CENTRE DE RECERCA MATEMÀTICA

MEMÒRIA D'ACTIVITATS
REPORT OF ACTIVITIES

2018





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Presentació

El lector trobarà en el present informe una visió general de les activitats organitzades i patrocinades pel CRM durant l'any 2018. Aquest ha estat un any prolífic: el CRM ha organitzat 2 programes de recerca internacionals amb 10 activitats internes, 6 conferències internacionals d'alt nivell, hem tingut més de 10 de seminaris i activitats de divulgació. Totes aquestes activitats s'han beneficiat amb més de 50 visitants.
Pel que a la producció de recerca, hem publicat més de 85 articles i els investigadors del CRM han participat en 81 activitats de recerca. A més, el CRM ha publicat diversos volums de les col·leccions Advanced Courses in Mathematics (Birkhauser), Extended Abstracts (Birkhauser), la sèrie de documents del CRM, i diversos preprints.

La informació de les nostres activitats està disponible a la nostra pàgina web

`http://www.crm.cat`

Presentation

The reader will find in the present report an overview of the activities organized and sponsored by CRM during 2018. This has been a prolific year: CRM has organized 2 international research programs with 10 internal activities, 6 high-level international conferences, we had more than 10 seminar series and outreach activities. All these activities have had the participation of more than 50 visitors. Concerning the research output, we have published more than 85 papers and the CRM researchers have participated in 81 research activities. Furthermore, CRM has published several volumes in the collections Advanced Courses in Mathematics (Birkhauser), Extended Abstracts (Birkhauser), CRM Document Series, and several preprints.

Information of our activities are available at our web page

`http://www.crm.cat`

Lluís Alsedà, Director

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Descripció Institucional

Institutional Description

1.1. Missió i objectius

L'objectiu definit als estatuts del CRM és el foment de la recerca i la formació avançada en l'àmbit de les matemàtiques, mitjançant la col·laboració i les sinergies amb les universitats i les institucions de recerca a Catalunya, amb l'objectiu d'ésser un referent científic internacional en aquest àmbit.

El CRM és un centre amb implantació interuniversitària en el sentit que de la seva activitat se'n beneficia el conjunt de la recerca en matemàtiques del país. La política científica del CRM per a l'assoliment de la seva missió té dos eixos d'actuació recollits en el seu pla estratègic i dins el marc del contracte-programa amb la Generalitat de Catalunya per al període 2014-2019:

- Donar suport als grups d'investigació catalans, organitzant activitats que depassen la capacitat dels mateixos, amb projecció internacional i acollint visitants amb qui treballen conjuntament.
- Des d'un punt de vista més proactiu, dissenyar i executar polítiques estratègiques que incideixin en debilitats de la recerca matemàtica a Catalunya entesa globalment, incentivant el desenvolupament d'àrees estratègiques i creant-ne grups propis.

1.1. Mission and Statement

As stablished in its charter, the aim of CRM 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.

CRM activities are for the benefit of the whole community of mathematical researchers in Catalonia. The scientific policy of CRM towards fulfilling such mission is structured around two main core concepts, stated in the strategic plan within the contract-program with the Generalitat de Catalunya for the period 2014-2019:

- *To give support to research groups, by organising activities whose size or nature go beyond the capabilities of the teams, achieving broad visibility and hosting visitors for joint work.*
- *To design and execute strategies addressing the weaknesses of the mathematical research activity in Catalonia, encouraging emergent areas and creating its own research groups in such areas.*

1.2. Estructura jurídica

El CRM va ser creat l'any 1984 per l'Institut d'Estudis Catalans (IEC) com a centre de recerca propi. El mateix any, l'IEC signà un conveni de col·laboració amb la Universitat Autònoma de Barcelona (UAB), en virtut del qual el Centre quedà ubicat físicament en uns espais d'aquesta universitat. L'any 1993 s'adequaren uns espais propis per al CRM a la Facultat de Ciències de la UAB amb finançament de la CIRIT. Per aquest motiu, es reformulà el conveni entre l'IEC i la UAB i se sol·licità l'adscripció del CRM a la UAB com a institut universitari.

L'acord del Govern de la Generalitat de 9 de juliol de 2002 (DOGC núm. 3693, de 6 d'agost de 2002) aprovà la constitució del Consorci Centre de Recerca Matemàtica, integrat per la Generalitat de Catalunya i l'IEC. El Consorci és una entitat pública amb personalitat jurídica pròpia. El desembre de 2013, la Universitat Autònoma de Barcelona es va incorporar al Consorci.

El CRM està regit pel Consell de Direcció i pel director, i compta amb un Consell Científic Assessor.

El CRM està integrat dins la Institució CERCA de centres de recerca participats majoritàriament per la Generalitat de Catalunya i forma part de l'Associació Catalana d'Entitats de Recerca (ACER). També forma part d'ERCOM, un comitè de la Societat Matemàtica Europea, i de la xarxa EPDI (European Post-Doctoral Institute).

1.3. Consell de Direcció

El Consell de Direcció, òrgan superior de decisió i d'administració del CRM, està format per:

- El president, que és el conseller d'Economia i Coneixement, o persona en qui delegui.
- El vicepresident, que és el president de l'IEC, o persona en qui delegui.
- Tres vocals en representació de la Generalitat de Catalunya.
- Dos vocals en representació de l'IEC.

1.2. Legal Status

CRM was established in 1984 as a research center within 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 CRM was to be hosted within UAB premises. In 1993, CRM opened its own premises at the UAB's Science Faculty, thanks to financial support from CIRIT. On that occasion, the CRM became associated with UAB as one of its research institutes.

The Government of Catalonia approved on July 9^{th}, 2002 (DOGC No. 3693, August 6^{th}, 2002) the creation of the CRM Consortium, formed 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 the Director, and has a Scientific Advisory Board.

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

1.3. Governing Board

The Governing Board, the highest level of decision and management of CRM, consist of:

- *The Minister of Economy and Knowledge or an appointed deputy, who acts as president.*
- *The president of the IEC, or an appointed deputy, who acts as vice president.*
- *Three representatives from the Generalitat of Catalunya.*
- *Two representatives from IEC.*

- Un vocal en representació de la UAB.
- El director del CRM, que hi participa amb veu però sense vot.

El Consell de Direcció es va reunir el dia 15 de Juny de 2018. En aquesta reunió, la Generalitat de Catalunya va estar representada per Francesc Subirada com a director general de recerca.

L'IEC hi va estar representat per Joandomènec Ros, que va presidir el Consell, i per Joan Solà-Morales en substitució de Joan Girbau. Francisco Javier Lafuente, vicerector de Projectes Estratègics i de Planificació de la UAB, va assistir a la sessió en representación del rector de la UAB. Van assistir també el director del CRM, Lluís Alsedà, i la gerent, Àngels Huertos. Com a representant del CERCA va assistir el senyor Lluís Rovira. Va actuar com a secretari Josep María Alcoberro.

- *One representative from UAB.*
- *The Director of CRM, who participates with a voice but not a vote.*

The Governing Board met on June 15th, 2018. In that meeting, the Generalitat de Catalunya was represented by Francesc Subirada, in his capacity of Director General de Recerca.

The IEC was represented by Joandomènec Ros, who assumed the Chairmanship of the Board, and by Jooan Solà-Morales replacing Joan Girbau. Francisco Javier Lafuente, the vice-rector of Strategic Projects and Planning of the UAB, assisted to the meeting on behalf of the rector of the UAB. The CRM director, Lluís Alsedà, and the general manager, Àngels Huertos, also attended the meeting. CERCA was represented by Lluís Rovira. Josep Maria Alcoberro acted as Secretary.

Generalitat de Catalunya

Institvt d'Estvdis Catalans

Universitat Autònoma de Barcelona

1.4. Consell Científic Assessor

El Consell Científic Assessor (CCA) està integrat per personalitats de prestigi científic en l'àmbit d'actuació del Centre, nomenats pel Consell de Direcció a proposta del director.
El CCA va celebrar la seva reunió anual presencial el 16 de novembre de 2018.
La composició de l'actual Consell Científic Assessor, aprovada en reunió del Consell de Direcció del 15 de juny de 2018, és:

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 held its annual meeting in person on November 16th, 2018.
The Governing Board approved on September 27th, 2017, the new composition of the Scientific Advisory Board:

Nicolas Brunel	Duke University
Helen Byrne	University of Oxford
Albert Cohen	Université Pierre et Marie Curie 4
Peter Imkeller	Humboldt-Universität zu Berlin
Henrik. Jensen	Imperial College London
Gábor Lugosi	Universitat Pompeu Fabra, Barcelona
Robert MacKay	University of Warwick
Eva Miranda	Universitat Politècnica de Catalunya
Jaroslav Nešetřil	Charles University, Prague
Peregrina Quintela	Universidad de Santiago de Compostela

1.5. El pla estratègic del CRM 2014–2019

El primer contracte-programa del CRM amb la Generalitat de Catalunya es va signar el 18 de juny de 2003. Es va mantenir vigent fins a 2006 i es va prorrogar durant l'any 2007. El 14 de febrer de 2009 es va signar un segon contracte-programa que cobreix el període de 2008 a 2013, emanat del primer pla estratègic del centre. Aquest contracte-programa es va prorrogar durant el 2014, mentre s'elaborava el nou pla estratègic.
El pla estratègic del CRM per al període 2014-2019, aprovat pel Consell de Direcció a la reunió de l'11 de juliol de 2014, conté un apartat introductori sobre "Missió i visió del CRM", seguit d'una secció "El CRM al final del pla estratègic 2008-2013"en la qual es fa un retrat de la situació actual del centre. Seguidament s'aborda pròpiament el nou pla, el qual té per objectiu servir de full de ruta del centre en sintonia amb la seva missió estatutària. El nou pla es proposa desenvolupar determinades polítiques orientades a diferents àmbits i assolir uns objectius concrets, agrupats com segueix.

1.5. The CRM strategic plan 2014–2019

The first contract-program between CRM and the Catalan Government was signed on June 18^{th}, 2003, originally valid until 2006, it was extended for a further year. On February 14^{th}, 2009, a new contract-program, was signed for the period 2008–2013, and extended for a further year until 2014. Meanwhile, a new strategic plan was designed.
The CRM strategic plan for the period 2014–2019, approved by the Board of Governors on July 11^{th}, 2014, contains an introductory section on "Mission and vision of CRM", followed by a section on "The CRM at the end of the strategic plan 2008–2013"which offered a description of the situation of CRM at that time. Next, the document addresses the new plan, which is a roadmap for the center, in line with its mission statement. The new plan proposes the development of policies oriented to different areas and to achieve specific goals, grouped as follows.

Pla estratègic CRM 2014-2019		
Àmbit		**Objectius**
RECERCA	**Pol atractor d'investigadors a Catalunya**	Atraure dos investigadors ICREA consolidats addicionals en els propers sis anys
		Atraure una mitjana de 1,5 investigadors júnior per any en els propers sis anys a través de beques Marie Curie i Ramón y Cajal
	Recerca aplicada i col·laborativa en matemàtiques	Aconseguir pel final del pla, una unitat de recerca consolidada en Matemàtica Aplicada Col·laborativa, formada per 13 IP's
		Crear una unitat mixta CRM-CRG en Exploratory Data Analysis
	Creació de sinergies entre grups	Millorar la cooperació entre els grups de recerca amb una acurada planificació en la preparació de propostes a convocatòries competitives.
		Promoure la sodirecció de tesis de doctorat dins el CRM
	Xarxes temàtiques i nvestigadors col·laboradors	Augmentar nombre col·laboradors d'altres institucions, en particular els que participen a les xarxes temàtiques del CRM
		Posar en marxa altres xarxes temàtiques en un futur proper; per exemple, en Biologia de Sistemes o Epidemiologia Matemàtica
	Paper CRM en formació d'investigadors	Arribar a una mitjana de dos estudiants de secundària per any que facin el seu treball de recerca al CRM
		Enfortir activitats de difusió dirigides als joves per comunicar els valors de la investigació matemàtica a la societat
		Designar els investigadors del CRM com a col·laboradors científics a les universitats, com així ho permeten els actuals acords. A més, el projecte BGSMath hi tindria un efecte molt positiu
		Millorar i potenciar el programa d'estades d'investigació al CRM d'estudiants de grau i màster, fins arribar a una mitjana de 4 per any
		Crear i consolidar la Unitat de Formació Doctoral del CRM
		Aconseguir taxa mitjana de 2 tesis doctorals per any durant tot el pla
		Obtenir recursos per a places postdoctorals en els projectes competitius atrets pels investigadors del CRM
		Obtenir recursos del sector privat per a la formació doctoral i postdoctoral en el CRM

REFORÇAMENT DEL SISTEMA	**CRM y BGSMath**	Completar redisseny institucional del CRM impulsant la BGSMath
	Com a centre ERCOM organitzador d'activitats	Trobar finançament estable per als seus programes de recerca temàtica fora del sector públic
		Obtenir un rendiment econòmic de l'organització d'esdeveniments científics en el centre
		Requerir als coordinadors dels PR i als visitants a llarg termini d'usar també una afiliació temporal al CRM quan signen documents originats durant la seva estada al centre
	Com a centre promotor de la mobilitat dels investigadors	Obtenir un finançament estable per als programes de visitants *DevMath* i *Lluís Santaló*

CRM strategic plan 2014-2019		
Ambit		**Goals**
RESEARCH	**Attraction pole for researchers in Catalonia**	Attract two additional consolidated ICREA researchers in the next six years
		Attract 1,5 junior researchers per year on average in the next six years through Marie Curie Fellowships and Ramón y Cajal contracts.
	Collaborative applied research in mathematics	Achieve, by the end of this plan, a consolidated research unit in Collaborative Applied Mathematics, consisting of 13 IP's
		Create a joint CRM-CRG unit on Exploratory Data Analysis
	Creating sinergies among groups	Improve cooperation among research groups in order to prepare proposals to apply to competitive calls
		Promote co-supervision of PhD theses within the CRM
	Thematic networks and scientific collaborators	Increase the number of scientific collaborators coming from other institutions, in particular those participating in the CRM thematic networks
		Launch other thematic networks in the near future; for instance, in Systems Biology or Mathematical Epidemiology
	Role in research training	Achieve an average of two college students per year to develop their research project at the CRM
		Reinforce diffusion activities addressed to young students to spread the impact of mathematical research on society
		Appoint CRM researchers as scientific collaborators of the local universities, as the current agreements with univiersities allow. In addition, the BGSMath project would have a very positive effect in this respect
		Improve and potentiate research internships of undergraduate and masters'students at CRM, up to 4 stays per year on average
		Create and consolidate the CRM Doctoral Training Unit
		Achieve two PhD thesis per year on average along the 2014-2019 plan
		Obtain funds for postdoctoral position through the competitive projects attracted by CRM researchers
		Obtain funds from the private sector for doctoral and postdoctoral training at CRM
SYSTEM REINFORCEMENT	**CRM and BGSMath**	Complete institutional redesign of the CRM by promoting the BGSMath
	As an ERCOM centre organiser of events	Find stable non-public funding for its thematic intensive research programmes
		Obtain an economic yield from scientific events organised in the centre
		Require coordinators of IRP and long-term visitors a temporary affiliation to the CRM when signing documents originated from their stay at the centre
	As a centre promoting researchers' mobility	Obtain stable funding for the DevMath and Lluís Santaló visiting programmes

CAPTACIÓ DE RECURSOS I TRANSFERÈNCIA	**Projectes de recerca**	Augmentar la participació del CRM en projectes de recerca finançats per la UE
		Aconseguir almenys un projecte de l'ERC durant els propers sis anys
	Transferència de coneixements i serveis a les empreses	Aconseguir en transferència de coneixement una mitjana de 2 contractes per any. El laboratori experimental hi podria tenir un paper important
		Posar en marxa una *star-up* en el camp de la Matemàtica Financera
	Explotació instal·lacions	Aprofitar les instal·lacions del CRM per a obtenir ingressos addicionals

PUBLICACIONS I IMATGE	**Activitat editorial**	Consolidar com una subcol·lecció dels *CRM Documents* els informes anuals dels programes de recerca temàtics i fer una nova sèrie amb els *extended abstracts* dels congressos i *workshops* celebrats al CRM
		Arribar a una taxa de publicació mitjana de 2 númeeros a l'any de la sèrie *Advanced Courses CRM Barcelona* , editada per Birkhäuser, i reduir a 6 mesos el retard entre el curs i l'edició
	Divulgació científica i imatge institucional	Organitzar, dues vegades l'any, una jornada temàtica amb altres centres CERCA en les àrees de matemàtiques col·laboratives cultivades al CRM

PROCESSOS, ADMINISTRACIÓ I INSTAL·LACIONS	Elaboració i implementació d'un pla d'igualtat del centre que comprengui tots els àmbits d'actuació del centre i en consideri tots els aspectes (diversitat, gènere, et.)
	Posar en marxa i executar la *HR Strategy for Researchers* (HRS4R)
	Posar en marxa un servidor de càlcul intensiu
	Dissenyar i posar en marxa una intranet, que permeti millorar la gestió econòmica dels projectes de recerca, la comptabilitat i la logística

FUNDRAISING AND TRANSFERENCE	**Research projects**	Increase participation in research projects funded by the EU
		Achieve, at least, one ERC contract in the next six years
	Knowledge transfer to industry and services offered to private companies	Obtain 2 contracts on knowledge transfer per year on average. The CRM experimental lab could play an important role in this regard
		Launch a start-up in the field of Financial Mathematics
	Exploitation of the premises	Make the most of the CRM premises to get additional income

PUBLICATIONS AND IMAGE	**Editorial activity**	Consolidate as a subcollection of the CRM Documents the annual reports of the IRP and promote new series around the extended abstracts of activities held at the CRM
		Achieve an average publication rate of two issues per year of the series Advanced Courses CRM Barcelona, edited by Birkhäuser, and reduce to six months period between the courses and the edition
	Scientific dissemination and institutional image	Organise, twice a year, a thematic day with other CERCA centres around the topics on collaborative mathematics cultivated in the CRM

PROCEDURES, MANAGEMENT, PREMISES	Ellaboration & implementation an equality plan including all the action areas and considering all aspects as diversity and gender, among others
	Implement the HR Strategy for Researcher (HRS4R)
	Set-up an intensive computing server
	Design and launch an intranet allowing to improve economic management of research projects, accounting and logistics

1.6. Col·laboració amb altres institucions

El CRM participa en iniciatives de diversa índole junt amb altres institucions acadèmiques.

1.6.1. BGSMath

Barcelona té una reconeguda excel·lència, al més alt nivell, en recerca en matemàtiques. En els darrers anys, s'han incorporat, de manera significativa, en aquest àmbit nombrosos estudiants estrangers, a través dels programes de màster i de doctorat de les universitats catalanes. En aquest escenari, el 2013 es va crear la *Barcelona Graduate School of Mathematics* (BGSMath) amb la intenció d'aportar una formació en recerca doctoral coordinada, d'alta qualitat i amb visibilitat internacional. La BGSMath també té com a objectius millorar l'ocupació de titulats en matemàtiques a la indústria i en l'àmbit no acadèmic en general, i esdevenir una plataforma per a tots els agents actius en recerca matemàtica orientada al desenvolupament de projectes col·laboratius.

Les institucions promotores de la BGSMath són:

- Facultat de Matemàtiques de la Universitat de Barcelona,
- Departament de Matemàtiques de la Universitat Autònoma de Barcelona,
- Facultat de Matemàtiques i Estadística de la Universitat Politècnica de Catalunya,
- Universitat Pompeu Fabra,
- Centre de Recerca Matemàtica,

La BGSMath va estar guardonada l'any 2015 amb la distinció "María de Maeztu" pel Ministeri d'Economia i Competitivitat del Govern Espanyol com a part del seu Programa d'Excel·lència". Aquesta distinció va adreçada a centres de recerca espanyols destacats en totes les àrees de la ciència o les humanitats. Són beques adreçades a estades de doctorands i postdoctorals internacionals a Barcelona.

1.6. Institutional collaboration

CRM participates in initiatives of various kinds with other academic institutions.

1.6.1. BGSMath

Barcelona has internationally recognized excellence in mathematics research at the highest level. In recent years, the number of foreign graduate students enrolled in the master 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 and PhD training with international visibility. Another mission of the BGSMath is the enhancement of employment of mathematicians in 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 School of Mathematics of the Universitat de Barcelona;*
- *The Department of Mathematics of the Universitat Autònoma de Barcelona;*
- *The School of Mathematics and Statistics of the Universitat Politècnica de Catalunya;*
- *Universitat Pompeu Fabra;*
- *Centre de Recerca Matemàtica;*

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

Els becaris finançats per la BGSMath que estan col·laborant amb els grups de recerca de les universitats catalanes i el CRM apareixen llistats a l'Apèndix d'aquesta memòria.
A part de l'activitat de formació de predocs i postdocs, la BGSMath organitza programes mensuals de recerca.

People funded by the BGSMath are listed at Appendix of this report.
Besides training activity for its PhD students and postdocs, BGSMath also organizes monthly research programmes aimed at the wider Mathematical community.

http://www.bgsmath.cat/

1.6.2. ERCOM

ERCOM és l'acrònim del comitè European Research Centres on Mathematics de la Societat Matemàtica Europea (EMS), format pels directors científics de diversos centres europeus de recerca en matemàtiques. Els centres representats a ERCOM són aquells el nombre de visitants dels quals supera essencialment el nombre d'investigadors permanents o de llarga durada i que cobreixen un espectre ampli de les matemàtiques. El CRM és membre d'ERCOM des de la seva fundació l'any 1997.
La reunió anual d'ERCOM de 2018 tingué lloc els dies 27 i 28 d'abril, a Bonn (Alemanya).

1.6.2. ERCOM

ERCOM, European Research Centres on Mathematics, committee of the European Mathematical Society (EMS), is composed by the scientific directors of European research centres in Mathematics. Only centres 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 2017 was held on April 27^{th} and 28^{th}, in Bonn (Germany).

http://www.ercom.org

1.6.3. ICREA

La Institució Catalana de Recerca i Estudis Avançats (ICREA) és una fundació impulsada per la Generalitat de Catalunya que, per mitjà d'un procés de selecció basat en el talent científic, contracta investigadors/es d'arreu del món per desenvolupar la seva tasca en universitats i centres de recerca de

1.6.3. 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

Catalunya. El CRM participa activament en totes les convocatòries de places d'ICREA presentant-hi candidatures d'investigadors en matemàtiques de reconegut prestigi. Actualment el centre compta amb la presència dels ICREA Sergey Tikhonov (des del 2012) i Tomás Alarcón (des del 2015).

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

*iCrea
INSTITUCIÓ CATALANA DE RECERCA I ESTUDIS AVANÇATS

http://www.icrea.cat/

1.6.4. Fundació Jaume Bofill

Des d'aquest any 2018, el Centre de Recerca Matemàtica participa en el programa "Magnet, aliances per a l'èxit educatiu", impulsat per la Fundació Jaume Bofill, el Departament d'Ensenyament de la Generalitat de Catalunya, la Diputació de Barcelona, el Consorci d'Educació de Barcelona i l'Institut de Ciències de l'Educació de la UAB.

El programa Magnet pretén lluitar contra la segregació escolar desenvolupant una aliança entre un centre educatiu i una institució de recerca.

L'Escola Joaquim Blume de Sabadell és un dels centres educatius seleccionats per desenvolupar aquest projecte d'innovació durant els propers 4 anys. Amb el lema "Al Blume, tots comptem. Suma-t'hi!", l'escola Joaquim Blume inicia una aliança amb el Centre de Recerca Matemàtica, que li permetrà desenvolupar un projecte d'innovació educativa amb la matemàtica com a eix vetebrador.

1.6.4. Jaume Bofill Fundation

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 Magnet program is to face the 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 the mathematics as a cornerstone.

1.7. Patrocinis

En la conjuntura econòmico-financera en què es mou actualment el CRM, alguns dels projectes endegats els darrers anys corren el perill de quedar-se en via morta. Afortunadament, els esforços del centre per captar l'interès de patrocinadors sensibles a la recerca en matemàtiques ha tingut alguns fruits al llarg de l'any 2018. El CRM està molt agraït a les institucions que es detallen a continuació perquè amb la seva contribució es podrà mantenir i incrementar la qualitat d'algunes de les activitats consolidades del centre.

