthetic ecosystems' terraformation. *Royal Society Open Science*, 7(8), 2020
- 3. J. Perona, E. Fontich, and J. Sardanyés. Dynamical effects of loss of cooperation in discrete-time hypercycles. *Physica D: Nonlinear Phenomena*, 406, 2020
- L. Alsedà, B. Vidiella, R. Solé, J.T. Lázaro, and J. Sardanyés. Dynamics in a time-discrete food-chain model with strong pressure on preys. *Communications* in Nonlinear Science and Numerical Simulation, 84, 2020
- A. Nurtay, M.G. Hennessy, L. Alsedà, S.F. Elena, and J. Sardanyés. Hostvirus evolutionary dynamics with specialist and generalist infection strategies: Bifurcations, bistability, and chaos. *Chaos*, 30(5), 2020
- 6. N. Conde-Pueyo, B. Vidiella, J. Sardanyés, M. Berdugo, F.T. Maestre, V. Lorenzo, and R. Solé. Synthetic biology for terraformation lessons from mars, earth, and the microbiome. *Life*, 10(2), 2020
- B. Vidiella, J. Sardanyés, and R.V. Solé. Synthetic soil crusts against green-desert transitions: A spatial model: Synthetic ecosystems' terraformation. *Royal Society Open Science*, 7(8), 2020

2.9 Knowledge Transfer Team

The unit of technology and knowledge transfer of the CRM was created in 2017 in order to support the initiative of Transfer originated in 2012.

From the transfer point of view, the CRM has potential to promote the advance and innovation in science's key areas. Specifically, the nature of the CRM is to host interdisciplinary scientific knowledge, thanks to the support of the mathematical community of the Catalan universities that provide international networking and promote high quality scientific research. Therefore, the CRM offers advanced knowledge in the development of solutions to current problems of the industry, society and the environment.

Due to the complexity involved in the transfer of interdisciplinary areas, in September 2017, the CRM started the KTT Unit with the mission of strengthening the links between



research and the real world, to endorse advising and understanding. This Unit guides and promotes the use of solutions based on science as the engine for innovation.

The objectives of the CRM's KTT Unit are to promote, collaborate and evaluate the transmission, transfer and creation of knowledge that links research with its application. Therefore, the KTT Unit is present in talent promotion processes, promotes the interdisciplinarity between researchers and acts as promoter of research results. In this last point, this year began an active participation by the CRM in studying and supporting innovation projects that begin within the industry. However, the KTT Unit participates in actions of outreach for the center, and this year it has participated in the BIST – Python Bootcamp Master of Multidisciplinary Research in Experimental Sciences.

Regarding the promotion of talent, KTT is attentive to attracting interest from students with interdisciplinary concerns, hosting them in stays at the center, as well as directing undergraduate and master's final projects. In addition, it encourages PhD students to participate in educational activities in order to enhance their communication skills, a key factor for transfer.

With regard to the promotion of interdisciplinarity between researchers, the main purpose is to endorse the use of top research in mathematics with other disciplines, that is why you want to promote the creation of associations and other collaborations. This year, thesis co-direction projects have continued, together with other centers and other contacts to foster new collaborations have been carried out.

Finally, besides of the above points and other some point collaborations, there are two main actions carried out by the KTT unit this year: the launch of KENIA project and the collaboration agreement with Transports de Barcelona S.A.

On the one hand, Knowledge Enhancing in Need-assessment Industrial for Advancement (KENIA) project is an option for small and medium-sized companies that need to incorporate a mathematically based knowledge profile, adapted to their specific needs. It responds to the needs raised by the customer with a team of experts in the area, ensuring the technological solvency of the company. Under the frame of KENIA, KBOX (https://kboxsalestools.com/) and CRM's KTT unit entered into a collaboration whose main aim is to integrate into their commertial analysis tool a module of budgeting and forecasting using artificial intelligence.

CHAPTER 2. RESEARCH GROUPS

On the other hand, Transports de Barcelona S.A. (TB) has been offering a local bus service called Bus del Barri. This service has grown, and the current model consists of 24 lines, which allow residents to get closer to shopping areas, care centers and facilitate access to the basic public transport network. During 2020, TB transmitted to CRM their willingness to improve the Bus de Barri by replacing the regular lines, where feasible, by a service of Transport on Demand (DRT) to achieve a better efficiency of the service, without diminishing the current level of quality offered to users. The idea is to replace them, where feasible, with a more agile and competitive DRT service. To perform such study of feasibility, in fact studies, one should deal with the Dial-A-Ride-Problem which is a generalisation of the *Traveling Salesman Problem*. To successful carry out these studies, a routing software have been developed. At the end of fall, CRM delivered the results of these studies which, at the end, they lead to a open call for tenders to manage the feasible DRT lines.

Complex Fluids Lab

The CRM Complex Fluids Lab is a service and experimental research unit. This unit is a joint venture between the Computational & Mathematical Biology and Industrial Mathematics groups, and the Knowledge and Technology Transfer Unit. The goal is to provide researchers with experimental facilities that allow to step up the research of these groups, providing the necessary tools to incorporate the experimental branch into the field of complex fluids. The scientific goal of this research unit is the study of the mechanical properties of fluids subjected to different dynamics, both by means of physical and mathematical models and by means of data analysis. The Complex Fluids Lab has been set up in collaboration with the group of Dynamics of Interfaces in Nanotechnology, Fluidics and Biophysics of the Faculty of Physics of the University of Barcelona, led by Prof. Aurora Hernández-Machado, scientific collaborator of the CRM. The main progress of the lab during 2020, has been the analysis and the set up of the facilities in order to offer a service of experimentation and analysis of fluids to other research groups and companies.



Red Española Matemática-Industria

CRM signed a collaboration agreement with Math-In in May 2012, with the goal of involving CRM researchers in technology transfer, through the exchange of information, co-ordinating grant proposals, support to conference organization and establishing links with companies and research centres.

The creation of the Math-In Network was one of the priorities of the Technology Transfer Plan of the previous i-MATH project, and was intended to be the evolution of the mathematical platform CONSULTING. Math-In is a network made up of almost forty research groups focused on communication and exchange of information and experiences to promote the transfer of research results produced into the field of industrial mathematics.



Industrial Doctorate

CRM has provided proposals for Industrial Doctorates since the set up of this plan by the Generalitat de Catalunya. At this moment, CRM has two insdustrial doctorates in collaboration with RheoDx, the CRM's spin-off. The doctorate students are Josep Ferré and Lourdes Méndez.





3 Activities

3.1 CRM Activities

The CRM has a long-standing tradition of organizing four types of activities on a competitive basis through open calls on its website:

- Intensive Research Programmes
- Advanced Courses
- International Conferences and Workshops
- Thematic Days

The scientific events and research programmes held at the CRM are open to participation by both local and international researchers at all stages of their careers. The CRM is particularly eager to serve as a meeting point for Catalan mathematicians and renowned specialists from all around the globe, inviting researchers to carry out long-term stays during the research programmes.

Applications can be submitted at

https://www.crm.cat/scientific-programmes-events/

CRM is socially committed to the popularization and dissemination of mathematics, also. One of the main goals of the center is to raise awareness of the usefulness of mathematics through an on-going dialogue with society. To this end, CRM also promotes Outreach activities.

It is worth to mention that this year has been strongly affected by the pandemic situation around the world and, hence, there have been several activities postponed to 2021. However, even with the difficulties presented by COVID-19 re lated restrictions, the following table presents an outline of the research activities carried out during 2020, some of them online.



3.2 Seminars

The CRM disseminates the activity of all the research seminars in mathematics in Catalonia, but it also organises seminars in emergent areas, either through its thematic networks or through the CRM's research staff.

Seminars Related to CRM's Research activity

- 1. The CRM Applied Mathematical and Physics (CAMP) Seminar. Coordinator: Víctor Navas (CRM).
- Computational Neuroscience Seminar. Organisers: Alex Roxin (CRM), Albert Compte (Institut d'Investigacions Biom'ediques August Pi i Sunyer (IDIBAPS)), Gustavo Deco (UPF), Jaime de la Rocha (IDIBAPS), Antoni Guillamon (UPC), Ruben Moreno-Bote (Fundació Sant Joan de Déu), Jordi G. Ojalvo (UPC).

Also, CRM is the (virtual) venue of

- 1. SIMBa: a youth mathematics seminar organized by graduate students of the Barcelona area.
- 2. The GSDUAB seminar: the seminar of the Grup de Sistemes Dinàmics de la UAB.

3.3 Intensive Research Programmes

The CRM Research Programmes consist of periods of intensive research in a particular area of the mathematical sciences and their applications, bringing together researchers from different institutions to work on open problems in the chosen area and to analyse its present state and perspectives.

Research Programmes can run for periods from two to five months, with both visiting researchers and activities organised within. Every programme has a scientific committee, which is fully responsible for the planning of all activities included in the programme, elaboration of the list of participants, and submission of a final report. Typically, participants in a programme include local full-time researchers, visitors on a full-time basis, post-doctoral fellows, and advanced doctoral students. A research programme generally includes one or two weekly seminars, one intensive workshop (preferably open to researchers not participating in the programme), a conference and an advanced course addressed to graduate students. The CRM Research Programmes are called internationally two years in advance and are evaluated by the Scientific Advisory Board.

In this context, in September 2020 the Basque Centre for Applied Mathematics (BCAM), the Centre de Recerca Matemàtica (CRM) and the Institute of Mathematical Sciences (ICMAT) agreed on the organization of the BCAM-CRM-ICMAT International Program on Mathematics and its Applications (BCI-IPMA). The BCI-IPMA capitalizes on the broad International expertise and vast organizational experience of the three partner institutions. It will be coordinated by the CRM and consists in the following 5 IRPs (to be held during 2021-2023):

The mathematics of emergent problems in Biomedicine

The impact of dynamics in systems and synthetic biology is of paramount importance. Typically, biological systems are highly nonlinear, and nontrivial dynamics can occur even in low-dimensional systems, with a huge impact on complex ecosystems, tumour dynamics, or cell circuits. Dynamical systems theory offers a unique opportunity to model, simulate, and understand the dynamical outcome in systems and synthetic biology. The program will foster the bidirectionality of modelling biological systems: models allow us to understand and predict the behaviour of biological systems; new biologically inspired models can give place to new mathematical phenomena.

Description

Harmonic Analysis has been and continues to be an active field of research for both purely mathematical interest and applications to difficult problems in other mathematical fields. The focus of this program will be on Harmonic Analysis and specially on its interface with closely related areas:

- Geometric Measure Theory: connections between singular integrals and rectifiability and other questions.
- *Partial Differential Equations*: harmonic and elliptic measure,

Dirichlet problem, Poincaré inequalities, Landis and Yau conjecture.

Harmonic Analysis

• *Operator Algebras*: noncommutative L^p -spaces, operator valued analysis.

_____ Singularities emerging in Geometry, Dynamics and Mathematical Physics

Description

The IRP will be focused on the blossoming of singularities in algebra, geometry, dynamics and mathematical physics. Toric manifolds show up naturally on the interface of algebraic and symplectic geometry. Any toric manifold has an integrable system naturally associated with it endowed with singularities of non-degenerate type. Integrable systems are ubiquitous in Geometry and Mathematical Physics and the role of their singularities are one of the newest facets of Mirror Symmetry. Symplectic Topologists' approach to tackle Arnold's and Weinstein conjecture in Hamiltonian Dynamics has flourished into a new world: Floer theory. Partly with Mirror Symmetry motivation, and partly as an attempt to understand Floer type theories from an algebraic geometric ways. We will analyse singular patterns emerging in symplectic and algebraic geometry and how can be applied to mathematical physics.

Machine Learning Foundations

Description

The mathematical foundations of machine learning (ML) have been instrumental to formulate and lay the basis of learning approaches and methodologies. The spectacular success of ML has been enabled by the use of probability theory, functional analysis,

information theory, and convex optimization. Conversely, research driven by ML has resulted on significant advances in other areas of mathematics. This cross-fertilization has led to results such as uniform laws of large numbers, kernel-based methods, concentration inequalities, and generalization bounds. The theory and algorithms developed have made possible important technological applications that are leading to new learning paradigms and performance requirements. Emerging trends and scenarios motivated by real-life problems are enabled by novel methods such as those of adversarial and large-scale Bayesian learning.