1.7.1. Obra Social "la Caixa"

L'Obra Social "la Caixa" és una institució compromesa amb la societat a través de projectes de suport al benestar, als drets humans, a la pau, a la justícia i a la dignitat de les persones. Aquesta fundació treballa conjuntament amb institucions de recerca per tal de generar coneixements científics obrint nous horitzons de recerca. El principal objectiu de l'acció de l'Obra Social "la Caixa" és la de finançar la ciència aportant més seguretat a aquestes institucions a l'hora de planificar la seva recerca i facilitant sinergies entre els diferents centres. A finals de 2013, l'Obra Social "la Caixa", en el marc d'un acord amb el Govern de la Generalitat de Catalunya, va aprovar el finançament d'un programa de formació en Recerca Matemàtica Col·laborativa presentat pel CRM. Vegeu

www.crm.cat/en/Research/Training/CollabMathResearch/Pages/Description.as px

L'objectiu del programa és promoure la recerca matemàtica col·laborativa i interdisciplinària. En el marc d'aquest programa, s'entén per matemàtica col·laborativa "la recerca matemàtica situada en alguna interfície orientada al desenvolupament, anàlisi i simulació de models contextualitzats, amb interès més enllà de les matemàtiques, contrastada per la interacció amb experimentalistes".

1.7. Sponsorships

In recent years, CRM has made a considerable effort in order to attract funding from a diversity of private and public funding. Fortunately, the efforts of the center to attract the interest of sponsors sensitive to research in mathematics has had some success along 2018. The CRM is deeply grateful to the institutions listed below since their contribution can maintain and increase the quality of some of the activities consolidated in the center.

1.7.1. "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 aim of the 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 centres. At the end of 2013, "la Caixa" Foundation, within the framework of the agreement with the Catalan Government, approved funding of the training program on Collaborative Mathematics presented by the CRM. See

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".

El finançament d'aquest programa per part de la Fundació "la Caixa" està permetent al CRM d'oferir un nombre important de contractes doctorals i postdoctorals al llarg de cinc anys a partir de gener de 2014. Cada membre del programa té assignat un projecte de formació en un tema específic escollit entre un investigador del CRM que actua de supervisor i un cosupervisor d'una altra disciplina. Durant el 2018 es van concedir les següents beques o contractes (investigadors, temes, supervisor al CRM, supervisors externs):

The funding of this program by "la Caixa" allows CRM to support a number of doctoral students and postdoctoral fellows over a period of five years, starting January 2014. Our fellowships students consist of 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. The latest cohort appointed in 2018 are:

Contractes postdoctorals / *Postdoctoral contracts*:

- Francesc Font Martínez, *Moving boundary problems at the nanoscale*.

Beques predoctorals / *Predoctoral grants*:

- Daria Stepanova, *Disentangling the network: mathematical modelling of angiogenesis as coordinated multicellular process.*
- Nicolás Pollán, *Prefrontal circuit specialization underlying task-triggered changes in population codes in spatial working memory*.

Obra Social "la Caixa"

http://obrasocial.lacaixa.es/laCaixaFoundation/home_en.html

1.7.2. European Mathematical Society

La European Mathematical Society (EMS) és una societat científica que representa matemàtics d'arreu d'Europa. Aquesta societat promou el desenvolupament de diversos aspectes de les matemàtiques a Europa, en particular, la recerca en matemàtiques, la relació de les matemàtiques dins la societat, les relacions amb institucions europees i la didàctica de les matemàtiques. Durant el 2018 l'ajut de la EMS ha permès finançar quatre activitats organitzades pel centre, millorant les condicions econòmiques dels seus ponents i permetent oferir beques a joves investigadors.

1.7.2. European Mathematical Society

The European Mathematical Society (EMS) promotes the development of all aspects of mathematics in Europe, in particular mathematical research, relations of mathematics to society, relations to European institutions, and mathematical education. During 2018, the EMS support has allowed to finance four scientific events, in particular, to enhance the economical conditions of their lecturers and offering several grants for young researchers.

European Mathematical Society

http://euro-math-soc.eu/

1.7.3. National Science Foundation

La National Science Foundation (NSF) és una agència federal independent dels Estats Units d'Amèrica que promou el progrés de la ciència, avançar en la salut nacional, la prosperitat i el benestar. Donen suport a la recerca i a la gent per crear coneixements que transformin el futur. Durant el 2018 la NSF ha permès finançar el programa de recerca IRP on Discrete, Combinatorial and Computational Geometry, millorant les condicions econòmiques de quatre investigadors sènior, de set estudiants doctorals i investigadors postdoctorals que van participar en els esdeveniments científics del programa.

1.7.3. National Science Foundation

The National Science Foundation (NSF) is an independent federal agency of the US to promote the progress of science; to advance the national health, prosperity, and welfare. They support basic research and people to create knowledge that transforms the future. During 2018, the NSF support has allowed to finance the program IRP on Discrete, Combinatorial and Computational Geometry, enhancing the economical conditions of four senior researchers and seven doctoral students and post-doctoral researchers that participated in the scientific events of the program.

https://www.nsf.gov

1.8. Estructura

1.8.1. Equip de direcció

El director del CRM és nomenat pel Consell de Direcció, a proposta del president, per a un període de quatre anys. L'actual director és Lluís Alsedà, que va ser nomenat a la reunió del Consell de Direcció del CRM de l'1 de desembre de 2015 per al període de 2016 a 2019.
El director, l'adjunt de direcció, càrrec representat per l'investigador principal Tomás Alarcón, la gerent i un representant del personal de recerca formen la Comissió Executiva del Centre, que es

1.8. Structure

1.8.1. Direction team

The Governing Board elects a Director, proposed by 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 1st, 2015
The director, the assistant director, represented by the principal investigator Tomás Alarcón, the manager and one representative of the researchers form the Executive Commission of the CRM, which

reuneix periòdicament per tractar afers de tràmit o urgents. El representant dels investigadors és Álvaro Corral.
Manuel Castellet, que va ser director del CRM des de la seva creació l'any 1984, va ser nomenat director honorari pel Consell de Direcció l'any 2007.

1.8.2. Gerència

Des d'octubre del 2014 fins al juny del 2018 el càrrec de gerent va estar ocupat per la Sra. Maria Àngels Huertos. Des del Novembre d'enguany el càrrec l'ocupa el senyor José Antonio Fuentes Pérez.

1.9. Equipament

Els espais que actualment ocupa el CRM estan situats en una ala de l'edifici de la Facultat de Ciències de la UAB, amb una superfície total de 2.125 m^2, després de la darrera ampliació finalitzada l'octubre de 2010, amb el finançament de la Generalitat i del fons FEDER. Permeten la ubicació de l'administració, la direcció, un màxim de 60 investigadors, tres sales de reunions, tres aules amb capacitat per a 40 persones i un auditori amb capacitat per a 100 persones.

Per a l'allotjament dels investigadors visitants, el CRM utilitza l'oferta d'apartaments de la Vila Universitària de Bellaterra.

Durant l'any 2018, l'equipament informàtic del CRM constava d'una xarxa LAN Ethernet d'aproximadament unes vuitanta estacions de treball basades en sistemes Microsoft i Linux, i estructurades sota un domini Windows. Entre d'altres serveis, la xarxa constava d'una sèrie de servidors virtuals, entre ells un servidor de fitxers, un d'impressió (que gestionava els treballs de cinc impressores), servidors de web i gestió i un *Firewall/Router* que la connectava a la infraestructura de la UAB mitjançant un enllaç d'1 Gb. Durant l'any 2018 es va externalitzar el correu cap a Google, contractant

meets regularly to discuss routine or urgent affairs. The representative of the researchers is Álvaro Corral.
Manuel Castellet, who had been director of the CRM since its creation in 1984, was nominated Honorary Director by the Governing Board in 2007.

1.8.2. General Management

From October 2014 to June 2018, CRM's general manager was Maria Àngels Huertos. Since November 2018, CRM's general manager is José Antonio Fuentes Pérez.

1.9. Equipment

The CRM facilities are located in a wing adjoint to the UAB Faculty of Sciences with a total floor space of 2,125 m^2, after completion in October 2010 of the enlargement of CRM premises, made possible through Generalitat and FEDER funding. The facilities include management offices up to 60 researcher places, three meeting rooms, three lecture rooms with capacity for 40 people and an auditorium with capacity for 100 people.

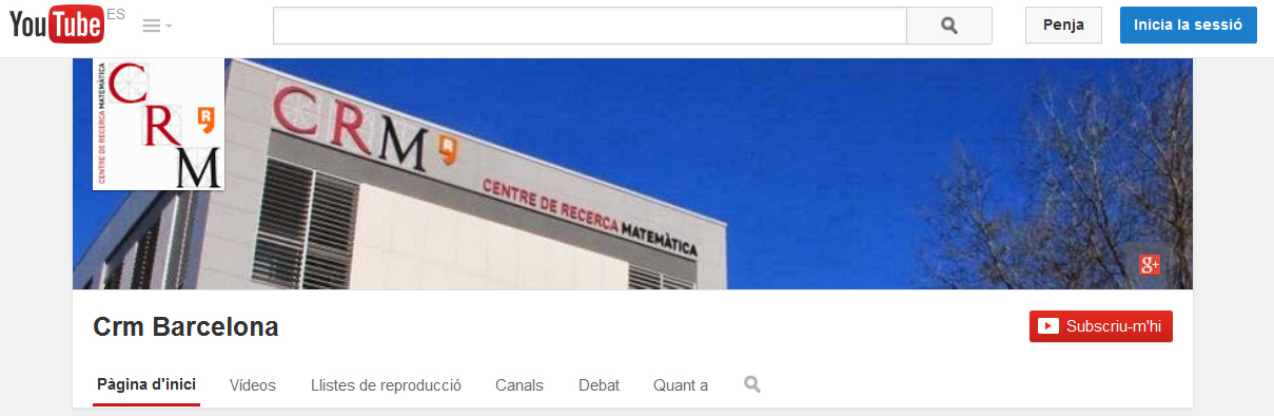
Accommodation for visiting researchers is provided by Vila Universitària at Bellaterra.

During 2018, CRM computer equipment was based on a LAN Ethernet net of, approximately, eighty workstations based both on Microsoft and Linux operating systems and structured under a Windows domain. Among other services, the net included an e-mail server, a printer server (managing the tasks of five printers), a file server and a Firewall/Router *that linked it to the UAB infrastructure by means of a 1 Gb connection. In the course of 2018 the mailing service was externalized to Google, by hiring the Gsuite services. The network was endowed with systems that allow the remote access via FTP, webmail access, SSH access to computing*

els serveis de Gsuite. Dins la xarxa tenim sistemes per a permetre el treball en remot utilitzant FTP, accés via SSH a servidors dedicats al càlcul i una securització a través de VPN per accedir a la resta de serveis del centre. Disposava també de connexió a internet sense, cables, de set canons de projecció i sistemes de gravació per a les aules i sales de reunions, recursos per a establir videoconferència, sistemes digitals de control d'aules, un panell tàctil de presentació i una infraestructura de retransmissió de gravacions, tant en directe com en diferit A més el CRM compta amb el canal d'emissió on podreu trobar vídeos de conferències celebrades al centre:

servers and a secure system through VPN to have access to the rest of center services. Facilities also included wifi internet connection, seven projectors and recording systems for all the meeting rooms, resources to videoconferencing, digital control systems for the meeting rooms, a tactile CRM presentation panel and the infrastructure for live broadcasting and streaming. Morevoer, the CRM has opened a broadcast channel where you can find videos of lectures held in the center:

https://www.youtube.com/user/CRMatematica



1.10. Serveis externs

El CRM té contractats els serveis de l'empresa externa "Gestió laboral: 3F Consultors".

1.10. External services

The firm "Gestió laboral: 3F Consultors" has service contracts with the CRM.

2

Recerca i transferència de coneixement al CRM

Research and Technology at CRM

2.1. Grups de Recerca

Tal i com s'ha esmentat a la secció 1.1, la política científica del CRM es concreta mitjançant dos eixos d'actuació, el segon dels quals contempla la creació de grups de recerca propis en àrees poc desenvolupades a Catalunya.
A continuació s'exposen les línies de recerca de cada grup i les principals activitats dutes a termes durant el 2018.

2.1. Research Groups

As mentioned in Section 1.1, the scientific policy of the CRM has two main axes, the second one encouraging research groups in underdeveloped areas in Catalonia, by supporting its own research groups in such areas.
The research lines of each group and their main activities that they have carried on during 2018 are outlined below.

2.1.1. Anàlisi Harmònica i Teoria de l'Aproximació
Harmonic Analysis and Approximation Theory

Sergey Tikhonov

Àmbit de recerca
L'anàlisi harmònica estudia la representació de funcions o senyals com a superposició d'ones elementals. Avui, és un dels camps amb més aplicacions en matemàtiques, entre les quals hi ha el processament del senyal, la transmissió d'imatges, diversos camps en enginyeria, electrònica, física, probabilitat i molts altres camps de les matemàtiques.
La teoria de l'aproximació considera el problema d'aproximar de la forma més senzilla i acurada possible senyals complicats per altres més senzills

Research Field *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

i més manipulables. El significat de "senzill", "acurada", i "manipulable" depèn de l'aplicació que es consideri. La teoria d'aproximació és un àrea establerta de les matemàtiques en fase de creixement per la varietat de les seves aplicacions, no solament en matemàtiques (anàlisi numèrica, anàlisi en ondetes) sinó també en ciències de la computació, tractament del senyal, biomedicina, geomàtica, etc. Els avenços recents de naturalesa teòrica en aproximació no lineal han permès incrementar la capacitat de manipular i extreure informació de grans conjunts de dades.

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.

Projectes vigents
Current Projects

- MTM2017-87409-P. *Teoria De La Aproximación Y Análisis Harmónico: Métodos y Aplicaciones*, 2018-2020. PI: S. Tikhonov.
- *Grup de teoria de funcions de la UAB/UB*, 2017-2019. PI: S. Tikhonov.

Membres del grup
Research Team

- Sergey Tikhonov (team leader)
- Thaís Jordão (post-doctoral researcher)
- Néstor Costa (PhD student)
- Alberto Debernardi (PhD student)
- Ainur Jumabayeva (PhD student)
- Askhat Mukanov (PhD student)
- Aizhan Ydyrys (PhD student)

Tesis defensades
Defended Theses

The following Theses were defended during 2018:

- Néstor Costa. PhD student (CRM). Title: *Innovació en el disseny i construcció de sensors rotatius òptics*. Supervisors Prof. J. Bruna (UAB) and Dr. S. Tikhonov (ICREA and CRM)
- Alberto Debernardi. PhD student (CRM). Title: *Convergence and integrability of Fourier transforms*. Supervisor by Dr. S. Tikhonov (ICREA and CRM)
- Ainur Jumabayeva. PhD student (CRM). Title: *Liouville-Weyl derivatives, best approximations, and moduli of smoothness*. Supervisor by Dr. S. Tikhonov (ICREA and CRM)
- Askhat Mukanov. PhD student (CRM). Title: *Integrability of Fourier transforms, general monotonicity, and related problems*. Supervisor by Dr. S. Tikhonov (ICREA and CRM)

Activitats relacionades
Related Activities

- Barcelona Analysis Seminar (every Monday, CRM or UB).
- Approximation Theory Seminar (every Monday or Tuesday; from September 2011).

Col·laboradors
Collaborators

• Andrey Bondarenko	Norwegian University of Science and Technology
• Feng Dai	University of Alberta
• Laura De Carli	Florida International University
• Michael Dyachenko	Moscow State University
• Erlan Nursultanov	EurasianUniversity
• Vladimir Temlyakov	University of South Carolina
• Walter Trebels	Technische Universität Darmstadt

Group Activity in 2018

During 2018 the members of the group studied the following topics: Fourier series, function spaces, embedding theorems, weighted norm for integral transforms, polynomial inequalities, energy minimization, moduli of smoothness, regularity problems of the Monge-Ampère equation.

In particular, Thaís Jordão investigated the Riemann-Lebesgue type results on the sphere. Nestor Costa studied optimal decoding and related problems of harmonic analysis. Alberto Debernardi continued working on his PhD dissertation focusing on convergence of Fourier transforms of general monotone functions. Ainur Jumabaeva studied the (L_p, L_q) inequalities for best approximation and moduli of smoothness of the generalized Liouville derivatives. Aizhan Ydyrys obtained several results on asymptotical behavior of double trigonometric series with convex and monotone coefficients. Askhat Mukanov investigated different types of convergence of trigonometric series.

□ Harmonic Analysis and Approximation Theory Publications

Articles

• D. Gorbachev, S. Tikhonov, *Wiener's problem for positive definite functions*, Math. Zeit. **289**, 859–874 (2018).
• D. Gorbachev, E. Liflyand S. Tikhonov, *Weighted norm inequalities for integral transforms*, Indiana Univ. Math. J. **67**, 1949–2003 (2018).
• M. Dyachenko, E. Nursultanov, S. Tikhonov, *Hardy–Littlewood and Pitt's inequalities for Hausdorff operators*, Bull. Sci. Math. **147**, 40–57 (2018).
• M. Dyachenko, E. Nursultanov, S. Tikhonov, *Hardy–type theorems on Fourier transforms revised*, J. Math. Anal. Appl. **467**, 171–184 (2018).

- M. Dyachenko, S. Tikhonov, *Smoothness and asymptotic properties of functions with general monotone Fourier coefficients*, J. Fourier Anal. Appl. **24**, 1072–1097 (2018).
- E. Nursultanov, S. Tikhonov, N. Tleukhanova, *Norm convolution inequalities in Lebesgue spaces*, Revista Matem. Iberoam. **34**, 811–838 (2018).
- A. Debernardi, *Uniform convergence of Hankel transforms*, Journal of Mathematical Analysis and Applications **468(2)**, 1179–1206 (2018).

Preprints

- D. Gorbachev, S. Tikhonov, *Doubling condition at the origin for non-negative positive definite functions*, to appear in *Proc. AMS* (2019).
- D. Gorbachev, V. Ivanov, S. Tikhonov, *Positive L^p-Bounded Dunkl-Type Generalized Translation Operator and its Applications*, to appear in *Consrt. Approx.* (2019).
- M. Dyachenko, A. Mukanov, S. Tikhonov, *Hardy-Littlewood theorems for trigonometric series with general monotone coefficients*, to appear in *Studia Math.* (2019).
- M. Dyachenko, A. Mukanov, S. Tikhonov, *Smoothness of functions and Fourier coefficients*, to appear in *Sbornik: Mathematics* (2019).
- M. Dyachenko, A. Mukanov, S. Tikhonov, *Uniform convergence of trigonometric series with general monotone coefficients*, to appear in *Canad. Jour. Math.* (2019).
- F. Dai, D. Gorbachev, S. Tikhonov, *Nikolskii constants for polynomials on the unit sphere*, to appear in *J. d'Analyse Math.* (2019).
- A. Debernardi, *Hankel transforms of general monotone functions*, to appear in *Topics in Classical and Modern Analysis: in memory of Yingkang Hu*, Applied and Numerical Harmonic Analysis series, Birkhäuser/Springer, Basel (2019).
- A. Debernardi, *Weighted norm inequalities for generalized Fourier-type transforms and applications*, to appear in *Publicacions Matemàtiques* (2019).
- A. Debernardi, *Boas' problem on Hankel transforms*, submitted to the *Journal of Fourier Analysis and Applications*.

Books or book chapters

- D. Dũng, V. Temlyakov, T. Ullrich, S. Tikhonov (Ed.), *Hyperbolic Cross Approximation*, in *Advanced Courses in Mathematics CRM Barcelona* (2018).

□ Harmonic Analysis and Approximation Theory Scientific activities

Participation in scientific activities

Invited lectures in conferences

- S. Tikhonov, St.Petersburg Summer Meeting in Mathematical Analysis, St. Petersburg, Russia. August 2018.
- S. Tikhonov, Jaen Conference on Approximation Theory, Jaen, Spain. July 2018.
- A. Debernardi, *Weighted norm inequalities for integral transforms with splitting kernels*, Mini-courses in Mathematical Analysis, Padova (Italy), July 2018.

Seminars

- S. Tikhonov, The Prague seminar on function spaces, Charles University, Prague, Czech Republic, December 2018.
- S. Tikhonov, Colloquium, Pontificia Universidad Católica del Perú, Peru, April 2018.
- S. Tikhonov, Colloquium, Universidad Complutense de Madrid, Spain, February 2018.

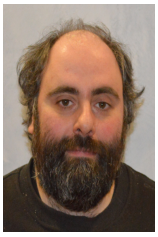
Research stays

- S. Tikhonov, March-April 2018: Invited Researcher at Institute of Mathematics of Acad. of Sciences, Prague, Czech Republic (2 weeks).

- S. Tikhonov, December 2018: Invited Researcher at Institute of Mathematics of Acad. of Sciences, Prague, Czech Republic (1 week)

□ Other

- S. Tikhonov, Member of Editorial board, Journal of Mathematical Analysis and Applications.
- S. Tikhonov, Member of Editorial board, Analysis Mathematica.
- S. Tikhonov, Member of Editorial board, Demonstratio Mathematica.
- S. Tikhonov, Member of Editorial board, Jaen Journal on Approximation.
- S. Tikhonov, Member of Editorial board, Abstract and Applied Analysis.
- S. Tikhonov, Member of Editorial board, Bulletin of Mathematical Analysis and Applications.
- S. Tikhonov, Member of Editorial board, The Scientific World Journal.
- S. Tikhonov, Member of International Society for Analysis, its Applications, and Computation.



2.1.2. Biologia matemàtica i computacional
Computational & Mathematical Biology

Tomás Alarcón

Àmbit de recerca

La majoria dels fenòmens estudiats per les Ciències Naturals, des de Ciència de Materials a Astrofísica, són processos d'escales múltiples, és a dir, fenòmens que impliquen l'acoblament de processos regits per escales espacials i temporals característiques molt diferents, de manera que el comportament global emergeix d'aquesta interacció. Mentre que en el camp de les Ciències Físiques s'ha fet un progrés considerable en el tractament d'aquest tipus de fenòmen, els resultats per a sistemes biològics són més modestos. Aquesta circumstància es deu a què la unitat fonamental en sistemes vius (la cèl·lula) és molt més complexa que les corresponents unitats en sistemes inerts. Per tant, es necessiten tant models com mètodes nous per analitzar els processos d'escales múltiples en Biologia. Aquest és el camp de recerca del grup de Biologia Computacional i Matemàtica al CRM: la formulació de nous models que siguin rellevants tant per a biòlegs experimentals com per a investigadors clínics, i el desenvolupament de les eines computacionals i analítiques necessàries per al seu estudi. Ens centrem en problemes de rellevància clínica, en particular els relacionats amb càncer.

L'activitat del nostre grup s'articula al voltant de les línies de recerca següents:

- Modelatge multiescala del creixement del tumor i l'angiogènesi.
- Mètodes híbrids per als models multiescala.
- Modelació estocàstica de la reprogramació de cèl·lules somàtiques.
- Robustesa i capacitat d'evolució i la seva relació amb la resistència als medicaments.
- Models estocàstics en dinàmica de poblacions.
- Biofísica teòrica: biofísica de membranes i

Research Field

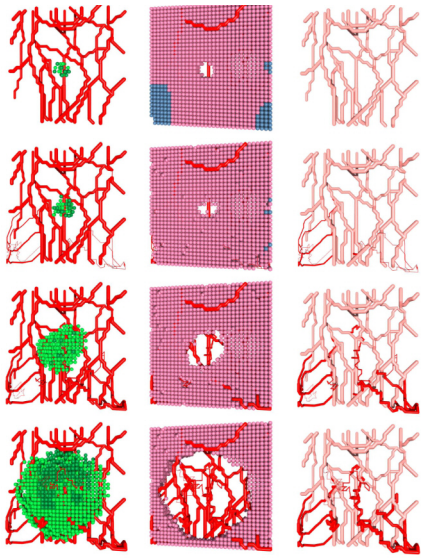
Most phenomena studied by the Natural Sciences, from Material Sciences to Astrophysics, are multi-scale processes, i.e., they involve the coupling of multiple different processes characterised by widely-ranging time and length scales, with the macroscopic behaviour emerging from the complex interactions 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 Computational & Mathematical Biology 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 angiogenesis.*
- *Hybrid methods for multiscale models.*
- *Stochastic modelling of somatic cell reprogramming.*
- *Robustness and evolvability and their relation to drug resistance.*
- *Stochastic models in population dynamics.*
- *Theoretical biophysics: membrane biophysics*

microfluídica.

and microfluidics.



Projectes vigents
Current Projects

• MTM2015-71509-C2-1-R, *Multiscale modelling and analysis in systems biology and biomedicine (Coordinated project CRM-UPC)*, 2016–2019. PI Tomás Alarcón.