Recent Major Trends in PDE's and Nonlocal Operators

Description

The last two decades have brought important contributions in the theory of PDEs partly inspired by those equations that include nonlocal terms, as it happens for example in fluid dynamics, in diffusion processes of Levy type, and in the discretization of classical local operators as the Laplacian. The study of the specific non-local features has opened a highly fruitful major new trend. Similarly, convex integration techniques, although initially pioneered in geometry, have started to make a significant impact in PDEs only with the striking applications to the existence of wild solutions of the 3D Euler. The developments in these areas have gained an independent life of their own and, in turn, the improved understanding gained in these directions (of convex integration and nonlocal operators) has returned to fluid dynamics questions, providing crucial, impressive advances. Finally, classical questions regarding unique continuation and propagation of smallness are far from being understood in the nonlocal setting. Their study is receiving plenty of attention in the last years, to find new techniques yielding quantitative results that lead to uniqueness.

The BCI-IPMA aims to leverage the international network and collaborations of the researchers in Mathematics and Applied Mathematics in Bilbao, Barcelona and Madrid; this will be achieved by bringing together the best of the world-class scientific capabilities of BCAM, CRM and ICMAT. In addition, the BCI-IPMA is expected to provide "spill out" benefits for the Spanish mathematical community at large, deploying five programs focused on a scientific and mathematical "hot topic" during 2021, 2022, and 2023. In this regard, this joint venture was submitted to the Simons Fellows Program. Unfortunately, it was not awarded. However, all the above Intensive Research Programmes will be carried out.



The CRM Research Programmes that took place in 2020 are described below. General information of Research Programmes can be found at

www.crm.cat/call/4/research-programs/4









Quantitative Finance

Postponed to 2021

This intensive program focuses on hot topics in Quantitative Finance. In the last decades, problems emerging in the financial industry have been a starting point for the development of quantitative techniques. These techniques cover a wide spectrum of mathematical fields, from probability theory to numerical and computational tools. A huge volume of research has done in the academia inspired by these problems. In the contrary direction, the financial industry is using more and more advanced (from the mathematical point of view) tools and concepts, due to the increasing complexity of markets, that can only be addressed with high-level quantitative methods. This program has been designed to create a bridge between the academia and the industry and it is thought to be a forum to gather professionals working in this area. This means, from the academia, the financial industry and specialized software companies.

Organizers:

Elisa Alòs (UPF) Luis Ortiz-Gracia (UB) Josep Vives (UB–IMUB)

Main activities of the event:

- 1. Two advanced courses focused on the mathematical and computational tools in Quantitative Finance. *Postponed to 2021*.
- 2. A workshop devoted to the current challenges in option pricing and hedging in the financial industry and the latest academic developments. *Postponed to 2021*.
- 3. A weekly seminar. Postponed to 2021.









DYNS³BIO: Dynamical Systems in Systems and Synthetic Biology

Postponed to 2021

The impact of dynamics in systems and synthetic biology is of paramount importance. Typically, biological systems are highly nonlinear, and nontrivial dynamics can occur even in low-dimensional systems. Nonlinear dynamics can have a huge impact on complex ecosystems, tumour dynamics, or cell circuits, to cite a few examples. Dynamical systems theory offers a unique opportunity to model, simulate, and understand the dynamical outcome in systems and synthetic biology. These outcomes range from stationary states, to transient phenomena, or to transitions between states (bifurcations). The current development of new technologies and data processing may allow to handle high-resolution dynamical information for complex biological systems. This fact, due to the development of low- and high-dimensional dynamical systems, offers a unique opportunity to provide qualitative and quantitative information by means of mathematical and computational models. The usage of dynamical systems to describe real-experimental dynamics is bidirectional: models allow us to understand and predict the behaviour of biological systems; new biologically-inspired models can give place to the discovery of new mathematical phenomena. The importance of dynamics in nonlinear systems spans the fields of theoretical ecology, biomedicine, diseases, epidemiology, among others.

The ultimate goal of this IRP is to bring together leading experts in dynamical systems, theoretical and computational biology, and both experimental and field biology.

Main activities of the event:

- 1. International Conference on Dynamics in Systems and Synthetic Biology ON-LINE *Postponed to 2021*
- 2. Online Seminars Postponed to 2021
- 3. Advanced Course on Applied Dynamics in Systems and Synthetic Biology *Postponed to 2021*

Organizers:

Tomás Alarcón, (ICREA, CRM)

Santiago F. Elena, (CSIC-UV)

Josep Sardanyés, (CRM)











Low dimensional dynamical systems and applications

February 3rd to March 12th, 2020

Dynamical systems is a wide area of research which goes beyond mathematics itself, and includes many applications. In addition, the tools are varied and come from most of the classic research lines in mathematics, such as real and complex analysis, measure theory, ergodic theory, numerical analysis and its computational implementation, topology, number theory, etc. Roughly speaking, the theory of dynamical systems consists in the rigorous study of one, several, or even infinitely many features associated to a process that depends intrinsically on parameters and that evolves when an independent variable (that we call time for obvious reasons) varies. Most of the problems in this context arise from physics (movement of celestial bodies, heat evolution in a rigid body...), biology (evolution in a structured population, neuroscience, cell growth...), economy (generational phenomena, market prices evolution...), chemistry (chemical reactions), new technologies (complex networks) or from mathematics themselves (graph theory, fractals, chaos...).

The main objects of interest in any dynamical system depending on parameters, no matter in which specific framework occurs, are the following:

- 1. The phase portrait for a fixed parameter of the system, which serves to determine the future value of the system features (or system states) in the phase space based on their present values;
- 2. The bifurcation diagram in the parameter space, which is meant to describe how a specific feature of the system varies as we move the parameters. In this respect it deserves particular attention the bifurcation phenomena that occur at those parameters which lie on the boundary between qualitatively different phase portraits.

Understanding these objects is formalized into different statements or challenges depending on the context. In particular there is a preliminary division based on whether the evolution of the process is continuous (real time) or discrete (natural or integer time), but there are other relevant considerations as the dimension of the problem (i.e., number of features we wish to observe), the topology of the phase space, the type of bifurcations in the parameter space, etc. The origin of the discrete version goes back to the studies of the chaotic dynamics by A.N. Sharkovskii (1964) and T.Y. Li and J.A. Yorke (1975) for the real case, together with the works of Cayley about Newton's method (1879), the memoirs of P. Fatou and G. Julia (1920), and the notes of Orsay written by A. Douady and J.H. Hubbard (1982). Both scenarios -real and complexshow that very simple models in low dimension can exhibit extremely rich dynamics. In this context the present proposal focuses in problems related to topological and combinatorial dynamics and the description of the period set of continuous maps in graphs and trees. We also want to study the topological and analytical properties of the connected components of the Fatou set and the dynamics on their boundaries, the existence and distribution of wandering domains inside the Fatou set and the description of the parameter space and its bifurcations.

Organizers:

Peter De Maesschalck, University of Hasselt

Antonio Garijo, Universitat Rovira i Virgili

Xavier Jarque, Universitat de Barcelona

David Juher, Universitat de Girona

Boguslawa Karpinska, Technical University of Warsaw

Lubomir Snoha, University of Bratislava

Joan Torregrosa, Universitat Autònoma de Barcelona

Jordi Villadelprat, Universitat Rovira i Virgili

General data: Gender ratio F:M Provenance Local:Non-local Provenance Local:Non-local Provenance Local:Non-local District States Provenance Local:Non-local Provenance Local:Non-local District States Provenance Local:Non-local Provenance Local:No

Main activities of the event:

- 1. Advanced Course on Recent Trends in Nonlinear Science February 3rd to 7th
- 2. Workshop on Bifurcations and finiteness problems in ordinary differential equations *February 17*th to 21st
- 3. Workshop on Topological and Combinatorial Dynamics Postponed to 2021
- 4. Transcendental dynamics and beyond: Topics in Complex Dynamics *Postponed* to 2021

Acknowledgements: This course is made possible in part by the generous support from the AGAUR (Ref: 2017SGR1617), by the Ministerio de Ciencia e Innovación (Ref: RED2018-102324-T, MTM2017-86795-C3-1-P, MTM2017-86795-C3-2-P, MTM2017-86795-C3-3-P, MTM2016-77278-PFEDER) and by the European Community (Ref: Dynamics-H2020-MSCA-RISE-2017-777911)

Advanced Course on Recent Trends in Nonlinear Science

Description

February 3rd to 7th

This Advanced Course, apart from being the starting point of the IRP on Low dimensional dynamical systems and applications, will also be the 17th international school of the series Recent Trends in Nonlinear Science by the DANCE (Dinámica, Atractores y Nolinealidad: Caos y Estabilidad) Spanish network.

The school will consist on the following three advanced courses of 9 hours each:

Course 1: Finiteness theorems for limit cycles by Yu. Ilyashenko

Abstract A polynomial vector field in the plain has but a finite number of limit cycles. Limit cycles of an analytic vector field cannot accumulate to a polycycle of this field. The first theorem is an immediate corollary of the second one. My current proof consists of the three parts:

- 1. reduction from the ODE to complex analysis
- proofs of the theorems above for vector fields with the so called "alternant" polycycles (those in which the maps TO and FROM central manifolds of the saddle nodes alternate)
- **3**. proof for the general case.

There are some gaps in the third part that I am filling now. The lectures will give a brief, yet comprehensive presentation of the first two parts, and a survey of the current state of matters for the third part.

Course 2: Continuity of Lyapunov exponents by Marcelo Viana

Abstract I will introduce the notions of linear cocycle and Lyapunov exponent, and will sketch of the proof of the fact that the Lyapunov exponents of random products of matrices vary continuously with the data.

This is based on joint work with C. Bocker, A. Avila and A. Eskin.

3.3. INTENSIVE RESEARCH PROGRAMMES

Course 3: Dynamical aspects of skew products over minimal dynamics by Mario Ponce

Abstract We will introduce the skew-product dynamics, especially those whose transformation in the fibre corresponds to an isometry. We will show how these simple dynamics give rise to several phenomena that are governed both by the arithmetic properties of the rotation numbers, as well as by geometric properties that force some rigid dynamic behaviours. In particular we will study the dynamics associated to invariant sections, to bounded orbits, among other phenomena. These skew-products constitute a geometric model for the resolution of linearised equations of more complex dynamics. We will investigate about the geometric and dynamic methods that allow us to solve such equations.

Lecturers

- 1. Yu. Ilyashenko
- 2. Marcelo Viana
- 3. Mario Ponce

— Workshop on Bifurcations and finiteness problems in ordinary differential equations

Description

February 17th to 21st

The purpose of this conference is to provide an adequate atmosphere to discuss the recent developments around the Hilbert's 16th and related problems, as well as to stimulate new research. The topics to be discussed include (but are not restricted to) desingularization of parametrized families, asymptotic expansions of time and return maps, blowing-up and normal forms of singularities, ideal of coefficients associated with an analytic unfolding, abelian integrals, Chebyshev systems, singular perturbations problems occurring in planar slow-fast systems, etc. It is aimed also to bring together methods from real and complex dynamical systems because the interplay between real and complex methods has been proved to be both useful and necessary for the solution of many interesting problems.

Lecturers

- 1. Claudio Buzzi, Universidade Estadual Paulista
- 2. Colin Christopher, Plymouth University
- 3. Peter De Maesschalck, Hasselt University
- 4. Armengol Gasull, Universitat Autònoma de Barcelona
- 5. Pavao Mardesic, Université de Bourgogne
- 6. Douglas Novaes, Universidade Estadual de Campinas
- 7. Dimitry Novikov, Weizmann institute of Science
- 8. Daniel Panazzolo, Université de Haute-Alsace

- 9. Salomon Rebollo, Universidad del Bio Bio
- 10. Robert Roussarie, Université de Bourgogne

Workshop on Topological and Combinatorial Dynamics

Description

Postponed to 2021

This workshop is intended to be a great opportunity to meet old and new colleagues working on the field of Topological and Combinatorial Dynamics, in a relaxed and exciting atmosphere of scientific collaboration and interchanging of ideas. The combination of both plenary and short talks may allow young and senior researchers to expose recent developments and establish fruitful discussions. The generic topics to be discussed include (but are not restricted to):

- Topological dynamics
- Quasi periodically forced systems
- Combinatorial dynamics
- Ergodic theory

The workshop is dedicated to the memory of our friend Pere Mumbrú i Rodríguez (1955-2005), sadly deceased 15 years ago in the fullness of his career.