Membres del grup
Research Team

• Tomás Alarcón	(team leader)
• Aurora Hernández-Machado	(scientific collaborator)
• Josep Sardanyés	(post-doctoral researcher)
• Elisa Beltran-Saez	(PhD student)
• Núria Floguera-Blasco	(PhD student)
• Ana Victoria Ponce Bobadilla	(PhD student, based at the University of Heidelberg)
• Daria Stepanova	(PhD student)
• Samantha Lopez-Mochales	(Industrial Doctorate)
• Lourdes Mendez-Mora	(Industrial Doctorate)

Tesis defensades
Defended Thesis

The following Thesis was defended on 2018:

• Núria Folguera. PhD student (CRM). Funded by Obra Social La Caixa through the CRM-LaCaixa programme in Collaborative Mathematics. Title: *Stochastic Modelling of Epigenetic Regulation: Analysis of its Heterogeinity and its Implications in Cells Plasticity*. Supervisors Dr. T. Alarcón (ICREA and CRM) and Dr. J. A. Menendez (ICO)

Activitats relacionades
Related Activities

• CRM Applied Mathematics and Physics Seminar

• Intensive Research Program on *Current Developments in Mathemtical Biology*. CRM April – June 2018

Col·laboradors
Collaborators

• Simone Ballocco	Universitat de Barcelona
• Mauricio Barahona	Imperial College London
• Rafael Barrio	(UNAM, México)
• Helen M. Byrne	University of Oxford
• Pilar Guerrero	Universdad Carlos III
• Philip K. Maini	University of Oxford
• Javier Ménendez	ICO - IDIBGI
• Anna Meseguer	VHIR
• Karen M. Page	University College London
• Rubén Pérez-Currasco	University College London
• Fabian Spill	MIT & University of Birmingham

Group Activity in 2018

During 2018, research of the Computational & Mathematical Biology Group has been focused on furthering our four ongoing projects, namely, ultiscale modelling of tumour growth and tumour-induced angiogenesis, stochastic modelling of epigenetic plasticity in ageing and cancer, noise-induced phenomena in complex models of population dynamics, and experimental and theoretical biophysics of blood flow at the microscale. Regarding research output, the group has published 6 papers in ISI journals. The group has also been heavily involved in the organisation of an CRM Intensive Research Programme on Current developments in Mathematical Biology, *April–June 2018*

□ Computational & Mathematical Biology Publications

Articles

• J. Sardanyés and T. Alarcón, *Noise-induced bistability in the fate of cancer phenotypic quasispecies: a bit-strings approach*, Scientific Reports **8**, 1027 (2018).
• R. de la Cruz, R. Pérez-Carrasco, P. Guerrero, T. Alarcón, K.M. Page, *Minimum Action Path theory reveals the details of stochastic biochemical transitions out of oscillatory cellular states*, Phys. Rev. Lett. **120**, 128102 (2018).
• N. Folguera-Blasco, E. Cuyàs, J.A. Menéndez, T. Alarcón, *Epigenetic regulation of cell fate reprogramming in aging and disease: A predictive computational model*, PLoS Comp. Bio. **14**, e1006052 (2018).
• J. Sardanyés, A. Arderiu, S.F. Elena, T. Alarcón, *Noise-induced bistability in the quasineutral coexistence of viral RNA under different replication modes*, J. R. Soc. Interface. **15**, 20180129 (2018).
• E. Cuyàs, S. Verdura, N. Folguera-Blasco, C. Bastidas-Velez, A.G. Martin, T. Alarcón, J.A. Menéndez, *Mitostemness*, Cell Cycle. **17**, 918 (2018).
• C. Trejo-Soto, E. Costa-Miracle, I. Rodriguez-Villareal, J. Cid, M. Castro, T. Alarcon, A. Hernandez-Machado, *Front microrheology of biological fluids*, J. of Physics: Conf. Series **1043**, 012058-1-6 (2018).
• Sardanyés J., Simó C, Martínez R., *Trans-heteroclinic bifurcation: A novel type of catastrophic shift*, Royal Society Open Science **5**, 171304 (2018).
• Sardanyés J., Alarcón T., *Noise-induced bistability in the fate of cancer phenotypic quasispcies: a bit-strings approach*, Scientific Reports **8**, 1027 (2018).
• Duarte J., Januário C., Martins N., Correia-Ramos C., Rodrigues C., Sardanyés J., *Optimal homotopy analysis of a chaotic HIV-1 model incorporating AIDS-related cancer cell*, Numerical Algorithms **77 (1)**, 261–288 (2018).
• Puig J., Farré G., Guillamon A., Fontich E., Sardanyés J., *Bifurcation gaps in asymmetric and high-dimensional hypercycles.* , International Journal of Bifurcation and Chaos **28 (1)**, 1–17 (2018).
• Solé R., Montañez R., Duran-Nebreda S., Rodríguez-Amor D., Vidiella B., Sardanyés J., *Population dynamics of synthetic Terraformation motifs*, Royal Society Open Science **5**, 180121 (2018).
• Vidiella B., Sardanyés J., Solé R., *Exploiting delayed transitions to sustain semiarid ecosystems after catastrophic shifts*, Journal of the Royal Society Interface **15**, 20180083 (2018).
• Sardanyés J., Arderiu A., Elena S.F., Alarcón T., *Noise-induced bistability in the quasineutral coexistence of viral RNA under different replication modes*, Journal of the Royal Society Interface **15**, 20180129 (2018).
• Gimeno J., Jorba À., Sardanyés J., *On the effect of time lags on a saddle-node remnant in hyperbolic replicators*, Journal of Physics A: Mathematical and Theoretical **51 (38)**, 386501 (2018).
• Corral Á., Alsedà L., Sardanyés J., *Finite-time scaling in local bifurcations*, Scientific Reports **8**, 11783 (2018).
• Fornés J., Lázaro J.T., Alarcón T., Elena S.F., Sardanyés J., *Viral replication modes in single-peak fitness landscapes: A dynamical systems analysis*, Journal of Theoretical Biology **460**, 170–183 (2018).

Preprints

- A.V. Ponce-Bobadilla, J. Arévalo, E. Sarró, H.M. Byrne, P.K. Maini, T. Carraro, S. Balocco, A. Meseguer, T. Alarcón, *Local migration quantification method for scratch assays*, to appear in *J. R. Soc. Interface* (2019).
- N. Folguera-Blasco, R. Pérez-Carrasco, E. Cuyàs, J.A. Menendez, T. Alarcón, *A multiscale model of epigenetic heterogeneity reveals the kinetic routes of pathological cell fate reprogramming*, to appear in *PLoS Comp. Biol.*.
- Ponce Bobadilla, A. V., Arévalo, J., Sarró, E., Byrne, H. M., Maini, P. K., Carraro, T., Balocco, S. & Alarcón, T, *In vitro cell migration quantification method for scratch assays*, to appear in *Journal of the Royal Society Interface*.
- Ponce Bobadilla, A. V.,Bartmanski, B.J., Grima, R., & Othmer, H. G, *The status of the QSSA approximation in stochastic simulations of reaction networks*, to appear in *2018 MATRIX Annals*.
- Nurtay A., Hennessy MG., Sardanyés J., Alsedà L., Elena SF., *Theoretical conditions for the coexistence of viral strains with differences in phenotypic traits: a bifurcation analysis*, to appear in *Royal Society Open Science* (2019).
- Sardanyés, J., *Viruses: Agents of evolutionary invention*, Review of the book by M. G. Cordingley. To appear (2019).

□ Computational & Mathematical Biology Scientific activities

Scientific activities organised

• T. Alarcón co-organiser (jointly with Jean Clairambault, INRIA, France, and Thomas Hillen, University of Alberta, Canada), of the workshop on *Mathematical challenges in the analysis of continuum models for cancer growth, evolution and therapy*, November 2018, BIRS, Casa Matemática de Oaxaca, Oaxaca, México.

• T. Alarcón co-organiser (jointly with Jose Antonio Carrillo, Imperial College London, UK, Silvia Cuadrado, Universitat Autonoma de Barcelona, and Antoni Guillamon, Universitat Politecnica de Catalunya) of the Intensive Research Programme *Current developments in Mathematical Biology*, April–June 2018, Centre de Recerca Matemàtica, Barcelona, Spain.

• T. Alarcón co-organiser (jointly with Jose Antonio Carrillo, Imperial College London, UK, Silvia Cuadrado, Universitat Autonoma de Barcelona, and Antoni Guillamon, Universitat Politecnica de Catalunya) of the workshop on *New trends in Mathematical Modelling* within the Intensive Research Programme *Current developments in Mathematical Biology*, held at the Centre de Recerca Matemàtica, Barcelona, Spain April 3-6, 2018.

• T. Alarcón co-organiser (jointly with Jose Antonio Carrillo, Imperial College London, UK, Silvia Cuadrado, Universitat Autonoma de Barcelona, and Antoni Guillamon, Universitat Politecnica de Catalunya) of the school on *Mathematical Modelling of Tumour Growth and Therapy* within the Intensive Research Programme *Current developments in Mathematical Biology*, held at the Centre de Recerca Matemàtica, Barcelona, Spain June 4-8, 2018.

• J. Sardanyés co-organiser of MURHPYS-HSFS-2018 *Interdisciplinary workshop on multiple scale systems, systems with hysteresis and trends in dynamical systems*, Centre de Recerca Matemàtica (CRM), Bellaterra, Barcelona, June – July 2018.

Participation in scientific activities

Invited lectures in conferences

- T. Alarcón. *Unlocking the pluripotent phenotype: A multiscale model of the epigenetic regulation of cell fate and plasticity*. Invited Talk, Workshop on Mathematical Models for Health Sciences, The Henri Lebesgue Centre for Mathematics, Nantes, France, June 2018
- T. Alarcón. *Heterogeneity in epigenetic regulatory systems: Epigenetic plasticity in aging and cancer*. Invited Talk, Workshop on Mathematical Perspectives in Biology and Therapeutics of Cancer, CIRM, Marseilles, France, July 2018
- T. Alarcón. *Heterogeneity in epigenetic regulatory systems: Epigenetic plasticity in aging and cancer*. Invited Talk, II Julio Palacios International Symposium: Synergies in the Biosciences, A Coruña, Spain, July 2018
- T. Alarcón. *Heterogeneity in epigenetic regulatory systems: Epigenetic plasticity in aging and cancer*. Invited Talk, Workshop on Differential Equations arising from Organising Principles in Biology, Mathematiches Forshunginstitut Oberwolfach, Oberwolfach, Germany, September 2018
- T. Alarcón. *Dysregulation of phenotypic plasticity in cancer and aging*. Invited Talk, Real Academia de las Ciencias Exactas, Fisicas, y Naturales, Madrid, Spain, November 2018
- T. Alarcón. *Heterogeneity in epigenetic regulatory systems: Epigenetic plasticity in aging and cancer*. Invited Talk, Workshop on Mathematical Challenges in the Analysis of Continuum Models for Cancer Growth, Evolution and Therapy, Banff Institute Research Station-Casa Matemática de Oaxaca, Oaxaca, México, November 2018
- N. Folguera. *Beating cancer "escape room": let's use mathematical modelling to unlock cells!*. Invited Talk, 4 th BGSMath Junior Meeting. 5-6th November 2018, Universitat de Barcelona (UB), Barcelona, Spain.
- A. Hernández *Front microrheology of the Non-Newtonian behavior of blood* . Invited Talk, XLVII Winter Meeting 2018, Puebla, Mexico 2018.
- A. Hernández *Elastic and dynamic properties of membrane phase-field models: the viscosity of blood and the bending rigidity of red blood cells* . Invited Talk, 13th World Congress on Computational Mechanics and 2nd Pan American Congress on Computational Mechanics, New York City, U.S.A. 2018.
- A. Hernández *Elastic and dynamic properties of membrane phase-field models: the viscosity of blood and the bending rigidity of red blood cells*. Invited Talk, 55th Annual Technical Meeting of the Society of Engineering Sciences (SES), Leganes, Spain, 2018.

Communications in conferences

• N., Folguera. *Unlocking the stem cell phenotype: a multi-scale model of the epigenetic regulation of cell fate and plasticity*. Oral Communication, 11th European Conference on Mathematical and Theoretical Biology (ECMTB 2018), July 2018, University of Lisbon, Lisbon, Portugal.
• A. V., Ponce *Age structure as key to delayed logistic proliferation in scratch assays*. Oral Communication, Annual Meeting of the Society for Mathematical Biology, July 2018, University of Sydney, Australia.
• A. V., Ponce *A quantitative framework for understanding cancer cell invasion through in vitro scratch assays*. Oral Communication, 60th British Applied Mathematics Colloquium, March 2018, University of St. Andrews, UK.

Seminars

• J. Sardanyés. *Some insights into stochastic drift on one-dimensional normally hyperbolic invariant manifolds.* Department of Mathematics and Computer Science (Universitat de Barcelona), Barcelona, 14th March 2018.
• J. Sardanyés. *Tipping points and catastrophes in cooperative systems.* Centre d'Estudis Avan cats de Blanes-CSIC, 26th April 2018.
• J. Sardanyés. *Normally hyperbolic invariant manifolds (NHIMs) in biological models and their role in novel mechanisms for noise-induced bistability.* IRP Recent Progress in Mathematical Biology. Centre de Recerca Matemàtica, 8th May 2018.
• J. Sardanyés. *Stochastic dynamics on a normally hyperbolic invariant manifold (NHIM) arising in a simple model of viral genomes replication.* Department of Mathematics. Universitat Autònoma de Barcelona (UAB), 14th May 2018.
• J. Sardanyés. *Nonlinear dynamics in RNA-based replicons.* Seminar series of the Institute of Integrative Systems Biology (I2SysBio), 19th June 2018.

□ Other

• T. Alarcón, Member of the Scientific Committee of the Catalan Mathematical Society. March 2015–Present.
• T. Alarcón, Member of the Scientific Committee of the Barcelona Graduate School of Mathematics (BGSMath). September 2014–Present.
• T. Alarcón, Deputy Director, Centre de Recerca Matemàtica, March 2016 – Present.
• A. Hernandez-Machado, *Premio de Científicos de Excelencia del Extranjero. Concurso Atracción de Capital Humano Avanzado del Extranjero.*

2.1.3. Epidemiologia Matemàtica
Mathematical Epidemiology

Andrei Korobeinikov

Àmbit de recerca Els models matemàtics de les malalties infeccioses dels éssers humans, els animals domèstics i silvestres i les plantes constitueixen una àrea de recerca molt rellevant i en ràpida expansió. L'objectiu del recentment creat grup de recerca en Epidemiologia Matemàtica és l'estudi matemàtica de l'aparició i propagació de malalties infeccioses. El grup investiga en diferents direccions, com ara l'aparició de nous agents patògens, la seva evolució, la dinàmica de les malalties infeccioses en una població, així com la dinàmica de microparàsits dins d'un hoste. També treballem en l'elaboració d'una descripció matemàtica de la resposta immune, per analitzar-ne fallades com la que es dóna en la infecció per VIH. Estem interessats, a més, en el control d'infeccions, tant a nivell d'un sol hoste com a nivell de població i, com a tasca de particular importància, ens proposem col.laborar amb epidemiòlegs i biòlegs per desenvolupar d'estratègies racionals pel control de malalties infeccioses.

Des del grup d'Epidemiologia Matemàtica treballem en estret contacte amb científics experimentals i amb el grup de recerca en Biologia Computacional i Matemàtica del CRM. En la nostra recerca emprem models matemàtics i tècniques de la teoria de sistemes dinàmics per a descriure i estudiar la dinàmica de les malalties infeccioses. Els nostres interessos particulars se centren en la invasió de les infeccions emergents, en l'estabilitat i persistència d'un agent patogen, així com l'estabilitat de la resposta immune. Estem també interessats en l'evolució viral i microbiana, que és probablement el factor més important responsable de l'aparició de noves infeccions i per al desenvolupament de soques resistents als medicaments, i la prevenció d'un desenvolupament de medicaments i vacunes eficaces. Una de les direccions que actualment estem explorant

Research Field *The mathematical modelling of infectious diseases of the humans, domestic and wild animals and plants is a rapidly expanding and a highly practically relevant area of research, and the aim of the Mathematical Epidemiology Research Group is to study the emergence and spread of infectious diseases from a mathematical point of view. The group is working in a number of directions such as the emergence of new pathogens, evolution of pathogens, the dynamics of infectious diseases in a population, as well as the dynamics of microparasites within a host. It is also dealing with mathematical description of immune response, as well as with its failure, as in the case of HIV infection. We are also interested in methods to control of infections, at both a single host and a population levels, and consider assisting the epidemiologists and biologists in the development of rational strategies for control of infectious diseases as a task of particular importance.*

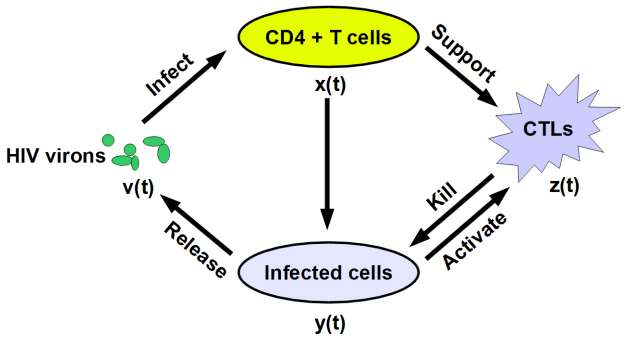
The Mathematical Epidemiology group, working in close contact with experimental scientists and the Computational & Mathematical Biology Research Group, employs mathematical modelling and the mathematical technique of the Dynamical Systems Theory to describe and study the dynamic of infectious diseases. Our particular interests are in the invasion of emerging infections, in the stability and persistence of a pathogen, as well as the stability of immune response. We are also interested in viral and microbial evolution, which is probably the most important single factor responsible for emergence of new infections and for development of drug resistant strains, and preventing a development of effective drugs and vaccines. One of the directions, which we are currently actively exploring, is application of the tools and methods of the Optimal Control Theory

activament és l'aplicació de les eines i mètodes de la teoria de control òptim pel control de malalties infeccioses.

A part d'aquestes investigacions, recentment el grup també va començar a investigar el càncer. La nostra intenció és estudiar el càncer aplicant les mateixes tècniques (en particular, la modelització matemàtica, la teoria de sistema dinàmic i la teoria òptima del control) en aquesta direcció. Estem particularment interessats en problemes com la interacció entre el sistema immunològic i el càncer, la immunoedició i la immunoteràpia del càncer, el desenvolupament de la resistència immune pel càncer i l'optimització de les teràpies anticancerígenes. Hem establert contactes estrets amb els biòlegs de l'Institut d'Oncologia de Vall d'Hebron (VHIO) i l'Institut Català d'Oncologia (ICO) i l'Institut de Recerca Biomèdica de Bellvitge (IDIBELL) i esperem que finalment desenvolupem aquesta connexió en una col·laboració duradora i productiva.

to the control of infectious diseases.

Apart from these areas, recently the Group also started research in cancer. Our aim is to study cancer applying the same techniques (in particular mathematical modelling, the dynamical system theory and the optimal control theory) in this direction. We are particularly interested in problems such as immune system and cancer interaction, cancer immunoediting and immunotherapy, the development of immune resistance by cancer and optimizing anticancer therapies. We established close contacts with biologists in the Vall d'Hebron Institute of Oncology (VHIO) and the Catalan Institute of Oncology (ICO) and the Bellvitge Institute for Biomedical Research (IDIBELL) and we hope to eventually develop these connection in lasting and productive collaboration.



Projectes vigents
Current Projects

- MTM2015-71509-C2-1-R, *Evolutionary and stochastic modelling and analisys of multi-scale dynamics in Bio-medicine*, 2016–2019. PI Andrei Korobeinikov and Tomás Alarcón.

Membres del grup
Research Team

- Andrei Korobeinikov (team leader)
- Anel Nurtay (PhD student)
- Stefano Pedarra (MSc student)
- David Masip Bonet (intern student)
- Ramon Tous Fernandez (intern student)
- Anna Maria Riera Escandell (intern student)
- David Moreno Martos (intern student)
- Vladimir Sobolev (medium-term visitor researcher)
- Elena Shchepakina (medium term visitor researcher)

Activitats relacionades
Related Activities

- Computational & Mathematical Biology Seminar

Col·laboradors
Collaborators

• Santiago F. Elena	Instituto de Biología Molecular y Celular de Plantas
• Lourdes Esteva	Universidad Nacional Autónoma de México
• Ellina Grigorieva	Texas Woman's University
• Tomas Kelly	University College Cork
• Evgenii Khailov	the Moscow State University
• Michael O'Callaghan	University College Cork
• Alexander Pimenov	Weierstrass Inst. for Applied Analysis and Stochastics
• Dmitry Rachinskiy	the University of Texas at Dallas
• Leonid Shaikhet	Donetsk State University of Management, Donetsk
• Konstantin Starkov	Instituto Politécnico Nacional-CITEDI
• Cruz Vargas de León	Universidad Nacional Autónoma de México
• Graeme Wake	Massey University

Group Activity in 2018

During 2018, research activities of the group was mostly focused towards following directions:
1. Stability, persistence and global property of models in mathematical epidemiology, and in mathematical biology in general. This direction is a continuation of the earlier research of Prof. Korobeinikov. However, recently this direction was extended, as modelling in cancer was also initiated by the Group.
2. Viral and microbial evolution. The goal of this project is mathematical study of pathogen evolution, including plant pathogens. Project run with participation of Vladimir Sobolev and Elena Shchepakina (the Samara University, Russia) and Graeme Wake (Massey University, New Zealand).

3. Optimal control of infectious diseases, at a population and a single host levels (including antiviral and cancer therapy). The goal is to employ the methods and tools of the optimal control theory to assist in the developing of the optimal (in a certain sense) antiviral therapy and rational strategies for control of infectious diseases. In collaboration with Prof. Ellina Grigorieva of Texas Woman's University, and Prof. Evgenii Khailov of the Moscow State University. Recently this research direction was also extended to incorporate research in optimal anti-cancer therapies.

4. Immune response, its failure, and development of AIDS. In collaboration with Prof. Leonid Shaikhet of Tel Aviv University, Israel.

In 2018, the members of Group actively participated in the Intensive research programm on Recent progress in Mathematical Biology ran by at CRM from April to June, 2018. The Group organized and hosted the Interdisciplinary workshop on multiple scale systems, hysteresis and dynamical systems MURPHYS-HSFS-2018 held in the CRM, Barcelona, May 28–June 1 of 2018 and participated in the workshop on New Trends in Mathematical Biology, CRM, Barcelona, June 4–8, 2018.

□ Mathematical Epidemiology Publications

Articles

- A. Archibasov, A. Korobeinikov, *Passage to the limit for models of viral evolution with random mutations*, Journal of Physics: Conference Series **1096**, 012050 (2018).
- A. Korobeinikov, *Immune response and within-host viral evolution: immune response can accelerate evolution*, Journal of Theoretical Biology **456**, 74–83 (2018). Q1
- E.V. Grigorieva, E.N. Khailov, A. Korobeinikov, *Optimal controls for an SEIR epidemic model with nonlinear incidence rate*, Studies in Applied Mathematics **141**, 353–398 (2018).
- S. Pagliarini, A. Korobeinikov, *A mathematical model of marine bacteriophage evolution*, Royal Society Open Science **5**, 171661 (2018).

Preprints

- L. Shaikhet, S.F. Elena, A. Korobeinikov, *Stability of a stochastically perturbed model of intracellular single-stranded RNA virus replication*, to appear in *Journal of Biological Systems* (2019).
- Nurtay A, Hennessy MG, Sardanyés J, Alsedà L, Elena SF, *Theoretical conditions for the coexistence of viral strains with differences in phenotypic traits: a bifurcation analysis*, to appear in *R. Soc. open sci.* (2019).
- A. Korobeinikov and A. Rezounenko, *Stability of a retrovirus dynamic model*, arXiv:1812.11456.
- A. Korobeinikov, V. Sobolev, E. Shchepakina, *A black swan and canard cascades in an SIR infectious disease model*, CRM Preprint Series 1240.