Lecturers

- 1. Jozef Bobok, Czech Technical University in Prague
- 2. Adrien Boulanger Aix Marseille Université
- 3. Kristian Bjerklöv, KTH Royal Institute of Technology
- 4. Armengol Gasull, Universitat Autònoma de Barcelona
- 5. Dominik Kwietniak, Jagiellonian University in Kraków
- 6. Jérôme Los, Aix Marseille Université
- 7. Jaume Llibre, Universitat Autònoma de Barcelona
- 8. Michal Misiurewicz, Indiana University Purdue University Indianapolis
- 9. Piotr Oprocha, AGH University of Science and Technology
- 10. Lubomir Snoha, Matej Bel University
- 11. Joan Carles Tatjer, Universitat de Barcelona

Transcendental dynamics and beyond: Topics in Complex Dynamics

Description

Postponed to 2021

The conference focusses on iteration of functions in the complex plane in the presence of essential singularities, in one and several dimensions and related topics. Many problems specific for these types of maps have received a lot of attention in the last few years like the understanding of Fatou components or the subsets of the Julia set which escape to infinity. The conference will also emphasize a variety tools from analysis and

3.3. INTENSIVE RESEARCH PROGRAMMES

topology which are involved and developed motivated by these questions. There will be four to five 2-hour minicourses focusing in different tools relevant to transcendental dynamics and given by leading experts in the field. We will enjoy also some invited lectures and numerous contributions by Ph.D. students and recent doctors.

Minicourses

- 1. Anna Benini, Universita' di Parma, Dynamics of Transcendental Henon Maps
- 2. Chris Bishop, Stony Brook University, Trees, Triangles and Tracts
- 3. Phil Rippon and Gwyneth Stallard, Open University UK, *Harmonic and Subharmonic Functions*

Lecturers

- 1. Matthieu Astorg, Université d'Orléans
- 2. Krzysztof Baranski, Warsaw University
- 3. Luka Boc Thaler, University of Ljubljana
- 4. Kostya Drach, Aix-Marseille University
- 5. Adam Epstein, Warwick University
- 6. Vasiliki Evdoridou, Open University UK
- 7. Boguslawa Karpinska, Technical University of Warsaw
- 8. Kirill Lazebnik, University of Toronto
- 9. David Martí-Pete, Liverpool University
- 10. Mónica Moreno-Rocha, CIMAT
- 11. Dan Nicks, University of Nottingham
- 12. Artur Nicolau, Universitat Autònoma de Barcelona
- 13. Han Peters, University of Amsterdam
- 14. Lasse Rempe, Liverpool University
- 15. Dierk Schleicher, Institut de Mathématiques de Marseille

3.4 Standalone CRM Activities

This section provides a list of the congresses and workshops sponsored and organized by CRM during 2020.

European Study Group with Industry: ESGI 158

Description

January 27th to 31st

We are pleased to announce that the 158th European Study Group with Industry (ESGI) will be held at the Centre de Recerca Matemàtica, Barcelona on the 27th-31st January 2020.

ESGIs are week-long problem-solving workshops which provide a unique opportunity for industrial scientists to work alongside academic mathematicians on problems of direct industrial relevance. The ESGIs first started in Oxford in 1968, there are now 5-7 meetings held annually in different European countries as well as many others throughout the world. They are an internationally recognised method of technology transfer between academic mathematicians and industry.

At the meeting in Barcelona we expect to work on 3-4 problems, employing the expertise of 20-30 academics. For any enquiries, please contact a member of the organising committee listed below.

Further information on study groups in general (their format, benefits, goals etc) may be found at the European Consortium for Mathematics in Industry website:

https://ecmiindmath.org/study-groups/

Study Group Problems

Problem 1 Human towers or castells modelling - Coordinadora de Colles Castelleres de Catalunya (CCCC)

One of the current projects of the CCCC involves the safety of the members of the pinya (the base of the tower) when a collapse occurs. In order to increase their protection, the Coordinadora is studying the possibility of implementing the use of a cervical protector for those castellers that are in the parts of the pinya where members of the castell are more likely to fall. The location of falls is not uniform and so the CCCC would like to have, for each type of castell, a "map" of the zones of the pinya where the castellers are more likely to fall and the intensity of this fall. This map would also allow them to know the minimum size of the pinya needed for building each type of castell in a safer way.

Problem 2 Can we predict the difficulty of our levels before playing them? - King

King is a video game developer. We became famous after releasing the world-wide known Candy Crush Saga. At King, levels are at the core of our games. Finding the right balance in difficulty, though, is quite a challenge!

The problem we present here aims at helping our Level Designers estimate how hard a level will be before it reaches our players. We will provide a dataset with different level definitions from a real game, descriptions of how the ingredients interact with each other, and a target indicator that should be closely related to the level difficulty.

Now, is it possible for us to estimate this indicator given a brand-new level?

Problem 3 Safe trajectory of a piece moved by a robot - F. EE Automation Engineering The company wants to control de motion of a robot which translates and rotates metal pieces. This motion may induce irreversible deformations on the metal piece which should be avoided. One of the goals is then to derive algorithms to detect large stresses on the pieces along given trajectories and to understand the suitable geometries for these motions.

Problem 4 Title and abstract to appear soon. - Frenos Sauleda. (Analysis of the manufacturing process of some mechanical motion inhibitors in the absence of potentially harmful chemical components).

Organizers

- Tim Myers, Centre de Recerca Matemàtica
- Joan Solà-Morales, Universitat Politècnica de Catalunya
- Maria Aguareles, Universitat de Girona
- Marta Pellicer, Universitat de Girona
- Francesc Font, Centre de Recerca Matemàtica

RheoDx Conference

February 4th

Description

How do you pronounce RheoDX? A CRM spin-off? Who is in office C1-014?

Rheo Diagnostics is a startup born in 2018 promoted by the Mobile World Capital Barcelona foundation. Its patented technology is born of the collaboration between the UB and the CRM.

Rheo Diagnostics develops a portable in-vitro diagnosis device for the analysis of the elastic properties of red blood cells and detect abnormalities fast (only takes 5 min) and cheaply with a single drop of blood. The test consists of a microfluidic consumable, a reader system and a cloud server where the data is processed and translated into clinical evidence. It is a device with multiple applications in haematology, from diagnosis to monitoring of patients receiving blood transfusions.

With this activity we intend to give an overview of the company and its trajectory; What is the starting point of the project and its link to the CRM; When and which factors made possible the consolidation of RheoDX and what is our day-to-day life in terms of funding, experimental validation and product, and finally which is our letter to the kings for the next years.