Books or book chapters

- A. Korobeinikov (Editor), *Slow-Fast Systems and Hysteresis: Theory and Applications*, in *Trends in Mathematics: Research Perspectives CRM Barcelona vol. 10* (2018). doi: 10.1007/978-3-030-01153-6

Conference proceedings

- A. Korobeinikov, S. Pagliarini, *A model of marine bacteriophage evolution*, Slow-Fast Systems and Hysteresis: Theory and Applications CRM, Barcelona (A. Korobeinikov (Editor)).doi: 10.1007/978-3-030-01153-6_5
- S. Pagliarini, A. Korobeinikov, *Order reduction for a model of bacteriophage evolution*, Slow-Fast Systems and Hysteresis: Theory and Applications CRM, Barcelona (A. Korobeinikov (Editor)).doi: 10.1007/978-3-030-01153-6_10
- P.A. Valle, K.E. Starkov, A. Korobeinikov, *A mathematical model of cancer evolutionary escape*, Slow-Fast Systems and Hysteresis: Theory and Applications CRM, Barcelona (A. Korobeinikov (Editor)).doi: 10.1007/978-3-030-01153-6_16

□ Mathematical Epidemiology Scientific activities

Scientific activities organised

- Principal organizer of *Joint international multidisciplinary workshop MURPHYS-HSFS-2018*, CRM, Barcelona, May 28–June 1, 2018.
- Member of the organising committee of *EECS-MACOB 2018: The 2nd European Conference on Mathematical and Computational Biology*, Bern, Switzerland, December 20–22, 2018.
- Member of the organising committee of *BBE 2018: The 2018 International Conference on Biology and Biomedical Engineering*, Prague, Czech Republic, May 19-21, 2018.
- Member of the organising committee of *BIO 2018: The 2018 International Conference on Biology and Biomedicine*, Venice, Italy, April 28–30, 2018.
- Member of the scientific committee of the *International Conference on Information Technology and Nanotechnology (ITNT-2019)*, Samara, Russia, May 21–24, 2019.
- Member of the scientific committee of the *6th International Conference on mathematical, computational and statistical sciences (MCSS '18)*, Corfu Island, Greece, August 25–27, 2018.
- Member of the scientific committee of the *5th Int.Conf. on Mathematics and Computers in Sciences and Industry*, Corfu Island, Greece, August 25–27, 2018.
- Member of the scientific committee of the *PMAMCM 2018: The 2018 International Conference on Pure Mathematics, Applied Mathematics and Computational Methods*, Majorca, Spain, July 14–17, 2018.

• Member of the scientific committee of the *PM-AM 2018: The 2018 International Conference on Pure Mathematics–Applied Mathematics*, Prague, Czech Republic, May 19–21, 2018.

• Member of the scientific committee of the *The International Conference on Medicine Sciences and Bioengineering (ICMSB2018)*, Suzhou, China, June 22–24, 2018.

• Member of the scientific committee of the *The 4th International Conference on Information Technology and Nanotechnology*, Samara, Russia, April 24–26, 2018.

Participation in scientific activities

Communications in conferences

• E.N. Khailov, A.D. Klimenkova, A. Korobeinikov, *Optimal control for anti-cancer therapy*, New Trends in Mathematical Biology, CRM, Barcelona, June, 2018.

• A. Korobeinikov, *Viral and cancer evolution*, Intensive research programm on Recent progress in Mathematical Biology, CRM, Barcelona, April to June, 2018.

• S. Pedarra, A. Korobeinikov, *Cancer evolution: the appearance and fixation of cancer cells*, MURPHYS-HSFS-2018: Interdisciplinary workshop on multiple scale systems, hysteresis and dynamical systems, CRM, Barcelona, May, 2018.

• A. Korobeinikov, S. Pedarra, *A discrete variant space model of cancer evolution*, MURPHYS-HSFS-2018: Interdisciplinary workshop on multiple scale systems, hysteresis and dynamical systems, CRM, Barcelona, May, 2018.

• A.M. Riera Escandell, A. Korobeinikov, *Mathematical modelling of HIV within-host evolution*, MURPHYS-HSFS-2018: Interdisciplinary workshop on multiple scale systems, hysteresis and dynamical systems, CRM, Barcelona, May, 2018.

• D. Moreno Martos, A. Korobeinikov, *A mathematical model of cancer evolution*, MURPHYS-HSFS-2018: Interdisciplinary workshop on multiple scale systems, hysteresis and dynamical systems, CRM, Barcelona, May, 2018.

• A. Archibasov, A. Korobeinikov, *Passage to the limit for models of viral evolution with random mutations*, The 4th International Conference on Information Technology and Nanotechnology, Samara, Russia, April, 2018.

• A. Klimenkova, E. Khailov, A. Korobeinikov, *Optimal strategies for suppressing cell division in anticancer therapy*, International Conference on Optimal Control and Differential Games dedicated to the 110th anniversary of L.S. Pontryagin, Moscow, Russia, December 2018.

• T.C. Kelly, M.J.A O Callaghan. R. Whelan, D. Rachinskii, A. Korobeinikov, *Patterns of avoidance shown by birds to moving aircraft*, The 6th Eurasian Ornithological Congress, Heidelberg University, April, 2018.

Seminars

- A. Korobeinikov. *Mathematical principles of biological evolution* Seminar at the Institute of Information Theory and Automation of The Czech Academy of Science, Prague , July 2018.
- A. Korobeinikov. *Methods of mathematical modelling of viral evolution* Seminar at the Department of Mathematics, Monash University, August 2018.

Research stays

- A. Korobeinikov, July, 2018: Invited Researcher at Institute of Information Theory and Automation of The Czech Academy of Science, Prague (2 weeks).
- A. Korobeinikov, August 2018: Visitor at Monash University, Australia (a weeks).

□ Other

- A. Korobeinikov, member of Editorial board, Mathematical Biosciences and Engineering
- A. Korobeinikov, member of Editorial board, Journal of Nonlinear Systems and Applications (JNSA)
- A. Korobeinikov, member of Editorial board, Nonlinear Modeling and Control (NMC)
- A. Korobeinikov, member of Editorial board, International Journal of Biology and Biomedical Engineering (IJBBE)
- A. Korobeinikov, member of Editorial board, International Journal of Mathematics and Computers in Simulation (IJMCS)
- A. Korobeinikov, member of Editorial board, International Journal of Pure Mathematics (IJPM)
- A. Korobeinikov, member of Editorial board, Infectious Diseases: Research and Treatment
- A. Korobeinikov, member of Editorial board, Journal of Mathematics and Statistics
- A. Korobeinikov, member of Editorial board, Abstract and Applied Analysis
- A. Korobeinikov, member of Editorial board, Research and Communications in Biological Sciences
- A. Korobeinikov, member of Barcelona Graduate school of Mathematics (BGSM).
- A. Korobeinikov, Editor of Slow-Fast Systems and Hysteresis: Theory and Applications, in Trends in Mathematics: Research Perspectives CRM Barcelona, Springer-Birkhäuser, Basel, 2018
- A. Korobeinikov, Editor of Proceedings of MURPHYS-HSFS-2018 Workshop, Trends in Mathematics: Research Perspectives CRM Barcelona, Springer-Birkhäuser (to appear in 2019)
- A. Korobeinikov, Guest Editor of a Special Issue *Singular perturbations and multiscale systems* of Mathematical Modelling of Natural Phenomena (to appear in 2019).

2.1.4. Matemàtica Financera i Control de Riscos
Financial Mathematics and Risk Control

Luis Ortiz

Àmbit de recerca

Les Finances Computacionals es troben en la intersecció entre el numèric i l'estocàstic. Un aspecte important de la recerca en aquest camp és millorar el rendiment dels mètodes de valoració i medició del risc.

De particular interès per al nostre grup és el càlcul eficient de les mesures de risc àmpliament utilitzades en risc de crèdit i de mercat, com ara el Valor en Risc (VaR) i la *Expected Shortfall* (deute esperat); l'estimació acurada de les contribucions individuals de risc també és un tema rellevant. Desenvolupem mètodes numèrics capaços de calcular aquestes mesures en un temps de CPU curt, el que permet la reavaluació de carteres molt grans freqüentment i evitar d'aquesta manera simulacions de Monte Carlo que consumeixen massa temps. També estem interessats en la valoració dels derivats de crèdit, com ara CDOs (obligacions de deute garantides), que s'utilitzen normalment per transferir el risc associat a una determinada cartera subjacent. Fins al moment, la maquinària per dur a terme aquest treball es basa principalment en ondícules de Haar.

Research Field

Computational Finance lies at the intersection between numerical analysis and stochastic calculus. An important area of current research within this field is to further increase the performance of pricing and risk measurement methods.

Specifically our group develops methods for the efficient computation of the risk measures widely used in credit and market risk such as the Value-at-Risk (VaR) and the Expected Shortfall. The accurate estimation of the individual risk contributions is an important issue as well. We develop numerical methods capable to calculate these measures in a short CPU time, allowing to rebalance very large portfolios frequently and avoiding this way the time-consuming Monte Carlo simulations. We are also interested in the valuation of credit derivatives such as Collateralized Debt Obligations, which are typically used to transfer the risk associated to a certain underlying portfolio. So far, the machinery to carry out this work is mainly based on Haar wavelets.

Membres del grup
Research Team

• Luis Ortiz	(team leader)
• Gemma Colldeforns	(PhD student, "la Caixa" and AGAUR)
• Ricard Alemany	(scientific collaborator)

Col·laboradors
Collaborators

• Cornelis W. Oosterlee	Centrum voor Wiskunde en Informatica and Delft University
• Elisa Alòs	Universitat Pompeu Fabra

Degut a canvis en el Pla Estratègic del CRM, que consistirán en la creació d'un grup de recerca en Big-Data, s'ha extingit el grup de recerca en Matemàtica Financera.

Due to changes in the Strategic Plan of the CRM, that will consist in the creation or a research group in Big-Data, the Financial Mathematics research group has been extinguished.

Theses

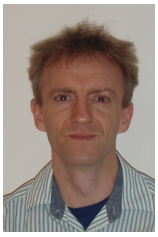
The following Thesis was defended on 2018:

- Gemma Colldeforns. PhD student (CRM). Funded by Obra Social LaCaixa through the CRM-LaCaixa programme in Collaborative Mathematics. Title: *Wavelet Approach in Computational Finance*. Supervisors by Dr. L. Ortiz Garcia (Universitat de Barcelona) and Prof. C.W. Oosterlee (TU Delft and CWI)

□ Financial Mathematics and Risk Control Publications

Articles

- G. Colldeforns-Papiol and L. Ortiz-Gracia, *Computation of Market Risk Measures with Stochastic Liquidity Horizon*, J. Compt. Appl. Math **324**, 431–450 (2018).
- G. Colldeforns-Papiol, L. Ortiz-Gracia and C.W. Oosterlee, *Wavelet Approach for Quantifying Credit Portfolio Losses under Multifactorial models*, J. Comput. Math , 1–22 (2018).



2.1.5. Matemàtica Industrial
Industrial Mathematics

Tim Myers

Àmbit de recerca

La matemàtica industrial es pot definir com l'aplicació de les matemàtiques als problemes del món real. El camp sembla estar guanyant popularitat a tot el món. A Europa, el European Consortium for Mathematics in Industry ha estat promovent l'assignatura des de fa més de 25 anys, recentment en conjunt amb la EU-Math-In i fins a 2019 per la EU COST Network MI-Net.

Actualment, el grup de Matemàtiques Industrials del CRM està contribuint, en termes de recerca, principalment en l'aplicació de les matemàtiques a la nanotecnologia. Les activitats més tradicionals de IM es tenen en compte a través de la participació del grup en grups d'estudi.

Els temes de recerca principals que aborden els membres del grup inclouen:

- Transferència de calor a nanoescala. Aquest treball està realitzat en col·laboració amb el departament de física de la UAB. L'objectiu principal és desenvolupar i analitzar models matemàtics per al flux de calor en situacions on la llei de Fourier es descompon. Els resultats s'han comparat molt favorablement amb experiments sobre nanocables de silici.
- Captació d'energia mitjançant nanofluids en una cèl·lula solar d'absorció directa. Això segueix el treball de Cregan & Myers de 2015. Actualment estem buscant diferents dissenys i configuracions de flux per millorar l'eficiència.
- Creixement de nanocristalls de la solució. Aquest projecte va sorgir a partir d'un problema presentat al 2016 European Study Group with Industry, que es va celebrar al CRM l'any 2016. És una col·laboració amb l'Institut Català de Nanociència i Nanotecnologia.
- Efecte Kirkendall. Com a primer intent d'analitzar la producció de nanocristalls buits, es

Research Field

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 until 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 nanotechnology. More traditional IM activities are not forgotten through the group's involvement in Study Groups.

The primary research topics dealt with by group members included:

- *Heat transfer at the nanoscale. This work is in collaboration with the physics department at UAB. The main goal is to develop and analyse mathematical models for heat flow in situations where Fourier's law breaks down. Results have compared very favourably with experiments on silicon nanowires.*
- *Energy capture using nanofluids in a Direct Absorption Solar Cell. This follows the work of Cregan & Myers in 2015. We are currently looking into different designs and flow configurations to improve efficiency.*
- *Nanocrystal growth from solution. This project grew from a problem presented at the 2016 European Study Group with Industry, held at the CRM in 2016. It is a collaboration with the Catalan Institute for Nanoscience and Nanotechnology.*
- *Kirkendall effect. As a first attempt to analyse the production of hollow nanocrystals we developed*

va desenvolupar un model de difusió binària (entre dos metalls). El treball inicial ha avançat bé, en el futur esperem incloure nano-efectes.

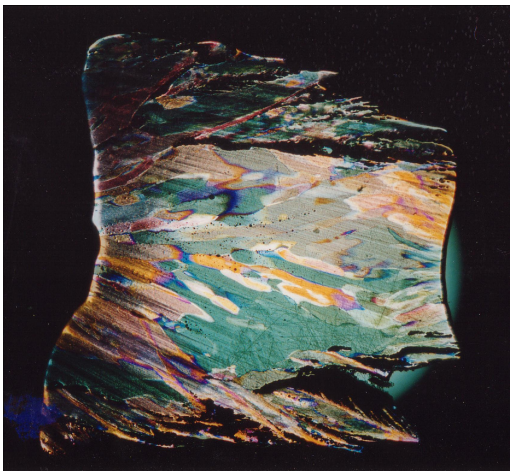
□ Imatge de nanopartícules amb llum visible. Es tracta d'una col·laboració amb un centre de recerca francès, CEMES. L'objectiu és desenvolupar un model matemàtic per ajudar a analitzar les franges d'interferència produïdes per una nanopartícula en una ona de llum.

En reunions de matemàtiques industrials a Sud-àfrica i Irlanda, els membres del grup han treballat en la combustió espontània; el fluid prop de les parets d'una caldera de sucre i amortiment del soroll.

a model for binary diffusion (between two metals). Initial work has progressed well, in the future we hope to include nano-effects.

□ *Imaging of nanoparticles with visible light. This is a collaboration with a French research centre, CEMES. The goal is to develop a mathematical model to help analyse the interference fringes produced by a nanoparticle on a light wave.*

In industrial mathematics meetings in South Africa and Ireland group members worked on spontaneous combustion; flow near the walls of a sugar boiler and noise damping.



Projectes vigents
Current Projects

- MTM2017-82317-P. *Mathematics in Nanotechnology and Industry*, 2017 – 2019. PI: T. Myers.
- Marie Skłodowska-Curie Actions Individual Fellowship: Nanoheat, *fund Post-doc Matt Hennessy*, 2016 – 2018. PI: T. Myers & M. Hennessy
- COST Action TD1409, Mathematics in Industry Network. *Lensless imaging of nanoparticles*, 2018. PI: T. Myers.

Membres del grup
Research Team

- Tim Myers (Team Leader)
- Matt Hennesy (post-doctoral researcher)
- Francesc Font (post-doctoral researcher)
- Helena Ribera (PhD Student)
- Marc Calvo (PhD Student)
- Claudia Fanelli (PhD Student)
- Gary O'Keeffe (PhD student based at University of Limerick)

Tesis defensades
Defended Theses

The following Thesis was defended during 2018:

- Helena Ribera. PhD student (CRM). Title: *Mathematical modelling of diffusion processes at the nanoscale*. Supervisor Dr. T. Myers (CRM)
- Helena Ribera. PhD student (University of Limerick). Title: *Mathematical modelling of nanofluid-based direct absorption solar collectors*. Supervisor Dr. S.L. Mitchell (University of Limerick), Dr. T. Myers (CRM)

Activitats relacionades
Related Activities

- Tim Myers is currently the Short Term Scientific Mission Manager and a member of the Management Committee for the EU COST Action TD1409 Maths for Industry Network, MI-Net. He is the co-ordinator of the European Study Groups with Industry and the Spanish Representative on the council for the European Consortium for Mathematics in Industry. He was a member of the scientific committee for the conferences Recent Advances in Moving Boundary Problems in Mechanics, International Union of Theoretical and Applied Mechanics, held in New Zealand, Feb. 2018 and the Knowledge Exchange Community Meeting – Industrial Maths in Action, held in Edinburgh in September, 2017.

Tim Myers He is on the editorial board of Mathematics in Industry Case Studies and the RSME-Springer book series and also a Panel Member for the evaluation of this year's Portuguese ministry funding for mathematics projects.

Matt Hennessy and Tim Myers both presented projects for the undergraduate course on Mathematical Modelling at UPC (although since Tim Myers was also visiting France for most of this period Helena replaced him on the course). Marc Calvo teaches undergraduate mathematics at the EAE Business school.

Col·laboradors
Collaborators

• Sarah Mitchell	University of Limerick
• Brian Wetton	University of British Columbia
• Matt Hennessy	University of Oxford
• Víctor Puntes	Institut Català de Nanociència i Nanotecnologia
• Neus Bastus	Institut Català de Nanociència i Nanotecnologia
• Vincent Cregan	University of Limerick
• Iain Moyles	York University
• Xavier Alvares	Universitat Autònoma de Barcelona
• Wolfgang Bacsa	Centre d'Elaboration de Matériaux et d'Etudes Structurales

Group Activity in 2018

The group has continued working primarily in nanotechnology, with research involving nanocrystal growth, nanoscale heat flow and phase change and also viewing nanoparticles with visible light. We also started a new line of research, modelling carbon capture. There were a number of changes to the group membership, Matt Hennesy's ERC Post-doc came to an end and he has taken up a position in Oxford. Matt has been replaced by Francesc Font, who comes on a La Caixa grant. Helena Ribera and Gary O'Keeffe both successfully defended their PhDs and are both now working in the US. Marc Calvo is expecting to submit his PhD on non-Fourier heat flow and phase change in early 2019.

In total group members published 12 articles in ISI journals, ranging from applied mathematics to renewable energy and power source journals. Work was also presented in conferences throughout Europe and in particular the whole group attended the European Consortium for Mathematics in Industry (ECMI) conference in Budapest. TM was an invited expert at the Maths In Industry Study Group held in Johannesburg in January where he worked on spontaneous combustions of coal piles.

Teaching activities included Tim Myers and Claudia Fanelli acting as mentors on the course Teaching Mathematical Models in Technology at UPC. Marc Calvo teaches a mathematics course at the EAE business school. Tim Myers, Claudia Fanelli & Marc Calvo also gave a (four hour) lecture as part of the Bojos per les Matemàtiques *series for talented high school students. Tim Myers visited the local primary school "*Joaquim Blume*" to help on a project to build a solar car out of recycled materials (and a solar panel).*

Tim Myers has also been working on a variety of EU projects, including the COST Action, Maths for Industry Network (as a member of the Management Committee and Short Term Scientific Mission Manager), a council member of ECMI and the co-ordinator of all European Study Groups with Industry.

□ Industrial Mathematics Theory Publications

Articles

• G.J. O'Keeffe, S.L. Mitchell, T.G. Myers, V. Cregan, *Modelling the efficiency of a low-profile nanofluid-based direct absorption parabolic trough solar collector*, International Journal of Heat and Mass Transfer **126**, 613-624 (2018).

• M. Calvo-Schwarzwälder, M.G. Hennessy, P. Torres, T.G. Myers, F.X. Alvarez, *Effective thermal conductivity of rectangular nanowires based on phonon hydrodynamics*, International Journal of Heat and Mass Transfer **126**, 1120-1128 (2018).

• F.S. Alkasmoul, M.T. Al-Asadi, T.G. Myers, H.M. Thompson, M.C.T. Wilson, *A practical evaluation of the performance of Al2O3-water, TiO2-water and CuO-water nanofluids for convective cooling*, International Journal of Heat and Mass Transfer **126**, 639-651 (2018).

• G.J. O'Keeffe, S.L. Mitchell, T.G. Myers, V. Cregan, *Time-dependent modelling of nanofluid-based direct absorption parabolic trough solar collectors*, Solar Energy **174**, 73-82 (2018).

• M.G. Hennessy, M.C. Schwarzwälder, T.G. Myers, *Asymptotic analysis of the Guyer – Krumhansl – Stefan model for nanoscale solidification*, Applied Mathematical Modelling **61** , 1-17 (2018).

• M. Calvo-Schwarzwälder, M.G. Hennessy, P. Torres, T.G. Myers, F.X. Alvarez, *A slip-based model for the size-dependent effective thermal conductivity of nanowires*, International Communications in Heat and Mass Transfer **91**, 57-63 (2018).

• G.J. O'Keeffe, S.L. Mitchell, T.G. Myers, V. Cregan, *Modelling the efficiency of a nanofluid-based direct absorption parabolic trough solar collector*, Solar Energy **159**, 44-54 (2018).

• M Hennessy, A Uppal, R Craster, O Matar, *Evaporation of gelled sessile drops*, Bulletin of the American Physical Society , (2018).

• A Uppal, M Hennessy, R Craster, O Matar, *Morphology models for cracking drying droplets*, Bulletin of the American Physical Society , (2018).

• A Vitale, M Hennessy, O Matar, J Cabral, *Controlling the evolution of frontal photopolymerization waves for 3D polymeric patterning*, Abstracts of Papers of the American Chemical Society **255**, (2018).

Preprints

• T.G. Myers, C. Fanelli, *On the incorrect use and interpretation of the model for colloidal, spherical crystal growth*, Journal of Colloid and Interface Science (2019).

• C. Fanelli, V. Cregan, F. Font, T.G. Myers, *Nanoparticle evolution via the precipitation method*, arXiv preprint.

• I.R. Moyles, M.G. Hennessy, T.G. Myers, B.R. Wetton, *Asymptotic reduction of a porous electrode model for lithium-ion batteries*, arXiv preprint.

• H. Ribera, T.G. Myers, B.R. Wetton., *Mathematical model for substitutional binary diffusion*, Submitted to *Applied Mathematical Modelling*.

Scientific reports

• T.G. Myers, M. Calvo, C. Fanelli, W. Bacsa, *Mathematics in Nanotechnology*, To appear - ICIAM Intelligencer , (2019).

Conference proceedings

- T.G. Myers and B. Florio, *Spontaneous combustion of coal*, Proceedings Of The Mathematics In Industry Study Group Ed. Prof. D.P. Mason, University of the Witwatersrand, Johannesburg, South Africa (2018).
- C. Fanelli, T.G. Myers, V. Cregan, *Title*, to appear in *Conference Proceedings of ECMI 2018* (2018).

Industrial Mathematics Scientific activities

Scientific activities organised

- T. Myers, Member of the scientific committee of the *Recent Advances in Moving Boundary Problems in Mechanics*, Christchurch, New Zealand, February 2018.
- T. Myers, President of the organising committee of the *European Study Group with Industry*, Barcelona, Jan 2020.
- C. Fanelli, Member of the organising committee of *IV BGSMath Junior Meeting*, Universitat de Barcelona, Barcelona, Spain, November 2018.

Participation in scientific activities

Communications in conferences

- T. Myers, *Nano Research at CRM*, European Consortium for Mathematics in Industry Conference, Budapest, June 2018.
- B. Florio & T. Myers, *Nano Research at CRM*, Mathematics in Industry Study Group, Johannesburg, Jan. 2018.
- C. Fanelli, *Mathematical modelling of nanocrystal growth*, European Conference on Mathematics for Industry (ECMI 2018), Budapest (Hungary), June 2018.
- M. Calvo, *Thermal transport equations and boundary conditions at the nanoscale*, European Conference on Mathematics for Industry (ECMI 2018), Budapest (Hungary), June 2018.
- M. Calvo, *Thermal transport equations and boundary conditions at the nanoscale*, Bringing Young Mathematicians Together (BYMAT 2018), Madrid (Spain), May 2018.
- M. Calvo, *Industrial Mathematics Group at the CRM*, Maths for Industry 4.0 Workshop @ Mobile Week, Barcelona (Spain), February 2018.

Research stays

- T. Myers, February – March, 2018: Visiting Researcher at Centre d'Élaboration de Matériaux et d'Etudes Structurales, France (2 months).
- M. Calvo, September – October, 2018: Research stay in Oxford.

□ Other

- T. Myers, Member of Editorial board, Real Sociedad Matemática Española-Springer book series.
- Member of Editorial board, Mathematics in Industry Case Studies journal.
- T. Myers, Member of Advisory board, BigMathNetwork blog, https://bigmathnetwork.org/advisory-board-members/.
- T. Myers, Member of Management Committee and Short term Scientific Mission Manager, COST Action TD1409, Mathematics in Industry Network.
- T. Myers, Council member, European Consortium for Mathematics in Industry.
- T. Myers, Co-ordinator for all European Study Groups with Industry.
- T. Myers, Evaluator for Fundação para a Ciência e a Tecnologia, Portugal.
- T. Myers, Evaluator for AGAUR - Agency for Management of University and Research Grants, Catalunya.
- T. Myers, Reviewer for Applied Mathematical Modelling, Computers and Mathematics with Applications, International Journal of Heat and Mass Transfer, Journal of Engineering Mathematics, Physical Review Fluids.

2.1.6. Neurociència Computacional
Computational Neuroscience

Alex Roxin

Àmbit de recerca

La neurociència computacional és un subcamp de la neurociència en el qual el models computacionals s'usen per a entendre millor com funciona el sistema nerviós. Es tracta d'un camp molt vast, que disposa de molts tipus diferents de model, des dels estadístics o probabilístics, fins a les equacions diferencials. Com que la major part del treball experimental en neurociència requereix algun grau de modelatge, encara que només sigui a nivell d'anàlisi de dades, no hi ha una divisió clara entre la neurociència experimental i la computacional. Això implica que una col.laboració estreta entre teòrics i experimentalistes és molt important, i fa que la tasca computacional estigui molt condicionada per les dades experimentals.

En el Grup de Neurociència Computacional del CRM, ens centrem principalment en la dinàmica de microcircuits corticals, és a dir, conjunts de centenars o milers de neurones de l'escorça cerebral. En particular, s'estudia la paper de la connectivitat recurrent en la conformació de l'activitat espontània en models de microcircuits corticals. Aquest tema de recerca molt oportú en aquests moments perquè les dades de connectivitat cortical han anat en augment en l'última dècada, i s'han produït millores notables en mesures d'activitat simultània d'un gran nombre de neurones. Un objectiu futur seria identificar quins aspectes de la connectivitat de la xarxa són més importants per al processament cortical en els models, i llavors dirigir els experiments a buscar patrons similars en el cervell. Estudiem models de formació i consolidació de la memòria per tal d'explorar els límits computacionals dels sistemes de memòria biològics i orientar sobre els mecanismes fisiològics involucrats en la memòria del cervell animal.

Desenvolupem també models computacionals de circuits computacionals per tal d'aclarir els

Research Field

Computational neuroscience is a sub-field of neuroscience proper in which computational models are used to learn something about how the nervous system works. It is a broad field, encompassing many different types of models, from statistical or probabilistic models, to differential equations. As most experimental work in neuroscience already requires some degree of modeling, if only at the level of data analysis, there is no clear divide between experimental and computational neuroscience. This means that close collaboration between theorists and experimentalists is important. At the very least, modeling work must be constrained by experimental data.

In the Computational Neuroscience group at the CRM, we focus mainly on the dynamics of cortical microcircuits, that is ensembles of hundreds or thousands of neurons in the cerebral cortex. In particular, we study the role of the recurrent connectivity in shaping spontaneous activity in models of cortical microcircuits. This is a timely topic because data on cortical connectivity has been increasing over the past decade, as well as improved measurements of the simultaneous activity of large numbers of neurons. A future goal would be to identify which aspects of network connectivity are most important for cortical processing in models, and then direct experimentalists to look for similar patterns in the brain. We study models of memory formation and memory consolidation in order to explore the computational limits of biological memory systems and shed light on the physiological mechanisms involved in memory in the animal brain.

We also work on developing computational models of cortical circuits to shed light on the neural

mecanismes dinàmics subjacents a la conducta animal durant tasques cognitives elementals tal com la memòria de treball o les preses de decisions perceptuals. Complementem els projectes de modelització amb l'anàlisi de dades neuronals d'alta dimensió obtingudes per col.laboradors del nostre grup (e.g. registres simultanis de poblacions grans de neurones o dades de neuroimatge funcional amb humans), fent servir mètodes estadístics d'ùltima generació i mètodes d'aprenentatge automàtic.
Des de l'any 2017 es va incorporar un nou investigador Ramón i Cajal al Grup en qualitat de co-IP, el Klaus Wimmer. El seu camp de treballa és la recerca en dinàmica de xarxes neuronals sustentant funcions cognitives bàsiques com ara la memòria operativa i la presa de decisions de percepció. Compagina l'estudi de models de xarxes neuronals amb l'anàlisi de dades experimentals (obtingudes d'enregistraments neuronals en primats ensinistrats i neuroimatges humanes obtingudes en laboratoris de col·laboradors experimentals). En particular, treballarà en estendre les models computacionals de circuits locals actuals de processos de presa de decisió cap a una xarxa de circuits interactius que permetran estudiar la contribució de diverses àrees del cervell al còrtex parietal i prefrontal per elaboració de decisions i manteniment de memòria.

network dynamics underlying an animal's behavior during elementary cognitive tasks such as working memoryh and perceptual decision making. Modelling efforts are complemented by analysis of typically high-dimensional neural data obtained by collaborators (e.g. simultaneous recordings from large populations of neurons or human neuroimaging data) involving state-of-the-art statistical and machine learning tools.

Since 2017, Klaus Wimmer joined the group as a Ramón y Cajal researcher and co-PI. His focus is on investigating the neural network dynamics underlying elementary cognitive functions such as working memory and perceptual decision making. He complements the study of neural network models with analysis of experimental data (obtained from neural recordings in behaving primates and from human neuroimaging in the laboratories of experimental collaborators). In particular, he will work on extending current local-circuit computational models of decision making processes towards a network of interacting circuits that will allow to study the contribution of different brain areas in the parietal and prefrontal cortex to decision build-up and memory maintenance.

Projectes vigents
Current Projects

- MINECO, BFU2017-86026-R, *Neural network dynamics of distributed decision circuits*, CRM, 1/1/2018–31/12/2020 PI: Alex Roxin, Klaus Wimmer.

Membres del grup
Research Team

- Alex Roxin (team leader)
- Klaus Wimmer (team leader)
- Marina Vegué (PhD student)
- Bernat Rovira (PhD student)
- Genís Prat (PhD Student)
- Helmut Schmidt (BGSMath Postdoctoral researcher)

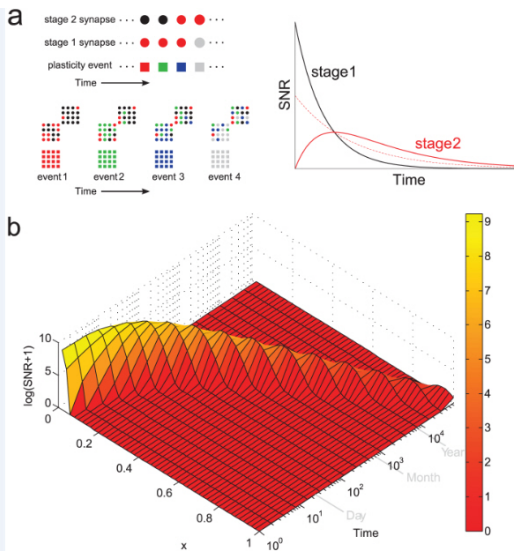
Tesis defensades
Defended Thesis

The following Thesis was defended on 2018:

- Marina Vegué. PhD student (CRM). Title: *A study of cortical network models with realistic connectivity*. Supervisor Dr. A. Roxin (CRM)

Col·laboradors
Collaborators

- Albert Compte IDIBAPS
- Jaime de la Rocha IDIBAPS
- Duane Nykamp University of Minnesota
- Ernest Montbrió UPF
- Tobias Donner UKE Hamburg
- Tatiana Pasternak University of Rochester



Group Activity in 2018

During the year 2018 we continued our work on network dynamics, memory formation and perceptual decision making. We published three major papers, the first on hippocampal place cells dynamics and replay generation, in eLife, and two papers in PLoS Comp. Biol. on oscillations and sychrony in neuronal networks. We were granted an ERA-ict project from the Spanish Ministry of Science, Innovation and Universities which will fund our Flag-Era project from the Human Brain Project. In this project we will be working with experimentalists from Marseille and Budapest to understand the role of heterogeneity in the place-cell code in the rodent hippocampus.

□ Computational Neuroscience Publications

Articles

- P. Theodoni, B. Rovira, Y. Wang, A. Roxin, *Theta-modulation drives the emergence of network-wide connectivity patterns underlying replay in a model of hippocampal place cells*, eLife **7**, e37388 (2018).
- H. Schmidt, D. Avitabile, E. Montbrió, A. Roxin, *Network mechanisms underlying the role of oscillations in cognitive tasks*, PLoS Comp. Biol. **14(9)**, e1006430 (2018).
- F. Devalle, A. Roxin, E. Montbrió, *Firing rate equations require a spike synchrony mechanism to correctly describe fast oscillations in inhibitory networks*, PLoS Comp. Biol. **13(12)**, e1005881 (2018).
- Wimmer K, Barbosa J, Galan A, Constantinidis C, Mongillo G, Compte A, *Persistent neurons drive stable population-level working memory representations*, COSYNE Conference 2018, Denver, CO , (2018).
- Wimmer K, Barbosa J, Galan A, Constantinidis C, Mongillo G, Compte A, *Neuronal dynamics underlying stable population-level working memory representations in prefrontal cortex*, AREADNE Conference 2018, Santorini, Greece , (2018).
- Prat-Ortega G, Wimmer K, Roxin A, de la Rocha J, *Flexible categorization in perceptual decision making*, Bernstein Conference 2018, Berlin, Germany , (2018).
- Islam M, Samu D, Wimmer K, Pasternak T, *Inactivation of posterior prefrontal cortex compromises processing of visual motion in area MT*, Program No. 144.17. 2018 Neuroscience Meeting Planner **San Diego, CA: Society for Neuroscience**, (2018).
- Prat-Ortega, Genís, and Jaime de la Rocha, *Selective Attention: A Plausible Mechanism Underlying Confirmation Bias*, Current Biology: CB 28 (19): R1151-54 , (2018).

Preprints

- Malone PS, Eberhardt SP, Wimmer K, Sprouse C, Klein R, Glomb K, Scholl CA, Bokeria L, Cho P, Deco G, Jiang X, Bernstein LE, Riesenhuber M, *Neural mechanisms of vibrotactile categorization.*, to appear in *Human Brain Mapping* (2019).

□ Computational Neuroscience Scientific activities

Scientific activities organised

- A. Roxin, Member of the organising committee of *Barcelona Computational Cognitive and Systems Neuroscience*, Institut d'Estudis Catalans, June 2018.
- K. Wimmer, Member of the organising committee of *Circuit Dynamics in Working Memory (COSYNE 2018)*, Denver, March 2018.

Participation in scientific activities

Invited lectures in conferences

- A. Roxin *Fluctuation-driven plasticity allows for flexible rewiring of neuronal assemblies* Invited talk at the AMCOS Meeting. PRBB, Barcelona, March 2018.

Communications in conferences

- H. Schmidt, *Network mechanisms underlying the role of oscillations in cognitive tasks*, AMCOS, Barcelona, March, 2018.
- H. Schmidt, *The role of oscillations in networks of spiking neurons during memory tasks*, New Trends in Mathematical Biology, CRM, Barcelona, June, 2018.
- G. Prat, *Flexible categorization in perceptual decision making*, Bernstein Conference, Berlin, September, 2018.

Seminars

- A. Roxin. *A model of plasticity-dependent network activity in rodent hippocampus during exploration of novel environments* Seminar at the Gatsby Computational Neuroscience Unit, UCL, London, April 2018.

2.1.7. Sistemes Complexos
Complex Systems

Álvaro Corral

Àmbit de recerca

Podem considerar com a sistemes complexos aquells formats per un nombre molt gran de components que interactuen intensament. Molts dels reptes actuals de la humanitat estan en comprendre el comportament de sistemes complexos, com ara el clima, l'economia, la societat, el cervell humà, la biologia del desenvolupament, etc. En oposició a aquest concepte, l'àtom d'hidrògen, el sistema solar o un gas ideal serien sistemes simples, malgrat que per descriure'ls necessitem conceptes profunds de la física i matemàtiques sofisticades. Tanmateix, si tot allò que és complex és un sistema complex, què aporta de nou el nou paradigma de la complexitat? Tots aquests sistemes d'àmbits tan diversos poden ser tractats des d'una única perspectiva? Una de les idees clau en els estudis de complexitat és que les estructures apareixen en aquest tipus de sistemes a tots els nivells, incloent nivells molt llunyans dels propis de la interacció entre els components i, a més, mostren regularitats estadístiques sorprenents.

En el grup de Sistemes Complexos del CRM ens concentrem en dues línies de recerca: la primera, desastres naturals i fenòmens meteorològics, resultat de l'activitat complexa de la Terra; i la segona, l'estructura de la informació en la comunicació entre humans, originada per l'activitat complexa de les zones cerebrals que les controlen i de les relacions socials entre els comunicadors. A la línia de desastres naturals investiguem els patrons d'ocurrència de terratrèmols, incendis forestals, huracans, pluja, etc., amb la idea que les seves propietats estadístiques amaguen claus per a la seva comprensió, modelització i previsió. Pel que fa a la comunicació humana, ens fixem tant en el llenguatge humà com en la música. Novament,

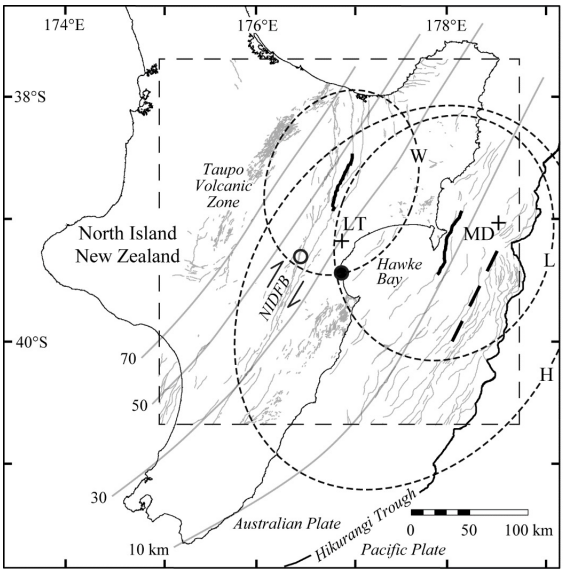
Research Field

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,

estudiem patrons d'ocurrència, aquest cop dels símbols que componen els textos o les peces musicals, per tal d'entendre millor com funcionen aquestes característiques tan exclusives del gènere humà i, per què no?, esbrinar si les màquines les podrien reproduir.

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.



Projectes vigents
Current Projects

- 2017-SGR-01735 AGAUR. *CRM research group in Collaborative*, Mathematics 2014–2017. PI: Álvaro Corral
- FIS2015-71851-P. *Sistemas invariantes de escala: herramientas, evidencia empírica, modelos y limitaciones*, Ministerio de Economía y Competitividad, 2016–2018. PI: Álvaro Corral.
- MAT2015-69777-REDT. *Avalanchas en Biofisica, Geofisica, Materiales y Plasmas*, ABIGMAP, MINECO, 2016–2017. PI: Eduard Vives Santa-Eulalia.

Membres del grup
Research Team

- Álvaro Corral (team leader)
- Isabel Serra (post-doctoral researcher)
- Jordi Baró (post-doctoral researcher)
- Álvaro González (post-doctoral researcher)
- Patrícia Paredes (post-doctoral researcher)
- Víctor Navas (PhD student)

Activitats relacionades
Related Activities

- VII Jornada complexitat.cat, UPF, Barcelona, May 2018.

Col·laboradors
Collaborators

• Elsa Arcaute	University College London
• Ramon Ferrer-i-Cancho	Universitat Politecnica de Catalunya
• Francesc Font-Clos	ISI Foundation, Torino
• Rosalba Garcia-Millan	Imperial College London
• Abigail Jimenez	Ulster University
• Eugenio Lopez Periago	Universidad de Vigo
• Cristina Masoller	Universitat Politècnica de Catalunya
• Nicholas R. Moloney	London Mathematical Laboratory
• Pedro Puig	Universitat Autònoma de Barcelona
• Joan Serrà	Telefonica I+D
• Eduard Vives	Universitat de Barcelona

Group Activity in 2018

During this year the group has had the privilege of incorporing Jordi Baró and Álvaro González as a postdoctoral fellows, and Patricia Paredes as predoctoral fellow. The main research of the group has focused on scaling laws, power laws (and the important distinction between both) applied to natural catastrophes, fractures, and linguistics. Some papers about these topics have been published in important journals. The group has continued also some consulting projects. Some guests of the group that have contributed to the CRM CAMP Seminars are Ian Hatton (ICTA UAB), Michelle Starnini (now at ISI Foundation, Torino), Juan Manuel R. Parrondo (Complutense de Madrid), and Rosalba Garcia-Millan (Imperial College London). The group also fuels fruitful internal group seminars every week or every second week. Since 2018 several group members have become active in the social networks to promote there scientific research and knowledge.

□ Complex Systems Publications

Articles

• A. Corral, J. Sardanyés, Ll. Alsedà, *Finite-time scaling in local bifurcations*, Scientific Reports **8**, 11783 (2018).

• V. Navas-Portella, I. Serra, A. Corral, E. Vives, *Increasing power-law range in avalanche amplitude and energy distributions*, Physical Review E **97**, 022134 (2018).

• A. Corral, R. Garcia-Millan, N. R. Moloney, F. Font-Clos, *Phase transition, scaling of moments, and order-parameter distributions in Brownian particles and branching processes with finite-size effects*, Physical Review E **97**, 062156 (2018).

• Zirak, P., Gregori-Pla, C., Blanco, I., Ana Fortuna, Fortuna, A., Cotta, G., Bramon, P., Serra, I., Mola, A., Solà-Soler, J., Giraldo-Giraldo, B.F., Durduran, T., Mayos, M.,, *Characterization of the microvascular cerebral blood flow response to obstructive apneic events during night sleep*, Neurophotonics 5(4) , (2018).

Preprints

- D. Moriña, I. Serra, P. Puig, A. Corral, *Probability estimation of a Carrington-like geomagnetic storm*, to appear in *Scientific Reports* (2019).
- V. Navas-Portella, A. Jiménez, A. Corral, *Effect of Coulomb Stress on the Gutenberg-Richter Law for the Seismicity after the Landers Earthquake*, submitted to *Scientific Reports*.
- A. Corral, A. González, *Power-law distributions in geoscience revisited*, submitted to *Earth and Space Science*.
- A. Corral, I. Serra, *Time window to constrain the corner value of the global seismic-moment distribution*, submitted to *PLoS ONE*.
- A. Corral, R. Ferrer-i-Cancho, *The distinct flavors of Zipf's law in the rank-size and in the size-distribution representations, and its maximum-likelihood fitting*, .
- Gregori-Pla, C., Blanco, I, Camps-Renom, P., Zirak, P., Serra, I., Cotta, G., Maruccia, F., Prats, L., Martínez-Domeño, A., Busch, D., Giacalone, G., Marti-Fabregas, J., Durduran, T., Delgado-Mederos, R., *Early microvascular cerebral blood flow response to head-of-bed elevation is related to outcome in acute ischemic stroke*, .

□ Complex Systems Scientific activities

Participation in scientific activities

Invited lectures in conferences

- Á. Corral, *Scaling of moments and order-parameter distributions in Brownian particles and branching processes with finite-size effects.*
Invited talk at the Workshop Cracking Noise in Materials. Nordita, Stokholm, Sweden, April 30, 2018.
- Á. Corral, *Finite-time scaling in local bifurcations: Application to branching processes.* Invited talk at the Workshop Cracking Noise in Materials. Nordita, Stokholm, Sweden, May 3, 2018.
- Á. González, Invited lectures *Size-frequency distributions of hazardous natural phenomena*, and *Evaluation and prevention of risks associated to active faults*, Master on Mineral Resources and Geological Hazards, Universitat de Barcelona and Universitat Autònoma de Barcelona.

Communications in conferences

- J. Baró, *Tuning triggering and critical failure through material rheology*, SES 2018: 55th Annual Technical meeting of the Society of Engineering Science, Universidad Carlos III, Madrid, October 2018.

□ Other

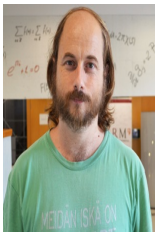
• Á. Corral, President of the Associació Catalana per a l'Estudi dels Sistemes Complexos (complexitat.cat).

• Á. Corral, Member of the Scientific Committee of the Grupo Especializado en Física Estadística y No Lineal (GEFENOL) School (belonging to the Real Sociedad Española de Física).

• Á. Corral, Member of the Doctoral Committee of the Mathematics Department of the UAB.

• Á. Corral, In charge of the CRM Doctoral Training Unit

. • Á. González, Member of the American Geophysical Union (AGU), section of non-linear geophysics.



2.1.8. Matemàtica del Desenvolupament i l'Evolució
Mathematics of Development and Evolution

Isaac Salazar-Ciudad

Àmbit de recerca

El nostre grup intenta entendre les bases matemàtiques de l'evolució. La pregunta principal que volem abordar és: com van sorgir els organismes complexos en l'evolució? O, més en general, com pot evolucionar la complexitat en els èssers vius, la cultura, la societat i els sistemes prebiòtics. En el cas dels organismes les preguntes serien:

1. Com es transforma una cèlula d'òvul fecund en un organisme adult complex caracteritzat per moltes cèlules, tipus cel.lulars i una distribucó específica d'aquestes en l'espai? Podem entendre les bases matemàtiques d'aquest procès de formació de patró tan aparent.

2. Com va sorgir aquesta complexitat en l'evolució per selecció natural? Respondre a aquesta pregunta implica explicar també l'evolucó del desenvolupament que produeix aquesta complexitat en cada generació.

3. Existeixen requisits o principis lògics o matemàtics que les xarxes ghniques han de complir per tal de poder produir morfologies complexes durant el desenvolupament?

Per fer front a aquestes preguntes, construim models matemàtics del desenvolupament embrionari. Aquests models inclouen un conjunt d'equacions diferencials que descriuen com els gens regulen l'expressió els uns dels altres i un conjunt d'equacions diferencials que descriuen com les cèl.lules es mouen, modifiquen la seva forma i regulen comportaments cel.lulars (creixement cel.lular, contracció cel.lular, divisió cel.lular, etc.). Cada cèl.lula conté el mateix conjunt de gens i equacions, però, com a resultat de la dinàmica del model, diferents cèl.lules acaben expressant gens

Research Field

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:

1. *How does a fertilized egg cell transforms into a complex adult organism? This is a complex functional organism characterized by many cells, cell types and a specific distribution of those in space. Can we understand the mathematics of such a dramatic pattern formation?*

2. *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 fulfill 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?*

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 behaviors (cell growth, cell contraction, cell division, etc?). Each cell contains the same set of genes and equations, but, as a result of model

a diferents intensitats. Aquests gens afecten les propietats mecàniques i els comportaments de les cèl.lules en els què s'expressen. Com a resultat, les cèl.lules es mouen i es reorganitzen en l'espai i, al seu torn, afecten, a traves de senyalització cel.lulars, on s'expressen els gens.

L'activitat del nostre grup s'articula al voltant de les línies de recerca següents:

- Modelització de múltiples escales de la formació de patró i la morfogènesi en el desenvolupament embrionàri
- Modelització de l'evolució en sistemes biològics i no biològics.
- Biologia del desenvolupament estadística
- Combinació i contrast de les aproximacions de la biologia del desenvolupament i la genètica quantitativa a la comprensió del mapa genotip-fenotip i l'evolució

dynamics, different cells end up expressing genes at different intensities. Genes affect the mechanical properties and behaviors of the cells in which they are expressed. As a result, cells move and rearrange themselves in space and, in their turn, affect back gene expression by differentially affecting, through cell-cell signaling, 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*

Membres del grup
Research Team

- Isaac Salazar-Ciudad (team leader)

Col·laboradors
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

Group Activity in 2018

My research in the CRM started in 2018. During 2018, our research has been focused on furthering our ongoing projects. We have specifically focused in applying our general model of development to mammalian tooth morphogenesis, both in its early and late stages (two published papers). We have also used our general model to approach the question of which are the requirements, at the level of gene network topology, for the production of complex robust morphologies in development (one paper in preparation, one submitted). Related to that we have develop new measures of complexity and distance for complex 3D morphologies. In another paper, currently in preparation, we have quantifyied the accuracy of the linear approach of quantitative genetics, the most prevalent mathematical framework for animal and plant breeding, in predicting evolutionary change when dealing with a realistically complex genotype-phenotype map (as provided by our mathematical models of development).