Virtual Workshop on Micromechanics, statistics and hazards of mechanical failure

Description

October 19th to 23rd

The interdisciplinary and intersectoral workshop "Micromechanics, statistics, and hazards of mechanical failure" aims to establish a common understanding of the theoretical foundations and the practical characterization of avalanche phenomena and failure in mechanical systems, stimulating new interdisciplinary collaborations between professionals and scholars working in different areas and contexts. We invite contributions on the study of: transformation events in crystalline and amorphous

solids; fracture in heterogeneous materials and rocks; structural failure of engineered constructions; rock-falls, landslides and snow avalanches; natural and anthropogenic seismicity, and any other processes related to mechanical failure. This workshop is sponsored by the AXA Research Fund, through the project RehMechFail.

3.5 BGSMath

This section provides a list of the congresses and workshops sponsored by BGSMath during 2020.

Description

Quantum Error-Correcting Codes

on

January 21-30th

When storing or transmitting data, the data can be corrupted. Classical error-correcting codes have been used since the 1960's to detect and correct these errors. Quantum mechanics allows for the storage of data on quantum particles which are also susceptible to corruption. Thus, the need for quantum error-correction. This course will be an introduction to quantum codes which will assume no prior knowledge of quantum mechanics or error-correcting codes. We will focus for a large part of the course on stabiliser codes which have an analogue in classical error-correcting codes. This will give us an opportunity to delve into classical error-correction too and it will turn out that some constructions of quantum codes can be lifted from the classical case. We will also discuss how certain stabiliser codes are equivalent to geometrical objects which occur in finite projective spaces.

The target audience are graduates and faculty staff. It is expected that some of the students who have taken the coding theory option in the master's course will be interested. It is also aimed at the many researchers in the Barcelona area who are working on combinatorics, coding theory and information theory.

https://bgsmath.cat/event/quantum-error-correcting-codes/

Organizers

Simeon Ball



Career Management beyond PhD in Math

Description

February 26th

Career Guidance Activity organized by the UAB Occupational Service with the aim of improving the employability of university students and graduates.

These actions are funded by the Servei d'Ocupació de Catalunya, with funds provided by the Ministerio de Ocupación y Seguridad Social, through the Servicio Estatal Público de Empleo (SEPE). https://bgsmath.cat/event/career-management-beyond-phd-in-math/

Organizers

Gemma Benet



BCAM Colloquium 2020 – Mean estimation: statistical and algorithmic problems

Description

November 12th

We discuss the perhaps most basic problem of statistics: how can one estimate the expected value of a random variable from a sample of independent copies? We argue that the usual empirical mean is far from being optimal and we survey various alternatives and their performance guarantees. The multivariate case presents interesting challenges, both statistical and algorithmic. The talk is based on joint work with Shahar Mendelson.

https://bgsmath.cat/event/bgsmath-bcam-colloquium-2020/

Organizers

Gábor Lugosi



BCAM Colloquium 2020: An introduction to time

series mining

Description

November 12th

In this talk we will give an overview on time series mining. Particularly we will concentrate on classical problems in data mining such as clustering, supervised classification and outlier (anomaly) detection. For these problems we will emphasise the differences between working with time series or regular vectors. In addition to that

we will present new problems that appear in the area of data mining when working with time series and also point out to the complexity of working with time series streams.

https://bgsmath.cat/event/bgsmath-bcam-colloquium-2020/

Organizers

• José Antonio Lozano



3.6 Outreach

In 2020, the CRM started a renewed approach to outreach and public communication. The closure of the previous strategic plan period (2014-2019) was an appropriate steering point to identify the needs of an integral outreach plan.

The CRM's mission includes the integration of its mathematical research into the society, by means of a knowledge transfer to industry (KTT unit), but also by improving the scientific culture of citizens through outreach and dissemination. 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, reducing overheads on the researchers work, and overall achieving a higher impact on more society groups.

The most significant step for this new outreach plan was the creation of the CRM-Outreach commission in April 2020. It is composed by core members of the direction and structure of the CRM, and a new external consultant (Daniel Ramos), experienced in mathematical communication. The commission is formed by: Lluís Alsedà (Director), Consol Roca (Director's assistant), José Antonio Fuentes (Managing director), Pau Varela (Communication & HRS4R), David Romero (KTT unit & SciTech services), and Daniel Ramos (Outreach coordinator).

The aim of this commission and the external consultant is to actively propose and answer outreach requests that arrive to the CRM, and to help the researchers to make a better and more efficient outreach. The commission meets regularly to plan outreach actions that involve the CRM as an entity, and to follow outreach activities that may come at the initiative of the researchers.

The new outreach plan involves four lines of action to direct outreach activities:

- Activities on schools and other events aimed to students. This line continues successful established programs such as Magnet, Escolab, or the science week.
- Collaborations with museums, teachers' associations, and cultural entities. This line aims to open the outreach to a broader general public, and training teachers and other agents that work on science communication.
- Dissemination of the research done at CRM. As a long-term goal, all research groups should have at least one outreach action that explains their research at a popular level.
- Communication actions about topics of relevance. This line of action should be quick and responsive to current hot topics for the society, such as epidemic models, artificial intelligence, climate change models, etc.

The list below describes the specific outreach actions carried out in 2020, highlighting their connection to these lines of action. The COVID-19 epidemic situation has of course prevented many activities from taking place, although many were converted to on-line formats.

Connected to the line of action 2, the CRM has designed and is applying for funding for an outreach project, that will create new interactive outreach materials and will offer those as teachers training. This project will span for several months, involve several research groups from CRM, partnerships with other institutions, and it will have a dedicated budget. That type of more ambitious projects will materialize the new outreach approach of the CRM.

Activities carried out by the CRM along 2020

Researcher's night 2020

CRM organized a joint online activity for the Researcher's night 2020 with Early-Stage Researchers of the CAFE network (Climate Advanced Forecasting of sub-seasonal Extremes), on which CRM is a node. The activity was hosted by the Universidad de la República (Uruguay), and it had the title "The extremes of climate". Four ESRs (Niclas Rieger, Iago Perez, Noémie Ehstand, and Meriem Krouma) presented their PhD research projects and findings.

The CAFE project undertakes several outreach actions in the period 2019-2022 to expose results of the PhD candidates and the research and goals of the network; this is line with the action 3 above.

Tales of Laura and Joan

The tales of Laura and Joan is a series of comic books for children, commissioned by the Research and Universities department of the Catalan Government, to display the activities carried on research institutes. Mónica Minjares (Complex Systems group, CAFE network) collaborated with the author and illustrator of the books Josep Maria López to create a volume about the CRM's climate research group. To be published in 2021.