This implies combining the statistical approaches of classical evolutionary biology with the dynamical system approaches of current developmental biology (one paper submitted). We have also combined transcriptomics and evolutionary genomics approaches to quantify natural selection over the different parts of the body (one paper published) and the different stages of development (one paper under revision).
In December 2018, a PhD dissertation from a student I co-supervised was defended. Its title was Mapping natural selection through the Drosophila melanogaster development following a multiomics data integration approach
Regarding research output, the group has published 4 papers in ISI journals, all of them within the first quartile of their respective categories (4 more articles under preparation and 1 under revision). I have also written a book chapter. I have also been invited to several national and international conferences, workshops and summer schools, including invited talks at the joint annual symposium of the French, Portuguese, Spanish Developmental Biology Societies

□ Mathematics of Development and Evolution Publications

Articles

• Savriama Y, Valtonen M, Kammonen JI, Rastas P, Smolander OP, Lyyski A, Häkkinen TJ, Corfe IJ, Gerber S, Salazar-Ciudad I, Paulin L, Holm L, Löytynoja A, Auvinen P, Jernvall J., *Bracketing phenogenotypic limits of mammalian hybridization*, R Soc Open Sci. **11**, 8180903 (2018).
• Matamoro-Vidal A, Huang Y, Salazar-Ciudad I, Shimmi O, Houle D., *Quantitative Morphological Variation in the Developing Drosophila Wing*, Genetics, Genomics and Genes. G3 (Bethesda). **8**, 2399-2409. (2018).
• Marín-Riera, M., Moustakas-Verho JE., Jernvall, J Salazar-Ciudad*. I., *Study of ectodermal organ epithelial-mesenchymal mechanical interactions in vitro and in silico during tooth development.*, PLoS Comput. Biol. **14**, e1005981 (2018).
• Salvador-Martínez, I, Coronado-Zamora, M, Castellano, D, Barbadilla, A and Salazar-Ciudad I*., *Mapping selection within Drosophila melanogaster embryo's anatomy.* , Mol Biol Evol. **35**, 66-79 (2018).

Books or book chapters

• Salazar-Ciudad, I., *The relationship between genetics, epigenetics and epigenesis in evolution and developmen*, in *Perspectives on Evolutionary and Developmental Biology Essays for Alessandro Minelli* (2018).

□ Mathematics of Development and Evolution Scientific activities

Participation in scientific activities

Invited lectures in conferences

- Salazar-Ciudad I,*Systems Biology of Development*. Series of lectures on current topics in Developmental Biology, PhD Course, Tallin Technical University (Estonia), October 2018.
- Salazar-Ciudad I, *Why do they say developmental bias when they mean development.* Invited talk at the Name Of The Meeting. Santa Fe Institute, Santa Fe (USA), November 2018.
- Salazar-Ciudad I, *EmbryoMaker a general computational model for pattern formation, morphogenesis and evolution* Invited talk at the Annual Symposium of the French, Portuguese and Spanish Societies of Developmental Biology, Porto, Portugal, November 2018.

Communications in conferences

- Salazar-Ciudad I., *Principles in the Evolution of Complex phenotypes*, Conference of the European Society of Evolutionary Developmental Biology (Euro-evo-devo), Galway, June 2018.

Research stays

- Salazar-Ciudad I, 10th-25th October, 10th-15th September, 5th-12th December, Biotechnology Institute, University of Helsinki

□ Other

- Salazar-Ciudad I, Member of Editorial board, Bulletin of Particle Populations.

2.2. Transferència de Coneixement

2.2.1 Equip de Transferència de Coneixement

La unitat de transferència de tecnologia i coneixement del CRM va ser creada al 2017 amb la finalitat de recolzar la iniciativa de transferència que es va originar al 2012.

Des del punt de vista de transferència, el CRM té potencial per a promoure l'avanç e innovació en els principals àmbits de la ciència. Concretament, la naturalesa del CRM és allotjar coneixement científic interdisciplinari, a més conta amb el recolzament de la comunitat matemàtica de les universitats catalanes que proporcionen enllaços internacionals i promouen la recerca científica d'alta qualitat. Per tant, el CRM ofereix coneixement avançat en el desenvolupament de solucions a problemes actuals de la indústria, societat i medi ambient.

Per la complexitat que suposa la transferència d'àmbits interdisciplinaris, al setembre de 2017, el CRM va iniciar la unitat de KTT amb la missió d'enfortir els lligams de connexió entre la recerca i el món *real*, promovent l'assessorament i l'enteniment. Aquesta unitat aconsella i promou l'ús de solucions en base científica com a motor de la innovació.

Els objectius de la unitat de KTT del CRM son promoure, col·laborar i avaluar la transmissió, transferència i creació de coneixement que enllacin la recerca amb l'aplicabilitat. Per això, la unitat de KTT està present en processos de promoció de talent, promou la interdisciplinarietat entre investigadors i actua de promotor dels resultats de recerca. En aquest darrer punt, aquest any s'ha iniciat la participació activa del CRM en estudiar i recolzar projectes d'innovació que s'inicien en indústria. Tanmateix la unitat de KTT participa en accions de visualització del centre, aquest any ha participat en el MOOC de Coursera sobre Big Data.

Pel que fa a la promoció de talent, KTT està atent de captar interès dels estudiants amb inquietuds interdisciplinaris, des de acollir-los en estades al centre, així com dirigir treballs de fi de grau i

2.2. Knowledge Transfer

2.2.1. 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 MOOC of Coursera on Big Data.

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

màster. Tanmateix, promou que els estudiants de doctorat participin en activitats docents amb la finalitat de que avancin en les seves capacitats de comunicació, factor clau per a la transferència. Aquest any s'ha comptat amb la col·laboració del departament de Matemàtiques de la UAB i la Universitat adscrita a la UPC, EAE.

Pel que fa a la promoció de interdisciplinarietat entre investigadors. La principal finalitat és promoure l'ús de la recerca més puntera en matemàtiques a d'altres disciplines, per això es vol promoure la creació d'associacions i d'altres col·laboracions. Aquest any s'han continuat, e iniciat, projectes de co-direcció de tesis conjuntament amb d'altres centres. Així com planejar la Jornada entre el CRAG i el CRM.

Per últim, la principal acció del CRM aquest any ha estat la promoció dels resultats obtinguts en l'àmbit de biologia matemàtica. Això ha donat lloc a la creació de la Spin-Off Rheo dx. Rheo dx neix de CRM i Mobile World Capital a través del programa d'acceleració Collider. Rheo Dx ha llicenciat la patent del CRM sobre viscositats de fluids complexos a micro-escala. Ha fet la primera ronda d'inversió amb èxit. Ha aconseguit dos doctorands industrials dirigits per investigadors del CRM. A més, s'ha signat un conveni amb el CRM per tal que el centre sigui el seu motor d'innovació.

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. This year, there has been a collaboration with the department of Mathematics of the UAB and the UPC's partner university, EAE.

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 begun, together with other centers. Along with organising a meeting session between the CRAG and the CRM.

Finally, the main action carried out by the CRM this year has been the promotion of the results obtained in the field of mathematical biology. This has led to the creation of the Spin-Off Rheo dx. Rheo dx was born from the CRM and the Mobile World Capital through the Collider acceleration program. Rheo Dx has licensed the CRM patent on the viscosities of complex micro-scale fluids. It successfully initiated the first round of investment. It has completed two industrial doctorates supervised by CRM researchers. In addition, an agreement with the CRM has been signed so as to secure that the center will be its engine of innovation.

Isabel Serra

2.2.2. Laboratori de Microreologia de Biofluids

El Laboratori de Microreologia de Biofluids del CRM és una unitat d'investigació experimental. Aquesta unitat s'ha establert conjuntament pels grups de Biologia Matemàtica i Computacional, de Matemàtica Industrial i de Transferència de Coneixement per tal de proporcionar una

2.2.2. Lab for Microrheology of Biofluids

The CRM Lab for Microrheology of Biofluids is an experimental research unit based at CRM. This unit was established in collaboration with the Computational & Mathematical Biology Group, the Industrial Mathematics Group, and the Technology Transfer Unit in order to provide an in-house

instal·lació experimental que permeti avançar en la investigació d'aquests grups, proporcionant resultats experimentals rellevants per alguns dels seus projectes relacionats amb la dinàmica de biofluids a micro-escala. L'objectiu científic d'aquesta unitat d'investigació és l'estudi, tant per mitjà de models matemàtics com per mitjà d'investigació experimental directa, de les propietats mecàniques de biofluids en situacions dinàmiques. Aquest laboratori s'ha endegat en col·laboració amb el grup de Dinàmica d'Interfícies en Nanotecnologia, Fluídica i Biofísica de la Facultat de Física de la Universitat de Barcelona, dirigit per la Prof. Aurora Hernández-Machado, col·laboradora científica del CRM.

experimental facility that allows to advance the mathematical research of those groups by providing experimental results relevant to some of their projects related to the dynamics of biofluids at the micro-scale. The scientific aim of this research unit is to study, both by means of mathematical models as well as by direct experimental investigation, the mechanical properties of biofluids in dynamical situations. This laboratory is ran by the Computational & Mathematical Biology Group and the Industrial Mathematics Group in collaboration with the Dynamics of Interfaces in Nanotechnology, Fluidics and Biophysics Group of the Faculty of Physics of the Universitat de Barcelona leaded by Prof. Aurora Hernández-Machado, scientific collaborator of CRM.

2.2.4. Red Española Matemática-Industria

El CRM va signar un acord de col·laboració amb math-in al maig de 2012, amb l'objectiu d'involucrar als investigadors del CRM en la transferència de tecnologia, mitjançant l'intercanvi d'informació, coordinant propostes de subvencions, oferint recolzament en l'organització de congressos i establint vincles amb empreses i centres de recerca.

La creació de la "Red math-in" ha estat una de les

2.2.4. 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 organisation and establishing links with companies and research centres.

The creation of the Red math-in network has

prioritats del Pla de Transferència de Tecnologia del projecte i-MATH i pretén ser l'evolució de la plataforma de Mathematica CONSULTING. La idea és que es converteixi en un foro per a la comunicació i l'intercanvi d'informació i experiències per a promoure la transferència dels resultats de recerca produïts en el camp de les matemàtiques.

been one of the priorities of the Technology Transfer Plan of the i-MATH project, and tries to be the evolution of the Mathematica platform CONSULTING. It is intended to become a forum for communication and exchange of information and experiences to promote the transfer of research results produced into the field of mathematics.

[math-in].net
Red Española Matemática-Industria

http://www.math-in.net/

2.2.5. Doctorat Industrial

El CRM ha aportat propostes de Doctorat Industrial des de la creació d'aquest pla per part de la Generalitat de Catalunya. L'estudiant que ha defensat el seu doctorat en aquest projecte, junt amb l'empresa Hohner Automáticos S.L., és Néstor Costa Jimeno.
Actualment, el CRM té dos doctorats industrials més en col·laboració amb RheoDx, l'spin-off del CRM. Les estudiants de doctorat són Samantha López i Lourdes Méndez.

2.2.5. Industrial Doctorate

CRM has provided proposals for Industrial Doctorates since the set up of this plan by the Generalitat de Catalunya. The student who has defended his PhD thesis in this project, in collaboration with Hohner Automáticos S.L., is Néstor Costa Jimeno.
At this moment, CRM has two insdustrial doctorates more in collaboration with RheoDx, the CRM's spin-off. The doctorate students are Samantha López and Lourdes Méndez.

DOCTORATS INDUSTRIALS

hohner AUTOMATICOS

RheoDx

2.3. Investigadors visitants

Diversos investigadors fan estades temporals al CRM durant el curs acadèmic, la majoria dels quals són participants invitats als programes de recerca i la resta s'acullen a les convocatòries públiques del CRM per a estades de recerca en col·laboració amb matemàtics/ques de les universitats catalanes:

- Estades de recerca al CRM.
- Estades de recerca en col·laboració.
- Places "Lluís Santaló" per a visitants d'Amèrica llatina (finançada per l'IEC).

El llistat de visitants de 2018 es detalla a l'Apèndix

2.3. List of visitors

CRM hosts a number of visiting researchers every year. Most of them are invited participants at CRM research programmes, and the rest apply to competitive calls for research stays in collaboration with mathematicians in local universities, namely:

- *Visiting the CRM.*
- *Research in pairs at CRM.*
- *"Lluís Santaló" visiting positions for Latin-American researchers (sponsored by IEC).*

The list of 2018 visitors is detailed at the Appendix

d'aquesta memòria continuació. Aquest llistat no inclou el personal investigador propi del CRM ni els visitants que hagin fet estades inferiors a vuit dies.

2.4. La formació en recerca

Hi ha tres vessants de formació al CRM: per a estudiants de grau i màster, doctoral i postdoctoral. Aquest darrer nivell ha estat tractat a la Secció 2.1 d'aquesta memòria. A continuació expliquem l'activitat referent als dos primers estadis durant el 2018.

2.4.1. La Unitat de Formació Doctoral

El CRM ofereix la possibilitat a estudiants graduats de participar en un projecte de tesi doctoral dins d'un grup de recerca o d'una xarxa temàtica del CRM. Els estudiants de doctorat del CRM s'inscriuen a la Unitat de Formació Doctoral del CRM (UFD-CRM). Cal que compleixin els requisits necessaris per ser admesos en un programa de doctorat en matemàtiques de les universitats catalanes i queden automàticament inscrits a la Barcelona Graduate School of Mathematics. La UFD està coordinada actualment per Álvaro Corral, amb el suport de l'equip de direcció del CRM.
La UFD compta amb un programa d'activitats que consisteixen en:

- Un cicle de cursos de perfeccionament impartits per investigadors i/o col·laboradors de les xarxes temàtiques del CRM. Aquests cursos s'integren dins de la Barcelona Graduate School of Mathematics, i, per tant, queden a disposició de tots els estudiants de doctorat de l'àrea de Barcelona. Els temes d'aquests cursos seran d'interès general per a tots els estudiants.
- Un seminari juvenil organitzat pels estudiants sobre una base mensual i amb la participació només de joves investigadors (estudiants de doctorat i postdoctorats).
- Un taller anual on els estudiants presentaran informes sobre l'estat actual de les seves tesis.

of this memoir. This list does not include CRM staff researchers nor visitors whose stay was shorter than eight days.

2.4. Research training

There are three training levels at CRM: undergraduate and masters, doctoral and post-doctoral. The latter has been explained in Section 2.1 of this report. Next, we explain the activity in the first two stages during 2018.

2.4.1. The Doctoral Training Unit

CRM offers the possibility for graduate students to engage in a PhD project within a research group or thematic network of CRM. Doctoral students of CRM are enrolled in the CRM-Doctoral Training Unit (UFD-CRM). They are required to fulfill the requisites to be admitted to a doctoral programme in Mathematics in a Catalan university and they become automatically enrolled in the Barcelona Graduate School of Mathematics. The UFD is currently co-ordinated by Álvaro Corral with the support of the CRM direction team.
The UFD has a programme of activities consisting of:

- *A cycle of advanced courses given by CRM researchers and/or collaborators from the thematic networks. These courses will be integrated within the Barcelona Graduate School of Mathematics, and thus made available to all the PhD students of the Barcelona area. The subjects of these courses will be of general interest for all students.*
- *A junior seminar organised by the students on a monthly basis and attended only by junior researchers (PhD students and postdocs).*
- *An annual workshop where students will present reports of the current state of their theses.*

CRM PhD students are funded from different

El estudiants de doctorat del CRM es financien a través de diferents fonts: beques competitives de la Generalitat de Catalunya (FI) o ministeris espanyols (FPI, FPU), beques del programa "la Caixa"-CRM d'investigació en matemàtica col·laborativa, beques finançades pel CRM i altres. Els estudiants de doctorat associats al CRM durant l'any 2018 es llisten a l'Apèndix d'aquesta memòria.

sources: competitive grants of the Generalitat de Catalunya (FI) or Spanish Ministeries (FPI, FPU), grants from the "la Caixa"-CRM program collaborative research, CRM-funded grants and others. PhD students associated to the CRM during this year are listed at Appendix of the present memoir.

2.4.2. Curs de màster

El Màster de Matemàtiques per als Instruments Financers es va impartir per vintena vegada el 2018 gràcies a la col·laboració del Departament de Matemàtiques de la UAB i el CRM amb diverses entitats: la Borsa de Barcelona (patrocinadora), els departaments d'Economia Aplicada, d'Economia de l'Empresa, i d'Economia i d'Història Econòmica de la UAB, i el Departament d'Econometria, Estadística i Economia Espanyola de la UB, juntament amb destacats especialistes que treballen en contacte directe amb els mercats. Les empreses col·laboradores que hi donen suport, mitjançant les beques per a la realització de pràctiques, aporten el component necessari d'aprenentatge pràctic. Així, s'estableix una línia directa de col·laboració entre els mons acadèmic i professional, que permet desenvolupar i ensenyar les últimes tècniques de valoració de productes financers derivats, càlcul d'estratègies de cobertura i avaluació i control de riscos.

El màster està estructurat en tres etapes: dues de teòriques (cadascuna amb 120 hores de docència) i una tercera etapa pràctica en una empresa de finances. La responsabilitat del màster recau en una Comissió Acadèmica i un Comitè Executiu. L'any 2018 han acabat el màster 10 alumnes.

2.4.2. Master's Course

The CRM master's course on Financial Mathematics was held for the twentieth time in 2018 thanks to the collaboration of the Mathematics Department of the UAB and the CRM with several financial companies such as the Barcelona Stock Exchange, which is the sponsoring institution. Other collaborating institutions are the departments of Economics and Economics History, Applied Economics, and Business Economics of the UAB, the Department of Econometrics, Statistics and Spanish Economy of the UB, and several outstanding specialists who work in direct contact with the markets. Participation companies promote practical training opportunities for the students by offering them internships. This facilitates a direct contact between the academic world and the professional world, allowing them to develop and teach innovative techniques about the valuation of derived financial products, calculation of coverage strategies, risk assessment and risk control.

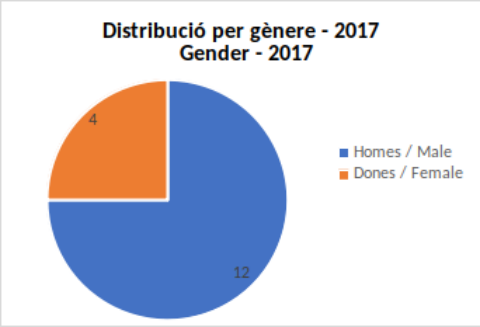
The course is structured in three terms, two theoretical, each with 120 hours of teaching, and a third practical in a financial company. The master's responsibility lies on an Academic Commission and an Executive Committee. In 2017 a total of 10 students completed the master's course.

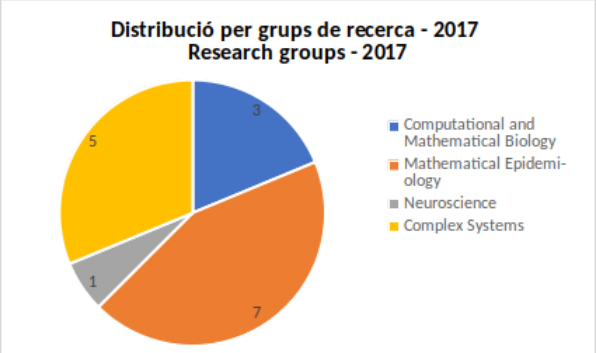
2.4.3. Estades d'iniciació a la recerca

El CRM va endegar el 2012 una convocatòria d'estades de recerca amb l'objectiu d'atraure l'interès dels joves cap a la recerca en matemàtiques. En el marc del programa, el CRM acull, en estades de 2 mesos, estudiants de grau o màster per tal de desenvolupar una etapa formativa en algun grup de recerca del CRM. Durant el 2018, un total de 16 estudiants. Els noms es llisten a l'Apèndix de la present memòria.

2.4.3. Internships for initiation to research

The CRM launched in 2012 a call for research stays aiming at attracting the interest of young people towards mathematical research. The CRM hosts, for a 2-month stay, undergraduate or master students willing to experience a training period in some of the CRM research groups. During 2018, 16 students visited the CRM within this program. Then names are listed at the Appendix of this report.





3

Organització d'activitats científiques

Organization of Scientific Events

El CRM organitza des de fa anys, sobre una base competitiva mitjançant convocatòries al seu web, quatre tipus d'activitats:

- Programes de recerca intensius
- Congressos internacionals i workshops
- Cursos avançats
- Jornades temàtiques

Les sol·licituds es presenten mitjançant les instruccions que es poden trobar a la secció corresponent de la web del CRM, actualment a *Visitors& Events > Scientific Events*.

CRM has a long steending tradition of organising on a competitive basis, through open calls in its website, four types of activities:

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

Applications can be submitted by following the guidelines given in the Visitors & Events > Scientific Events section of the CRM website.

`http://www.crm.cat/ca/Activities/Pagines/CallsForActivities.aspx`

El CRM també organitza *activitats divulgatives* i *seminaris de recerca*.

The CRM also organises Dissemination Activities and Research Seminars.

3.1. Programes de recerca

Un programa de recerca del CRM consisteix en un període intensiu de recerca en una àrea determinada de les matemàtiques i les seves aplicacions, durant el qual s'apleguen al CRM investigadors procedents de diferents institucions d'arreu del món per treballar en problemes oberts del seu àmbit d'especialització i per analitzar-ne l'estat i les perspectives.

3.1. Research Programmes

The CRM Research Programmes consist of periods of intensive research in a given 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.

Els programes de recerca del CRM duren, normalment, entre dos i cinc mesos. S'estructuren en dos vessants: els investigadors visitants i les activitats programades. Cada programa té un comitè científic responsable de planificar les activitats incloses en el programa, elaborar la llista dels investigadors visitants i lliurar un informe final. Típicament, en un programa hi participen investigadors locals a temps complet, investigadors visitants a temps complet, becaris postdoctorals i estudiants de doctorat avançats. Les activitats d'un programa inclouen generalment un o dos seminaris setmanals, un $workshop$ intensiu (preferentment obert a investigadors que no participin en el programa), un congrés internacional i un curs avançat dirigit a estudiants de doctorat.

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.

Els programes de recerca del CRM es convoquen a nivell internacional amb dos anys d'antelació i són avaluats pel Consell Científic. A continuació es descriuen els programes de recerca organitzats durant l'any 2017. La informació general sobre els programes de recerca es pot trobar a

The CRM Research Programmes are called internationally two years in advance and are evaluated by the Scientific Advisory Board. The CRM Research Programmes that took place in 2017 are described below. General information of Research Programmes can be found at

www.crm.cat/en/Activities/Pages/ResearchProgrammes.aspx

3.1.1. CRM Research Programme on Recent Progress in Mathematical Biology

April 16^{rd} *to June* 29^{th}, 2018

Scientific organizers	Tomás Alarcón	Centre de Recerca Matemàtica
	Jose Antonion Carrillo	Imperial College London
	Sílvia Cuadrado	Universitat Autònoma de Barcelona
	Toni Guillamon	Universitat Politècnica de Catalunya

Summary

Biology and biomedicine are experiencing a revolution driven by new high throughput technologies (OMICS, new imaging methodologies, etc.). These new technologies are producing a wealth of high-quality, high-resolution data that, perhaps for the first time, allow for quantitative characterisation of biological phenomena. However, there is also the danger that biologists and biomedical researchers are overwhelmed by the amount of data they are generating, unless new methods for data-management and quantitative theories allow them to interpret and contextualise their observations.

Driven by this need, new developments in Mathematical Biology have emerged. The aim of this program was to bring together experts from different areas of Mathematical Biology (neuroscience, tumour modelling, population dynamics,...) which have developed different methods trying to address the new challenges in their associated areas of biological and biomedical research. The members of the scientific committee have experience in the organization of intensive programs. Jose Antonio Carrillo and Toni Guillamon organized (together with Angel Calsina) the "Research program on Mathematical Biology: Modelling and Differential Equations"which took place at the CRM from January 2009 until June 2009. Silvia Cuadrado was the organizer of the weekly seminar of the previous program and was also a member of the scientific committee of the "Research Program on Mathematics of Biodiversity"which took place in June-July 2012 also at the CRM. Jose Antonio Carrillo together with Shi Jin and Peter Markowich organized a thematic program at the Newton Institute for the Mathematical Sciences at the University of Cambridge in fall 2010. Jose Antonio Carrillo together with Andrea Bertozzi, Wilfrid Gangbo, Yann Brenier, Jean Michel Morel and Peter Markowich organized a thematic program in Optimal Transport at the Institute of Pure and Applied Mathematics in UCLA during March-June 2008. These last two programs had lots of connections with mathematical biology via kinetic and transport modelling. This activity was included among the scientific activities organized in the framework of the "Year of Mathematical Biology"organized by the European Mathematical Society (EMS) and the European Society of Mathematical and Theoretical Biology (ESMTB) in 2018. Therefore, it was a way to increase the international impact of the CRM and the groups in mathematical biology of the Barcelona area. Jose Antonio Carrillo was the chairman of the Applied Mathematics Committee of the EMS and he acted as the main coordinator of this activity in 2018.

Webpage All program information can be found at: `www.crm.cat/2018/irp-Mathbio`

□ Recent Progress in Mathematical Biology Activities

• School on Mathematical Modelling of Tumour Growth and Therapy

Scientiffic Committe: Tomás Alarcón, José Antonio Carrillo, Sílvia Cuadrado and Toni Guillamon.

Dates: April 3^{rd} to 6^{th}, 2018

Webpage: `www.crm.cat/2018/cancerschool`

Summary: Recent years have witnessed a renewed interest in mathematical modelling of tumour growth and therapy. The increase in activity in this area has been boosted by enhanced access to data (OMICS, medical imaging) and recent developments in the area of multi-scale modelling. This course was aimed at introducing recent progress in the field of mathematical modelling applied to tumour growth and oncology, particularly focused in the emergence of new modelling and analytical multi-scale techniques and the new opportunities for model validation based on increased availability of data. The course was particularly aimed at an audience composed of graduate students and postdocs in mathematics with an interest in the applications of mathematics to biology.

• Conference on New Trends in Mathematical Biology

Scientiffic Committe: Tomás Alarcón, José Antonio Carrillo, Sílvia Cuadrado and Toni Guillamon.
Dates: June 4^{th} to 8^{th}, 2018
Webpage: `www.crm.cat/2018/mathbio`
*Summary:*The aim of this conference was to portray the current stay of the art in mathematical modelling of biological phenomena. Because of the depth and breadth of the subject, we focused on three broad topics, namely, Population and Evolutionary Dynamics, Mathematical Neuroscience, and Multi-scale modelling of Angiogenesis.

3.1.2. CRM Research Programme on Discrete, Combinatorial and Computational Geometry

April 16^{rd} *to June* 8^{th}, 2018

Scientific organizers	Oswin Aichholzer	TU Graz
	Prosenjit Bosem	Carleton University
	Erik Demaine	MIT
	Clemens Huemer	Universitat Politècnica de Catalunya
	Joe Mitchell	Stony Brook University
	János Pach	EPFL Lausanne
	Vera Sacristán	Universitat Politècnica de Catalunya
	Rodrigo I. Silveira	Universitat Politècnica de Catalunya

Summary

This intensive research program consisted of 8 weeks of activities focused on hot topics in discrete, combinatorial and computational geometry and their intricate relationships. The program brought together leading researchers from all over the world to work on open problems, and to analyze its present state and perspectives. The program was designed to be interesting for both senior researchers and advanced PhD students. The planned activities combined learning opportunities and research collaboration chances in problems of theoretical nature in combinatorial and discrete geometry, algorithmic problems from computational geometry, and implementation issues in specialized software.

The central part of the program was composed of 5 consecutive weeks, including two advanced courses, each followed by a week of topic-related inspiring lectures, and a hand-on course on geometric software.

Webpage

All program information can be found at: `www.crm.cat/2018/IRP-DCCG`

□ Discrete, Combinatorial and Computational Geometry Activities

• Advanced Course I: Advanced Techniques for Algorithmic Geometry
Scientiffic Committe: Oswin Aichholzer, Prosenjit Bosem, Erik Demaine, Clemens Huemer, Joe Mitchell, János Pach, Vera Sacristán i Rodrigo I. Silveira.
Dates: April 16^{th} to 20^{th}, 2018
Webpage:
`https://dccg.upc.edu/irp2018/details-of-the-activities/ac1/`

Summary: This course surveyed some of the most recent algorithmic paradigms and data structures that have led to the latest advances in the state of the art of computational geometry.

• Inspiring Lectures I: Computational Geometry Towards Applications

Scientiffic Committe: Oswin Aichholzer, Prosenjit Bosem, Erik Demaine, Clemens Huemer, Joe Mitchell, János Pach, Vera Sacristán i Rodrigo I. Silveira.

Dates: April 23^{th} to 27^{th}, 2018

Webpage: `https://dccg.upc.edu/irp2018/details-of-the-activities/il1/`

Summary: There was one lecture every morning, 2h long. For the rest of the time, attendees and lecturers worked together in open problems. There was a seminar talk every afternoon.

• Hands-on course on Geometric Software

Scientiffic Committe: Oswin Aichholzer, Prosenjit Bosem, Erik Demaine, Clemens Huemer, Joe Mitchell, János Pach, Vera Sacristán i Rodrigo I. Silveira.

Dates: April 30^{th} to May 4^{th}, 2018

Webpage: `https://dccg.upc.edu/irp2018/details-of-the-activities/gs/`

Summary: This activity was intended to provide practical knowledge about important software tools relevant to researchers dealing with geometric problems. It included lectures as well as hands on sessions.

• Advanced Course II: New Results in Combinatorial & Discrete Geometry

Scientiffic Committe: Oswin Aichholzer, Prosenjit Bosem, Erik Demaine, Clemens Huemer, Joe Mitchell, János Pach, Vera Sacristán i Rodrigo I. Silveira.

Dates: May 7^{th} to 11^{th}, 2018

Webpage: `https://dccg.upc.edu/irp2018/details-of-the-activities/ac2/`

Summary: This course covered current topics in combinatorial and discrete geometry, focusing on a selection of techniques that have enabled some of the latest breakthroughs in the area.

• Inspiring Lectures II: Challenges in Combinatorial & Discrete Geometry

Scientiffic Committe: Oswin Aichholzer, Prosenjit Bosem, Erik Demaine, Clemens Huemer, Joe Mitchell, János Pach, Vera Sacristán i Rodrigo I. Silveira.

Dates: May 14^{th} to 18^{th}, 2018

Webpage: `https://dccg.upc.edu/irp2018/details-of-the-activities/il2/`

Summary: There was one or two lectures every morning, each 1h 45m long. For the rest of the time, attendees and lecturers worked together in open problems. There was a seminar talk every afternoon.

• CONNECT Workshop on Geometric and Algorithmic Aspects of Networks

Scientiffic Committe: Oswin Aichholzer, Prosenjit Bosem, Erik Demaine, Clemens Huemer, Joe Mitchell, János Pach, Vera Sacristán i Rodrigo I. Silveira.

Dates: May 28^{th} to June 1^{st}, 2018

Webpage: `https://dccg.upc.edu/irp2018/details-of-the-activities/connect/`

Summary: Research workshop organized within the H2020 project CONNECT (COmbinatorics of NEtworks and CompuTation).

• **5th Austrian-Japanese-Mexican-Spanish Workshop on Discrete Geometry**

Scientiffic Committe: Oswin Aichholzer, Prosenjit Bosem, Erik Demaine, Clemens Huemer, Joe Mitchell, János Pach, Vera Sacristán i Rodrigo I. Silveira.

Dates: June 4^{th} to 8^{th}, 2018

Webpage: `https://dccg.upc.edu/irp2018/details-of-the-activities/ajms/`

Summary: This series of workshops started in 2014, promoted by Oswin Aichholzer, Ferran Hurtado and Jorge Urrutia, under the auspice of the EuroGIGA ComPoSe project. The workshop brought together a group of 20-25 researchers to work on open problems brought by the organizers and the participants.

3.1.3. Follow up of the Research Program Central Configurations, Periodic Orbits and Beyond in Celestial Mechanics

September 3^{rd} to 7^{th}, 2018

Scientific organizers	Montserrat Corbera	Universitat de Vic
	Josep Maria Cors	Universitat Politècnica de Catalunya
	Jaume Llibre	Universitat Autònoma de Barcelona

Summary

The conference HAMSYS2018 was a continuation of the conference HAMSYS2014 celebrated inside the research program on Central Configurations, Periodic Orbits and Beyond in Celestial Mechanics. In 1991 started the series of the HAMSYS Symposia. These symposia brought together top researches from several countries, working mainly in Hamiltonian Systems and Celestial Mechanics, as well as many graduate students who had the opportunity to learn from and connect with the experts in the field. The VIII HAMSYS Symposium, denoted HAMSYS-2018, took place at CRM. The emphasis of the talks was on Hamiltonian dynamics and its relationship to several aspects of mechanics, geometric mechanics, and dynamical systems in general. Previous Editions:

- Guanajuato, Mexico, September 30th - October 4th, 1991.
- Cocoyoc, Mexico, September 13th - 17th, 1994
- Pátzcuaro, Mexico, December 7th - 11th, 1998
- Guanajuato, Mexico, March 19th - 24th, 2001
- Guanajuato, Mexico, July 7th - 11th, 2008
- Ciudad de México, Mexico, November 29th - December 3rd, 2010
- Centre de Recerca Matemàtica, Bellaterra, June 2nd - 6th, 2014

HAMSYS2018 was mainly dedicated to the following topics: The study of the dynamics of n point masses interacting according to Newtonian gravity is usually called the n-body problem. It can be considered as old as the history of the science and has influenced most of the areas in mathematics. However, most of the problems in Celestial Mechanics are beyond the reach of current theories and many natural questions are difficult or impossible to solve when the number of bodies n is larger than 2.

In order to make progress against such complexity one must look for specific objects. From a geometrical point of view a key point consists in trying to understand the structure of the phase space looking for the equilibrium points, periodic orbits, invariant tori,... The stable and unstable manifolds associated to these objects form a kind of network of connections, which together with the previous invariants objects constitute a big part of the main skeleton of the system.

One of the main ingredients of the phase space are the periodic orbits. Over the years, many authors have contributed to study the periodic orbits of a wide variety of n-body problems from different points of view. A particular interesting type of periodic orbit in the planar n-body problem is one in which the particles remain in the same shape relative to one another. The possible configurations for the particles in such orbits are called central configurations.

Webpage: All program information can be found at: `www.crm.cat/2018/IRP-DCCG`

3.2. Congressos i Workshops

En aquest apartat es detallen els congressos i *workshops* que va organitzar la BGSMAth durant l'any 2018.

3.2. Conferences and Workshops

This section provides a list of the congresses and workshops organised by BGSMath during 2018.

□ BGSMath Monthly Programs

3.1.1. Monthly Programs de la BGSMath on Geometric Function Theory in Fluid Mechanics

June 2^{nd} *to* 20^{th}

Scientific organizers: Albert Clop (Universitat Autònoma de Barcelona)
Jordi Marzo (Universitat de Barcelona)
Albert Mas (Universitat de Barcelona)

Summary: A research program on "Geometric function theory in fluid mechanics" was held. The objective was to put together two communities apparently disconnected, and settle common interests and goals.

Webpage: `https://bgsmath.cat/event/geometric-function-theory-fluid-mechanics/`

□ BGSMath Activities

International Day of Women and Girls in Science 2018

February 9^{th}

Scientific organizers	Luca Tancredi Barone	(BGSMath)
	Natàlia Carulla	(IRB)

Summary: BGSMath and the Societat Catalana de Matemàtiques jointly organised a special event at the Institut d?Estudis Catalans in Barcelona to visualise successful female mathematicians and their research that has an impact on our everyday's lives. This event is organised within the "International Day of Women and Girls in Science".

Webpage: `https://bgsmath.cat/event/diadonanenaciencia/`

Maths for industry 4.0

February 19^{th}

Scientific organizers	Arantxa Sanz	(BGSMath)
	Helena Ramalhinho	(Universitat Pompeu Fabra)

Summary: "Maths for Industry 4.0" showcased how academic excellence at BGSMath is helping companies becoming digital. Among the topics covered: successful collaborative initiatives, such as industrial doctoral theses, as well as the range of expertise you could benefit from.
The workshop was closed by a round table on Data Analytics. Experts discussed common challenges and trends across sectors, and how mathematical creativity enable solutions for supply chain, risk management, control and monitoring.

Webpage: `https://bgsmath.cat/event/maths-industry-4-0/`

Metaheuristics Graduate course syllabus

February 21^{th} *to* 23^{th}

Scientific organizers	Helena Ramalhinho	(BGSMath)
	Jordi Castro	(Universitat Politècnica de Catalunya)
	Francisco Javier Heredia	(Universitat Politècnica de Catalunya)

Summary

This Graduate Course was dedicated to metaheuristics, a particularly attractive discipline regarding efficient solution of logistic decision problems in supply chains, transportation, telecommunications, vehicle routing and scheduling, manufacturing and production, timetabling, sports scheduling, facility location and layout, network design, and power generation, finance, marketing, among other areas.The first aim of this course is to give the students a general idea of the class of problems that benefit from and are amenable to be efficiently solvable by metaheuristics. With this view, the course starts by a gentle and intuitive introduction to complexity theory. Furthermore the course aimed at presenting students the main metaheuristics and their building blocks, so as that they could be able to propose or even develop simple solution strategies for practical problems. Finally, the course also shows and discusses with the students several practical applications of metaheuristics to real problems in logistics, retailing, marketing, sports, finance etc. in different industries.

Webpage `https://bgsmath.cat/event/metaheuristics-workshop/`

UAB – BGSMath Colloquium: Topological vistas in neuroscience

April 4^{th}

Scientific organizer Natàlia Carulla (IRB)

Summary

The speaker described results obtained in collaboration with the Blue Brain Project on the topological analysis of the structure and function of digitally reconstructed microcircuits of neurons in the rat cortex and outline our ongoing work on topology and synaptic plasticity. The talk included an overview of the Blue Brain Project and a brief introduction to the topological tools that we use.

Webpage `https://bgsmath.cat/event/topological-vistas-neuroscience/`

An Introduction To Parameterized Complexity

April 9^{th} *to* 12^{th}

Scientific organizer Servei D'Estadística Aplicada (Universitat Autònoma de Barcelona)

Summary

Parameterized complexity theory is now a mature field of Theoretical Computer Science and has developed a wealth of techniques for for designing parameterized algorithms (i.e., upper bounds) but also for proving that such algorithms probably do not exist (i.e., lower bounds). For proving lower bounds, Downey and Fellows introduced a hierarchy of parameterized complexity classes and suitable concepts of problem reducibility that permitted the systematic classification of numerous computational problems according to their parameterized complexity. This course covered the foundational concepts of this theory from the point of view of the lower bounds and the concept of problem parameterization, explained "why and how" this induced the definition of the parameterized complexity hierarchy, and provided some links of this theory to the classical complexity theory.

Webpage `http://bgsmath.cat/event/an-introduction-to-parameterized-complexity/`

Introduction to Functional Data Analysis With R

June 11^{th} *to* 15^{th}

Scientific organizer: Servei D'Estadística Aplicada (Universitat Autònoma de Barcelona)

Summary: Functional data arise when one of the variables of interest in a data set can be seen naturally as a smooth curve or function. Functional Data Analysis (FDA) can then be thought of as the statistical analysis of samples of curves. For last two decades, FDA techniques have evolved rapidly, which has allowed the FDA to reach a remarkable methodological maturity. Many standard statistical methods have been adapted to functional data: regression models (lm, glm, non-parametric regression,...), multivariate analysis (PCA, MDS, Clustering, Depth measures,...), time series, spatial statistics, among other. At the same time, its methods have been applied to quite broadly in medicine, science, business, engineering, demography and social sciences, etc. The course offered an introduction to FDA and presented some of the R libraries oriented to this type of data. The aim was that, at the end of the course, students be able to identify situations in which they can treat their data as functional, to represent them computationally, to apply simple FDA techniques (descriptions, dimensionality reduction, regression) and to visualize the results.

Webpage: `https://bgsmath.cat/event/introduction-functional-data-analysis-r/`

XXIX International Biometric Conference

July 8^{th}

Scientific organizers: Pere Puig (Universitat Autònoma de Barcelona)
Lupe Gómez (Universitat Politècnica de Catalunya)

Summary: The International Biometric Society organised the XXIX International Biometric Conference (IBC2018).
The meeting was hosted by the Spanish Region of the International Biometric Society (REsp). The Local Organizing Committee (LOC) was led by BGSMath Faculty members Pere Puig and Lupe Gómez.

Webpage: `https://bgsmath.cat/event/xxix-international-biometric-conference/`

BGSMath Summer Colloquium 2018

July 10^{th}

Scientific organizer: Marta Sanz-Solé (Universitat de Barcelona)

Summary

Diego Córdoba talked about Singularities in water waves and drops and Anna Cima about Global Attractors. Córdoba discussed recent progress in the study of the dynamics of the incompressible free boundary Euler equations: water waves and drops. In particular, he focussed on two plausible singular scenarios discovered first by numerical simulations which led later to a rigorous proof. Anna Cima explained the history of the solution of the dynamical conjecture introduced by Markus and Yamabe in 1960. She also presented some results on the discrete version of this conjecture, studying also other conditions on global attractors stablished by La Salle in his book "The Stability of Dynamical Systems".

Webpage

`https://bgsmath.cat/event/bgsmath-summer-colloquium-2018/`

Complex Dynamics and Applications

July 16^{th} *to* 20^{th}

Scientific organizers

Núria Fagella (Universitat de Barcelona)
Xavier Jarque (Universitat de Barcelona)

Summary

An introduction to complex dynamics, aimed at surveying its recent applications to statistical mechanics and the related open problems. A significant portion of this course was dedicated to review the classical theory of dynamics in one complex variables, initiated by Fatou and Julia. The emphasis was on the ideas and results used in the recent progress in statistical mechanics; specifically, on the zeros of the partition function of the hard-core gas model (Peters – Regts, Bezakova – Galanis – Goldberg – Stefankovic). The course ended with a discussion of open problems.

Webpage

`https://bgsmath.cat/event/complex-dynamics-applications/`

BGSMath 2018 Junior Meeting

November 5^{th} *to* 6^{th}

Scientific organizers

Gladston Duarte (Universitat de Barcelona)
Claudia Fanelli (CRM)
Marina Garrote (Universitat Politècnica de Catalunya)
Aapo Kauranen (Universitat Autònoma de Barcelona)
Álvaro Leitao (Universitat de Barcelona)

Summary

The Barcelona Graduate School of Mathematics organised its fourth BGSMath Junior Meeting, an excellent opportunity for young researchers of the BGSMath community to meet senior researchers and colleagues from various universities and share their knowledge and skills.

At the BGSMath Junior Meeting, early career researchers were able to present their current research in a informal and collaborative environment. This meeting was addressed to any researcher in any area of Mathematics. Also master or undergraduate students considering to start a PhD in math were very welcome to come, meet people and get an idea of the different research lines in BGSMath.

Webpage https://bgsmath.cat/event/bgsmath-2018-junior-meeting/

A Theory of Spectral Clustering

November 21^{th}

Scientific organizer Oriol Serra (Universitat Politècnica de Catalunya)

Summary Spectral clustering algorithms find clusters in a given network by exploiting properties of the eigenvectors of matrices associated with the network. As a first step, one computes a spectral embedding, i.e. a mapping of nodes to points in a low-dimensional real space; then one uses geometric clustering algorithms such as k-means to cluster the points corresponding to the nodes.
Such algorithms work so well that, in certain applications unrelated to network analysis, such as image segmentation, it is useful to associate a network to the data, and then apply spectral clustering to the network. In addition to its application to clustering, spectral embeddings are a valuable tool for dimension-reduction and data visualization. The performance of spectral clustering algorithms has been justified rigorously when applied to networks coming from certain probabilistic generative models.

A more recent development, which is the focus of this lecture, is a worst-case analysis of spectral clustering, showing that, for every graph that exhibits a certain cluster structure, such structure can be found by geometric algorithms applied to a spectral embedding. Such results generalize the graph Cheeger?s inequality (a classical result in spectral graph theory), and they have additional applications in computational complexity theory and in pure mathematics.

Webpage https://bgsmath.cat/event/theory-spectral-clustering/

BGSMath Autumn Colloquium 2018

November 29^{th}

Scientific organizer BGSMath

Summary

There are many situations in geometry and group theory where it is natural, convenient or necessary to explore infinite groups via their actions on finite objects – ie via their finite quotients. But how hard is it find finite quotients in general, and to what extent do they determine the group?
In this colloquium talk, Martin Brisdson sketched the rich history of this problem and describe some of the major progress of recent years. He explained why there is no algorithm that can determine whether or not a finitely presented group has a non-trivial finite quotient, and indicated how decidability varies as one replaces the family of all finite quotients with families of finite simple quotients. These algebraic results are proved via excursions into ideas that have played a fundamental role in the spectacular advances in low-dimensional topology in recent years.

Webpage `https://bgsmath.cat/event/chasing-finite-shadows-infinite-groups/`

□ BGSMath Activities on Transferable Skills and Career Development

Applying for Postdoctoral Positions. Writing your first Research Proposal

April 24^{th}

Scientific organizer BGSMath

Summary

During this seminar, the speaker started by reviewing the academic career path the PhD thesis until tenure, and what being a "postdoc" actually means. The session provided students with tips on how to apply successfully to open positions, which usually implies preparing an academic CV, motivation letters, and most importantly, devising a full research project perhaps for the first time. Furthermore, she analyzed examples of job offers and applications, to identify "do's and don'ts" and taught some basic concepts, vocabulary and techniques to write successful proposals.

Webpage `https://bgsmath.cat/event/writing-first-research-proposal/`

Fundraising and Writing Research Proposals: The IF MSCA example

July 8^{th} *and* 16^{th}

Scientific organizer	BGSMath
Summary	One of the professional skills to acquire and practise during postdoctoral fellowships is to secure resources to carry out your research. These 2 two-hour sessions aimed at showing how to identify funding opportunities suitable for mathematics-related projects ("Where to find the money"), and give tools to formulate winning proposals in competition with other people who want them ("How to get it"). The Writing Proposals Session was followed by a hands-on practice to deliver an Individual Fellowship Marie Skłodowska-Curie (IF MSCA) proposal.
Webpage	`https://bgsmath.cat/event/fundraising-writing-research-proposals-msca-example/`

Innovation inspirational talk: BGSMath and the Collider

September 27^{th}

Scientific organizer	BGSMath
Summary	The talk was focussed on innovation and ended up with a visit at the incubator The Collider. The list of topics covered is ☐ Introduction to innovation ☐ Start-up vs spin-off ☐ From start-up to company ☐ What do we mean by entrepreneurs? Can you become one? ☐ Incubators vs accelerators ☐ The Barcelona ecosystem in IT/Digital ☐ Visit to the Collider
Webpage	`https://bgsmath.cat/event/innovation-inspirational-talk-bgsmath-collider/`

Shapes of mathematics

September 29^{th}

Scientific organizers	Luca Tancredi Barone (BGSMath) Marina Garrote (BGSMath) Alessandro Oneto (BGSMath)

Summary	BGSMath participated in the European Researchers' Night 2018 with an initiative designed by Marina Garrote and Alessandro Oneto. They guided visitors in a mathematical tour in the evocative location of the Dipòsit del Rei Martí, in Barcelona, just next to the Bellesguard Tower, designed by the renowned architect Antoni Gaudí. An exhibition of a selection of fascinating Imaginary images, spanning from impossible tilings, surfaces and singularities, and the unimaginable projective plane was set up. Plus, a set of micro-talks on the applications of mathematics to many aspect of our lives: from pictures, to music or evolutionary science, and much more!
Webpage	`https://bgsmath.cat/event/nitrecerca2018/`

Training Session on Open Science and Open Access

December 11^{th}

Scientific organizer	BGSMath
Summary	Open Science represents a culture change in the way stakeholders in the research, education and knowledge-exchange communities create, store, share and deliver the outputs of their activity. This training session aimed to provide an introduction to the concepts and historical background into Open Science, as well as the diverse routes to guarantee Open Access and contribute to research open Data. Speakers finished by presenting the CRM Repository, which is expected to facilitate to comply with Open Access policies for BGSMath-CRM researchers, and how to make use of it.
Webpage	`https://bgsmath.cat/event/training-session-open-science-open-access/`

3.2. Congressos i Workshops

En aquest apartat es detallen els congressos i *workshops* que va organitzar el CRM durant l'any 2018 al marge dels programes de recerca.

3.2. Conferences and Workshops

This section provides a list of the congresses and workshops organised by CRM during 2018 not included in research programmes.