March, month of mathematics

In 2020 and 2021, the CRM has participated in the Spanish-wide initiative "March, month of mathematics" to celebrate the International Day of Mathematics (March 14th) with exhibitions, talks, printed materials, and other public outreach activities. The project is funded by the FECYT foundation, it is coordinated from the Universidad de la Laguna, and it involves over 70 researchers and science communicators of Spanish universities and entities. Although the project focuses on March 2021, the project spans from September 2020 to June 2021. Specifically, the CRM has created one of the exhibition panels and has supported the Catalan node for dissemination.

Magnet program

Magnet is a program promoted by the Jaume Bofill Foundation in collaboration with the Department of Education and the Institution of Educational Sciences of the UAB and the Diputació de Barcelona, whose objective is to accompany the educational centers in the development of an educational project in partnership with an institution. This alliance must allow the educational center to develop an innovative and quality educational project. The CRM continues its partnership with Primary School Joaquim Blume in Sabadell to promote mathematics among the students through a series of talks and activities carried out by CRM researchers. In 2020 the format was changed to a teacher's training session about COVID-19 and epidemic models. Director Lluís Alsedà and Daniel Ramos from CRM, with medical doctor Carles Brotons gave this training session.

Bojos per les matemàtiques

The Mathematics course of the program "Bojos per la ciència" of the Fundació Catalunya La Pedrera is a course developed jointly by the Federation of Entities for

3.6. OUTREACH

the Teaching of Mathematics in Catalonia (FEEMCAT) and the Societat Catalana de Matemàtiques (SCM) aimed at students of A levels in the field of science and / or technology with special interest and talent for mathematics. The basic objective of this course is to promote the scientific vocation of these young people and especially their enthusiasm for mathematics. The course has the support and collaboration of the Faculty of Mathematics and Computing Science of the UB, the Department of Mathematics of the UAB, the Faculty of Mathematics and Statistics of the UPC, Pompeu Fabra University and the CRM. The CRM holds a session of this programme every year, where students can run several experiments conducted by CRM's researchers to explore the practical Applications of Mathematical principles.

This established activity is framed within the line of action 1 above.

Published outreach articles

The following non-academic articles were published in general press media.

- Matemáticos de la UAB desarrollan un modelo para estimar los casos de coronavirus por Comunidad Autónoma. 20 Minutos 31/03/2020.
 www.20minutos.es/noticia/4211422
- 2. *De la ciencia al mercado: Analizando el fluido rojo*. La Vanguardia 13/06/2020. www.lavanguardia.com/economia/20200613/481723488241
4 CRM Publications

The publication of research documents is one of the CRM channels for spreading mathematical knowledge. Apart from publishing singular texts, the CRM has several stable publication series: *Advanced Courses in Mathematics, Research Perspectives CRM Barcelona, CRM Documents, Quaderns, Series on Popularization*, master's projects and PhD theses.

With the purpose of coordinating this activity, the *CRM Editorial Board* was created in November 2011. During 2020, it was formed by David Romero (Editor-in-Chief) and Claudi Lleyda (editing tasks). The Editorial Board meets regularly.

The COVID19 pandemic has had an impact on the CRM publications. Indeed, it has been a hard task from the editors and authors to manage the production along this year. It is for that reason that hereunder we provide an overview of the different series issued during the 2020 and the spring of 2021.



4.1 Advanced Courses in Mathematics CRM Barcelona

The volumes of this series, published by the Swiss publishing company Birkhäuser, cover the content of some of the advanced courses taught by specialists at the CRM. They are based on lecture notes handed out to students and later reworked by the authors. These volumes are specifically addressed to advanced doctoral and young post-doctoral students.

CHAPTER 4. CRM PUBLICATIONS

From 2008 to 2013, the responsible editor of this series was Carles Casacuberta (UB); he replaced Manual Castellet (UAB), who started the series in 2001. Starting in 2014, and until November 2019, the new editor of the series was Enric Ventura (UPC).
At the end of November 2019, David Romero (CRM) became the new editor. In 2020–2021, four volumes of this series have been issued:

- A. Hurtado, S. Markvorsen, M. Min-Oo and V. Palmer. Global Riemannian Geometry: Curvature and Topology, Advanced Courses in Mathematics - CRM Barcelona 2020
- A. Sims, G. Szabó, D. Williams and F. Perera. Operator Algebras and Dynamics: Groupoids, Crossed Products, and Rokhlin Dimension, *Advanced Courses in Mathematics - CRM Barcelona* (Ed.) 2020
- 3. K. Strung and F. Perera. An Introduction to *C**-Algebras and the Classification Program, *Advanced Courses in Mathematics CRM Barcelona* (Ed.) 2021
- Chevallard, Y., Barquero Farràs, B., Bosch, M., Florensa, I., Gascón, J., Nicolás, P., Ruiz-Munzón, N. Advances in the Anthropological Theory of the Didactic, *Advanced Courses in Mathematics - CRM Barcelona* (Ed.) 2021

4.2 Research Perspectives CRM Barcelona

In 2012, the CRM Editorial Board took over the edition of extended conference abstracts, collected among the contributions to the conferences and workshops organized by the center. The aim was to bring the opportunity to quickly spread recent research, including interesting new results not yet published, consolidating the scientific profit of CRM meetings and helping to fluently update the state of the art in each field. An agreement was reached allowing Birkhäuser to publish these materials as a new subseries of the series *Trends in Mathematics*; the new subseries is named *Research Perspectives CRM Barcelona*. From the 2020 series' editor was David Romero.

- Extended Abstracts Fall 2019, Spaces of Analytic Functions: Approximation, Interpolation, Sampling E. Abakumov, A. Baranov, A. Borichev, K. Fedorovskiy and J. Ortega-Cerdà, (Eds.) 2021. Trends in Mathematics, Vol. 12, Research Perspectives CRM Barcelona
- Extended Abstracts Spring 2019, Advances in the Anthropological Theory of the Didactic B. Barquero Farràs, I. Florensa, P. Nicolás and N. Ruiz-Munzón, (Eds.) 2021. Trends in Mathematics, Vol. 13, Research Perspectives CRM Barcelona

5 Economic summary

The following charts portray the expenditure and income that the CRM has carried out during the 2016-2020 period. In the first graph we can see that in the year 2020 the budget balance Income = Expenses has been nearly achieved, and in the following graph we show the evolution of the ratio between external funds versus funds contributed by the patronage, in 2020 we have been able to balance external funds with the ones from the Generalitat de Catalunya.



5.1 2020 Income Application (Capital Flow)

In the following chart, we want to portray how the CRM gets its resources and what its applications have been. It should be noted that 51.81% of the income comes from the Generalitat de Catalunya, 44.54% for the center's operation and the remaining 7.27% in capital grants, almost 50% of the resources are obtained through competitive calls, and 27.01% of these come from private entities, mainly the La Caixa Banking Foundation, Banco Santander and AXA, and finally we have to highlight that 6.04% of the income comes from transfer activities and research programs.

Of all this revenue, the vast majority goes to personnel expenses (77%) and 23% to other operating expenses (material, cleaning, telephony, maintenance, allowances and travel and training, among others).



Subv of Capital 0.16 M€

6 Appendix

6.1 People

Governing Board

Director

• Lluís Alsedà i Soler

Deputy Director

• Tomás Alarcón Cor

Managing Director

• José Antonio Fuentes Pérez

Head of Scientific Strategy and Internationalization

• Arantxa Sanz

Principal Investigators

- Tomás Alarcón Cor (ICREA)
- Álvaro Corral
- Alexandre Hyafil
- Tim Myers
- Alex Roxin

- Isaac Salazar
- Josep Sardanyés (Ramón y Cajal)
- Sergey Tikhonov (ICREA)
- Klaus Wimmer (Ramón y Cajal)

Researchers Classified by Funding

Gender ratio F:M

BGSMath Postdoctoral Fellows

- Gyla Csato, Universitat Politècnica de Catalunya
- Alvaro Leitao, Universitat de Barcelona
- David Moriña, Universitat Autònoma de Barcelona
- Alessandro Oneto, Universitat

BGSMath PhD Students

- Marta Bofill Roig, PhD Student
- Laurent Cantier, PhD Student
- Robert Cardona, PhD Student
- Damian Dabrowski, PhD Student
- Juan Carlos Felipe Navarro, PhD Student
- Marina Garrote López, PhD Student

La Caixa Collaborative Mathematics Program

- Kevin Martínez (PhD Student)
- Víctor Navas (PhD Student)
- Marc Plana (PhD Student)

Postdoctoral Fellows

- Jordi Baró (AXA Postdoctoral Fellowship)
- Jordi Canela (Banco Santander Fellowship)
- Federico Devalle (FLAG-ERA)
- Jose Mari Esnaola (MINECO)

PhD Students

- Mónica Minjares (ITN CAFE)
- Stefano Pedarra (AGAUR)
- Niclas Rieger (ITN CAFE)

- Politècnica de Catalunya
- Stefano Pasquali, Universitat Politècnica de Catalunya
- Antti Perälä, Universitat de Barcelona
- Sune Precht, Universitat Autònoma de Barcelona
- Anastasia Matveeva, PhD Student
- Waleed Mirza, PhD Student
- Andrés Rojas Gonzalez, PhD Student
- Martí Salat Moltó, PhD Student
- Jordi Vila Perez, PhD Student
- Iñigo Urtiaga Erneta, PhD Student
- Maximilian Wötzel, PhD Student
- Nicolás Pollán (PhD Student)
- Daria Stepanova (PhD Student)
- Francesc Font Martínez (Juan de la Cierva Formación)
- Alvaro González (Juan de la Cierva Formación)
- Emma Roscow
- Dmitry Todorov (Marie Curie Fellowship)
- Travis Stewart
- Citlalli Vivar (MINECO)
- Pan Ye (MICINN)

Industrial Doctorate

 Josep Ferré • Lourdes Méndez

Research Technician

• Pau Blanco

KTT Unit

- Miquel Barcelona
- Irene González
- Claudi Lleyda
- Ricard Alemany

Collaborators

• Néstor Costa (Hohner Automáticos, S.L.)

· David Romero

Isabel Serra

- Aurora Hernández-Machado (Universitat de Barcelona)
- Albert Pitarque (Universitat de Barcelona)

Undergraduate & Master students

	Gender ratio F:M	
• Eric Agustín	• Joan Lorenzo	
Carles Díaz	Maria Pifarré	
Pablo Garcia	• Nil Puertas	
Andreu González	Marc Roig	
Davide Naddeo	Àngel Tapia	

Directed Undegraduate & Master Theses

- Ariadna Albó, Spatial dynamics of Hepatitis B virus with its δ -satellite and defective interfering particles, Universitat Politècnica de Catalunaya. Directed by Josep Sardanyés.
- Sara Martínez-Buera, Front

microrheology beyond the power-law model, Universitat de Barcelona. Directed by Tomás Alarcón, co-directed with Aurora Hernandez-Machado (School of Physics, Universitat de Barcelona).

Gender ratio F:MRatio National:Expat• Gustavo Ávalos Villaseñor• Douglas Duarte Novaes• Miriam Romero Cabrera• Keayley Dias• Bishnu Hari Subedi• Dimitry Novikov• Igsyl Domínguez Calderón• Peter De Maesschalck• Michal Misiurewicz• Robert Roussarie• Claudio Buzzi• Henk Bruin• Daniel Panazzolo• Yulij Ilyashenko• Pavao Mardesic• Marcelo Viana• Salomón Rebollo Perdomo• Mitsuhiro Shishikura• Lordí Cuní• Vanessa Ramírez• Jordi Cuní• Vanessa Ramírez• Núria Hernández• Consol Roca		Visitors
 Gustavo Ávalos Villaseñor Miriam Romero Cabrera Bishnu Hari Subedi Igsyl Domínguez Calderón Michal Misiurewicz Claudio Buzzi Daniel Panazzolo Pavao Mardesic Salomón Rebollo Perdomo Mitsuhiro Shishikura Administration Staff Gender Ratio F:M Vanessa Ramírez Núria Hernández Consol Roca 	Gender ratio F:M	Ratio National:Expat
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Núria Hernández Consol Roca	Jordi Cuní	Vanessa Ramírez
	Núria Hernández	Consol Roca
Gemma Martínez Mari Paz Valero	Gemma Martínez	Mari Paz Valero
Jordi Mullor Pau Varela	Jordi Mullor	Pau Varela
当 UAB Interns	I UAB Interns	

• Alejandra Marques

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