Barcelona Computational, Cognitive and Systems Neuroscience (BARCCSYN) 2018

May 24^{th} *to* 25^{th}, 2018

Organizing and Scientific Committee	Matthieu Gilson (Universitat Pompeu Fabra), Belen de Sancristóbal (Institut d'Investigaciones Biomèdicas August Pi i Sunyer), Vicky Puig (Institut Hospital del Mar d'Investigacions Mèdiques) i Alex Roxin (Centre de Recerca Matemàtica)
Summary	The BARCCSYN meeting is a forum for the computational, systems and cognitive neuroscience community from the Barcelona area, that takes place yearly.
Webpage	`www.crm.cat/2018/barccsyn`

MURPHYS-HSFS-2018: Interdisciplinary Workshop on Multiple Scale Systems, Systems with Hysteresis and Trends in Dynamical Systems

May 28^{th} *to June* 1^{st}, 2018

Organizing Committee	Andrei Korobeinikov (Centre de Recerca Matemàtica), Magdalena Caubergh (Universitat Autònoma de Barcelona), Pavel Gurevich (Institut für Mathematik), Tomás Lázaro (Universitat Politècnica de Catalunya), Dmitry Rachinskii (University of Texas), Josep Sardanyés (Centre de Recerca Matemàtica), Elena Shchepakina (Samara University), Vladimir Sobolev (Samara University).
Summary	This was a multidisciplinary workshop, devoted to mathematical theory and applications of the multiple scale systems, systems with hysteresis and trends in the dynamical systems theory. MURPHYS 2018 (Multi-Rate Processes and Hysteresis) was the 9th workshop that continued a series of biennial meetings focused on multiple scale phenomena, singular perturbations, phase transitions, hysteresis phenomena and open problems in dynamical systems theory. The previous workshops were held in Cork, Ireland (2002, 2004, 2006, 2008); Pechs, Hungary (2010); Suceava, Romania (2012) and Weierstrass Institute for Applied Analysis and Stochastics, Berlin (2014). The 8th workshop was also held in Barcelona, in 2016. HSFS (Hysteresis and Slow-Fast Systems) was the follow-up of a workshop organized in the framework of the Collaborative Research Center 910, Berlin. HSFS focuses on reaction-diffusion equations with hysteresis, systems with different temporal and spatial scales, and applications to self-organizing nonlinear systems. The previous workshops were organized in Lutherstadt Wittenberg, Germany (2011), Berlin, Germany (2014) and Barcelona, Spain (2016).
Webpage	`http://www.crm.cat/2018/MURPHYS2018`

16th School on Interactions between Dynamical Systems and Partial Differential Equations (JISD2018)

June 25^{th} *to* 29^{th}, 2018

Organizing Committee	Xavier Cabré (ICREA and Universitat Politècnica de Catalunya), Matteo Cozzi (BGSMath and Universitat Politècnica de Catalunya), Amadeu Delshams (Universitat Politècnica de Catalunya), Marcel Guàrdia (Universitat Politècnica de Catalunya), Eva Miranda (Universitat Politècnica de Catalunya), Tere M. Seara (Universitat Politècnica de Catalunya).

Summary: The "School on Interactions between Dynamical Systems and Partial Differential Equationsïs an international summer school that took place at the Facultat de Matemàtiques i Estadística of the Universitat Politècnica de Catalunya (UPC) every summer since 2002 until 2016. It is an annual meeting between scientists dedicated to dynamical systems and/or to PDEs to exchange knowledge and methods which may help to study new leading border problems in these two fields of mathematics. The school is aimed at researchers from any country, as well as at local researchers. The 2018 edition was the second edition that took place at the Centre de Recerca Matemàtica. It consisted of four advanced courses of about 6 hours each, complemented by some seminar talks as well as communications and posters by young attending researchers.

Webpage: `http://www.crm.cat/2018/JISD2018`

4th Barcelona Summer School on Stochastic Analysis

July 9^{th} *to* 13^{th}, 2018

Organizing Committee: Xavier Bardina (Universitat Autònoma de Barcelona), Lluís Quer-Sardanyons (Universitat Autònoma de Barcelona), Marta Sanz-Solé (Universitat de Barcelona), Josep Vives (Universitat de Barcelona).

Summary: The Barcelona Summer School on Stochastic Analysis is a one-week scientific activity consisting mainly of courses addressed to PhD students and young researchers on current research topics in Stochastic Analysis, which takes place every two years. Selected participants are also given the opportunity to deliver short talks or to display posters. The courses in 2018 were the following. For a detailed description see below: Some stochastic models in eco-evolution, by Sylvie Méléard (École Polytechnique, Palaiseau, France). Zero sets of random functions, by Mikhail Sodin (Tel Aviv University, Israel).

Webpage: `www.crm.cat/2018/StochasticAnalysisBCN`

Barcelona-Toulouse Probability Days

October 4^{th} *to* 5^{th}, 2018

Organizing Committee: Lluís Quer-Sardanyons (Universitat Autònoma de Barcelona), Anthony Reveillac (INSA Toulouse).

Summary: The Barcelona-Toulose Probability Days is a two-day scientific activity whose main objective consists in gathering researchers on probability theory, and particularly on stochastic analysis, from different institutions of Barcelona and Toulouse. The workshop constitutes an opportunity for researchers working on various fields of probability theory to meet and discuss about cutting-edge problems in the area, to exchange ideas and to establish long-term collaborations. The first edition of the Barcelona-Toulouse Probability Days took place in 2016 in Toulouse.

Webpage: `http://www.crm.cat/2018/WK_Toulouse`

Barcelona Weekend on Operator Algebras
November 16^{th} *to* 17^{th}, 2018

Organizing Committee	Joan Bosa (Universitat Autònoma de Barcelona), Francesc Perera (Universitat Autònoma de Barcelona).
Summary	This workshop is aimed at becoming an annual meeting of the Operator Algebras community in Barcelona. The scientific organizers wanted to bring together leading experts and active researchers in the field to disseminate results as well as to set out perspectives for the future. Interactions between Algebra, Geometry and Topology were fostered.
Webpage	`www.crm.cat/2018/BCN_OA`

3.4. Seminaris del CRM

El CRM difon l'activitat de tots els seminaris de recerca matemàtica de Catalunya, però també actua com a organitzador de seminaris en àrees emergents, bé a través de les seves xarxes temàtiques o bé a través dels investigadors del centre.

3.4. CRM 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

- The CRM Applied Mathematical and Physics (CAMP) Seminar. Coordinator: Víctor Navas (CRM).
- Computational Neuroscience Seminar. Organisers: Alex Roxin (CRM), Albert Compte (Institut d'Investigacions Biomèdiques 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).

3.5. Activitats divulgatives

El CRM promou activitats de divulgació en l'àmbit de la matemàtica, a diferents nivells formatius. Durant el 2018 es van oferir les següents activitats:

3.5. Dissemination Activities

The CRM promotes dissemination activities around mathematics, at different specialization levels. During 2018, the following activities were offered:

- □ On March 2nd, CRM participated in *Youth Mobile Festival Barcelona*.
- □ On May 4th, J. Sardanyés lectured on *applied Dynamical Systems* during the day *Undegraduate Meet-and-Greet at the CRM*.
- □ On November 5th, Lluís Alsedà (CRM) participated in *Cicle Salut i medi ambient* organized by *l'Obra Social "la Caixa"* lectured on *Biografia i salut, models aplicats a escala territorial*.
- □ On November 19th, Klaus Wimmer (CRM) participated in *Cicle Dilluns de Ciència* organized by *Residència dâInvestigadors i CERCA*lectured on *Xarxes neuronals per a la presa de decisions*.
- □ On December 22th, Lluís Alsedà (CRM) and Isabel Serra (CRM) participated in *Intel·ligència artificial, ètica i participació ciutadana. Reptes de futur* organized by *Centre de Visió per Computador* and *Centre de Recerca Matemàtica*.

- On December 18th, Roger Domingo-Roca (University of Glasgow & Strathclyde University) lectured on *Development of an experimental platform for rapid prototyping of UmTDD methods*

- In the framework of *Programa Magnet* CRM has participated in the following meetings and activities:

Day	**Action(s)**
Jaunary 23th	Meeting Joaquim Blume school and CRM teams.
March 6th	Talks delivered to Joaquim Blume's students by CRM's researchers: • *Com ens afecta la temperatura a les persones?*, P. Paredes • *Per què surem més en el mar? Què hi té a veure la sal?*, T. Myers • *Com es calcula la distància entre nosaltres i l'horitzó?*, K. Wimmer • *Per què hi ha països pobres i rics?*, V. Navas
March 9th	Meeting Joaquim Blume school and CRM teams.
March 13th	Day at Joaquim Blume school.
April 5th	Press conference at Jaume Bofill foundation.
April 12th	Faculty of Joaquim Blume's school visited CRM.
May 8th	Several talks delivered by Ll. Alsedà, E. Beltran and V. Navas.
May 25th	Monitoring Comission meeting at Joaquim Blume school.
December 14th	Meeting Joaquim Blume school and CRM teams.

4

Publicacions del CRM

CRM Publications

La publicació de documents de recerca és un dels canals de difusió del coneixement matemàtic per part del CRM. El CRM compta amb diverses sèries de publicacions estables: *Advanced Courses in Mathematics*, *Research Perspectives CRM Barcelona*, *CRM Documents*, *Quaderns*, *Preprints*, *Series on Popularization*, treballs finals de màster i tesis doctorals.

Per tal de coordinar aquesta activitat, es va crear, a finals de 2011, el **Comitè Editorial del CRM**. Durant l'any 2018, ha estat format per Enric Ventura (editor en cap) i Raquel Hernández (responsable d'edició). El Comitè Editorial es reuneix bimensualment.

A continuació, donem una breu descripció de cadascuna de les sèries i un llistat dels *preprints* que han aparegut al llarg de 2018.

The publication of research documents is one of the CRM channels for spreading mathematical knowledge. Apart from editing singular texts, the CRM has several stable publication series: Advanced Courses in Mathematics, Research Perspectives CRM Barcelona, CRM Documents, Quaderns, Preprints, 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 2018, it was formed by Enric Ventura (Editor-in-Chief) and Raquel Hernández (editing tasks). The Editorial Board meets every two months.*

We give provide an overview of the different series and a list of the preprints issued along the year 2017.

4.1. Advanced Courses in Mathematics CRM Barcelona

Els volums d'aquests sèrie, publicada per l'editorial suïssa Birkhäuser, recullen el contingut d'alguns dels cursos avançats impartits al CRM, a partir de les notes prèvies lliurades als participants i reelaborades pels mateixos autors. Es tracta de

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

llibres de text, especialment adreçats a estudiants de doctorat avançats i a joves investigadors postdoctorals.

reworked by the authors. These volumes are especially addressed to advanced doctoral and young post-doctoral students.

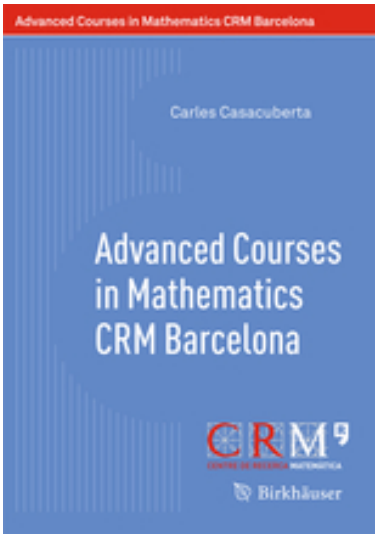
Des de setembre de 2008 fins a finals de 2013, l'editor responsable d'aquesta sèrie va ser Carles Casacuberta (UB) qui va substituir en aquest càrrec a Manuel Castellet (UAB), que va iniciar la sèrie l'any 2001. Des de principis de 2014, el nou editor de la sèrie és Enric Ventura (UPC).

From 2008 to 2013, the responsible editor of this series was Carles Casacuberta (UB); he replaced Manuel Castellet (UAB), who started the series in 2001. Starting in 2014, the new editor of this series is Enric Ventura (UPC).

L'any 2018 van aparèixer tres volums d'aquesta sèrie:

In 2018 three volumes of this series have been published:

- Chachólski, W., Dyckerhoff, T., Greenlees, J., Stevenson, G. . *Building Bridges Between Algebra and Topology*, edited by Herbera, Dolors, Pitsch, Wolfgang, Zarzuela, Santiago. Advanced Courses in Mathematics CRM Barcelona, Birkhäuser, Basel, 2017. ISBN 978-3-319-70156-1
- Brualdi, R.A., Carmona, Á., van den Driessche, P., Kirkland, S., Stevanovic, D. . *Combinatorial Matrix Theory*, edited by Encinas, Andrés M., Mitjana, Margarida. Advanced Courses in Mathematics CRM Barcelona, Birkhäuser, Basel, 2017. ISBN 978-3-319-70952-9
- Giordano, T., Kerr, D., Phillips, N.C., Toms, A.. *Crossed Products of C^*-Algebras, Topological Dynamics, and Classification*, edited by Perera, Francesc. Advanced Courses in Mathematics CRM Barcelona, Birkhäuser, Basel, 2017. ISBN 978-3-319-70868-3



4.2. Research Perspectives CRM Barcelona

L'any 2012, el Comitè Editorial del CRM es va embarcar en l'edició de resums ampliats de les comunicacions científiques del congressos i *workshops* hostatjats pel centre. La intenció era

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

la d'accelerar la difusió dels avenços en recerca, especialment dels resultats encara no publicats, consolidar el profit científic dels esdeveniments del CRM i ajudar a actualitzar de manera fluïda l'estat de l'art en el camp de recerca corresponent. Un acord amb Birkhäuser permet que aquesta editorial es faci càrrec de la publicació d'aquests materials, que s'han concebut com a una subsèrie de la sèrie *Trends in Mathematics*, anomenada *Research Perspectives CRM Barcelona*.

was bringing the opportunity to quickly spreading 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.

- *Extended Abstracts February 2016: Positivity and Valuations,* edited by J. Roe, M. Albertich, A. Kuronya, C. Galindo Research Perspectives CRM Barcelona, vol. 9, in *Trends in Mathematics* Birkhäuser, Basel, 2017. ISBN 978-3-030-00027-1
- *Extended Abstracts Summer 2016: Slow-Fast Systems and Histeresis: Theory and Applications,* edited by A. Korobeinikov Research Perspectives CRM Barcelona, vol. 10, in *Trends in Mathematics* Birkhäuser, Basel, 2017. ISBN 978-3-030-01153-6

L'editor de la sèrie és Enric Ventura.

The series editor is Enric Ventura.

4.4. Preprints

La sèrie de prepublicacions del CRM s'ha incrementat amb els 5 títols següents durant l'any 2018:

The CRM preprint series grew with the following 5 issues in 2018:

- K.A. Bekmaganbetov, Y. Toleugazy. *On the order of the triginometric diameter of the anisotropic Nikolskii – Besov class in the metric of anisotropic Lorentz spaces*, preprint no. 01/2017.2018
- A. Bolsinov, V. S. Matveev, E. Miranda, S. Tabachnikov. *Open problems, questions, and challenges infinite-dimensional integrable systems*, preprint no. 02/2017.2018
- D.V. Gorbachev, V.I. Ivanov, S. Yu. Tikhonov. *Riesz potential and maximal function for Dunkl transform*, preprint no. 03/2017.2018
- L. De Carli, D.V. Gorbachev, S. Yu. Tikhonov. *Weighted gradient inequalities and unique continuation problems*, preprint no. 04/2017.2018
- A. Korobeinikov, E. Shchepakina, V. Sobolev. *A black swan and canard cascades in an SIR infectious disease model*, preprint no. 05/2017.2018

5

Resum econòmic

Financial Summary

5.1 Ingressos

5.1. Revenue

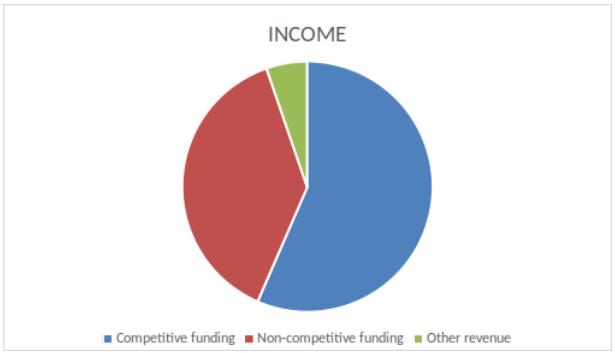
Ingressos competitius *Competitive funding*	1.289.729,45 €
Ingressos no competitius *Non-competitive funding*	870.949,64 €
Altres ingressos *Other revenue*	121.232,62 €
TOTAL	**2.281.911,71 €**

5.2 Despeses

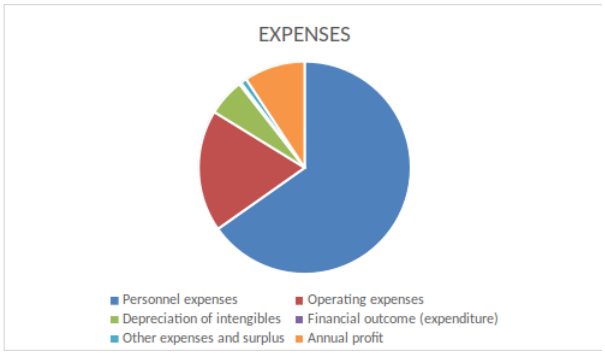
5.2. Expenses

Despeses de personal *Personnel expenses*	1.871.820,31 €
Despeses d'explotació *Operating expenses*	532.483,59 €
Amortització immobilitzat *Depreciation of intangibles*	162.408,93 €
Resultat financer (despesa) *Financial outcome (expenditure)*	9.084,8 €
Altres despeses i romanent *Other expenses and surplus*	-26.907,86 €
Total resultat financer *Annual profit*	-266.978,06 €
TOTAL	**2.281.911,71 €**

Ingressos/Income



Despeses/Expenses



6

Apèndix – Personal del CRM

Appendix – CRM Staff

Director

- Lluís Alsedà i Soler

Deputy Director

- Tomás Alarcón Cor

Managing Director

- José Antonio Fuentes Pérez

Researchers

- Tomás Alarcón Cor (ICREA),
- Álvaro Corral,
- Andrei Korobeinikov,
- Tim Myers,
- Alex Roxin,
- Isaac Salazar,
- Josep Sardanyés (Ramón y Cajal),
- Sergey Tikhonov (ICREA),
- Klaus Wimmer (Ramón y Cajal).

La Caixa Collaborative Mathematics Program

- Francesc Font Martínez (Postdoctoral Fellow),
- Marc Calvo (PhD Student),
- Gemma Colldeforns (PhD Student),
- Núria Folguera (PhD Student),
- Víctor Navas (PhD Student),
- Anel Nurtay (PhD Student),
- Nicolás Pollán (PhD Student),
- Genís Prat (PhD Student),
- Helena Ribera (PhD Student),
- Daria Stepanova (PhD Student).

Postdoctoral Fellows

- Jordi Baró (AXA Postdoctoral Fellowship),
- Jose Mari Esnaola (MINECO),
- Alvaro González (Juan de la Cierva Formación),
- Roberto Gualdi (Borsa FSB),
- Thaís Jordao

PhD Students

- Elisa Beltrán (FPU MECD),
- Alberto Debernardi (CRM Intern Program),
- Ainur Jumabayeva,
- Louisiane Lemaire,
- Askhat Mukanov,
- Patricia Paredes (Equatorian Government)
- Victoria Ponce (German Universities Excellence Initiative),
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- Marina Vegué ("la Caixa"-Becas España).

Industrial Doctorate

- Samantha López,
- Lourdes Méndez.

Collaborators

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- Néstor Costa (Hohner Automáticos, S.L.),
- Aurora Hernández-Machado (Universitat de Barcelona).

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- David Moreno (Universitat Autònoma de Barcelona),
- Stefano Pedarra (Università degli Studi di Padova),
- Alexia Zounias-Sirabella (Université de Panthéon Sorbonne Paris-1),
- Julien Moatti (ENS de Lyon),
- Barry Iyare (Samuel Adegboyega University),
- Ramon Tous (Universitat Autònoma de Barcelona),
- Fernando Saldaña (CIMAT).

- Complex Systems:

- Adrian Viñas (Universitat Autònoma de Barcelona),
- Víctor Mármol (Universitat Autònoma de Barcelona),
- Marc Monné (Universitat Autònoma de Barcelona),
- Marc Serra (Universitat Autònoma de Barcelona).

• Mathematical & Computational Biology:

- Laia Domingo (Universitat Autònoma de Barcelona),
- Carolina Martínez (Universitat Autònoma de Barcelona),
- Ruth Kristianingsih (Universitat Autònoma de Barcelona).

• Computational Neuroscience:

- Pedro Hack (Universitat Autònoma de Barcelona),
- Salvador Borrós (Universitat Autònoma de Barcelona).

BGSMath Postdoctoral Fellows

- Joan Bosa (Universitat Autònoma de Barcelona),
- Gyla Csato (Universitat Politècnica de Catalunya),
- Gonzalo Fiz (Universitat Politècnica de Catalunya),
- Alvaro Leitao (Universitat de Barcelona),
- David Moriña (Universitat Autònoma de Barcelona),
- Alessandro Oneto (Universitat Politècnica de Catalunya),
- Stefano Pasquali (Universitat Politècnica de Catalunya),
- Antti Perälä (Universitat de Barcelona)
- Sune Precht (Universitat Autònoma de Barcelona).

BGSMath PhD Students

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- Robert Cardona (Universitat Politècnica de Catalunya),
- Damian Dabrowski (Universitat Autònoma de Barcelona),
- Gladston Duarte (Universitat de Barcelona),
- Claudia Fanelli (Centre de Recerca Matemàtica),
- Juan Carlos Felipe Navarro (Universitat Politècnica de Catalunya),
- Marina Garrote (Universitat Politècnica de Catalunya),
- Joan Gimeno (Universitat de Barcelona),
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- Waleed Mirza (Universitat Politècnica de Catalunya),

- Carmelo Pulliati (Universitat Autònoma de Barcelona),
- Andrés Rojas (Universitat de Barcelona)
- Mallika Roy (Universitat Politècnica de Catalunya),
- Tomás Sanz (Universitat Politècnica de Catalunya),
- Jordi Vila (Universitat Politècnica de Catalunya),
- Maximilian Wötzel (Universitat Politècnica de Catalunya).

Visitors

- Karim Adiprasito (The Hebrew University of Jerusalem),
- Martha Alvarez (Universidad Autónoma de México-Iztapalapa),
- Imre Bárány (Alfréd Rényi Institute of Mathematics),
- Andriy Bondanrenko (Norwegian University of Science and Technology),
- Sergio Cabello (University of Ljubljana),
- Àngel Calsina (Universitat Autònoma de Barcelona),
- Maria del Pilar Cano Vila (Universitat Politècnica de Catalunya),
- José Antonio Carrillo (Universitat Autònoma de Barcelona),
- Erin Chambers (Saint Louis University),
- Jean Clairambault (INRIA Paris-Rocquencourt Research Centre),
- Montserrat Corbera (Universitat de Vic),
- Josep Maria Cors (Universitat Politècnica de Catalunya),
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- Laura De Carli (Florida International University),
- Amadeu Delshams (Universitat Politècnica de Catalunya),
- Laurent Desvillettes (CMLA Ens Cachan),
- Odo Diekmann (University Utrecht),
- Susanne Ditlevsen (University of Copenhagen),
- Vida Dujmovic (University of Ottawa),
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- Jean-Pierre Françoise (Université Pierre et Marie Curie),
- Fabrizio Frati (Università degli Studi di Roma Tre),
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- Antonio García (Universidad Autónoma de México),
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- Antoni Guillamon (Universitat Politècnica de Catalunya),
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- Yurii Kolomoisev (Institute of Mathematics of NAS of Ukraine),
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- Bojan Mohar (Simon Fraser University),
- Iain Moyles (Limerick University),
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- Brian Wetton (The University of British Columbia),
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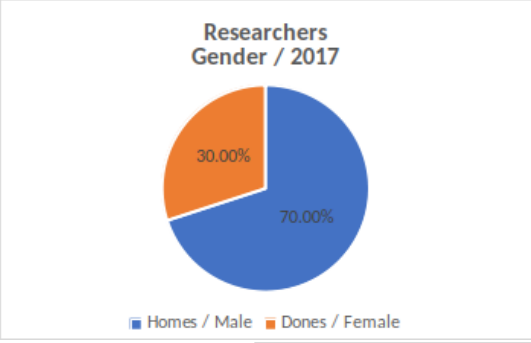

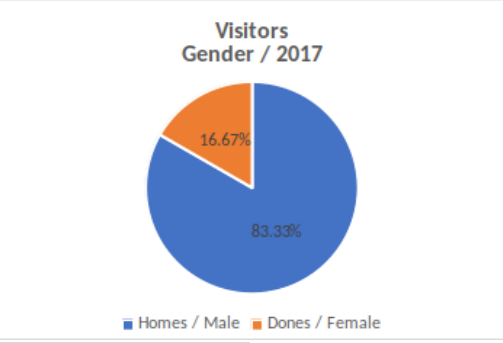

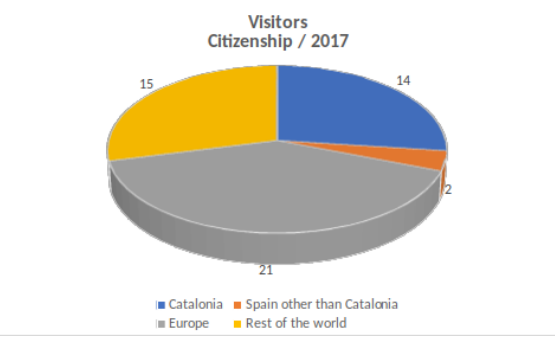

Consultants

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Projects & KTT Unit

- Arantxa Sanz (Project Manager),
- Isabel Serra (KTT Manager).

Administration Staff

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- Núria Hernández,
- Raquel Hernández,
- Jordi Mullor,
- Consol Roca,
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- David Romero,
- Luca Tancredi,
- Alba Tomàs,
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